final

NUREG-75/089

environmental statement

related to construction of

CHEROKEE NUCLEAR STATION, UNITS 1, 2, and 3

DUKE POWER COMPANY

OCTOBER 1975

Docket Nos. STN 50-491, STN 50-492, and STN 50-493

U. S. Nuclear Regulatory Commission • Office of Nuclear Reactor Regulation

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SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission, Division of Reactor Licensing.

1. This action is administrative.

2. The proposed action is the issuance of a construction permit to the Duke Power Company for the construction of the Cherokee Nuclear Station (CNS) Units 1, 2, and 3 located in Cherokee County, South Carolina (Docket Nos. STN 50-491, 50-492, and 50-493).

   The station will employ three identical pressurized water reactors to produce up to approximately 3817 MWt each. A steam turbine generator will use this heat to provide 1280 MWe (net) of electrical power capacity per unit. The exhaust steam will be cooled by a flow of water in a closed-cycle system incorporating circular mechanical-draft wet cooling towers utilizing makeup water from the Broad River. Blowdown from the circulating water system will be discharged into the Broad River.

3. Summary of environmental impact and adverse effects:

   a. A total of 2263 acres will be removed from public use for the CNS site. Construction-related activities on the site will disturb about 751 acres. Approximately 654 acres of land will be required for transmission line right-of-way, and a railroad spur will affect 83 acres. This constitutes a minor regional impact. (Sect. 4.1)

   b. Station construction will involve some community impacts. A total of 17 families will be displaced from the site. Traffic on local roads will increase due to construction and commuting activities. The influx of construction workers' families (an average of 1600 work force) is expected to cause no major housing or school problems. (Sects. 3.10, 4.4.1)

   c. The heat dissipation system will require a maximum water makeup of 55,814 gpm, of which 50,514 gpm will be consumed due to drift and evaporative losses. This amount represents 4.5% of the mean monthly flow and 23.8% of the low flow of the Broad River. The cooling tower blowdown and chemical effluents from the station will increase the dissolved solids concentration in the river by a maximum of 44 ppm. The thermal alterations and increases in total dissolved solids concentration will not significantly affect the aquatic productivity of the river. (Sect. 3.4.1)

   d. It is assumed that aquatic organisms entrained in the service water system will be killed due to thermal and mechanical shock. The applicant is committed to releasing water equal to plant consumptive requirements from already existing upstream reservoirs when such consumptive use would cause natural flow in the Broad River to drop below 470 cfs (the $7Q_{10}$ flow). Therefore, the maximum impact will be the destruction of approximately 23% of the entrainable organisms present in the river. This could constitute a significant impact during periods of low river flow and requires additional data on important species before the impact can be quantified. (Sect. 5.5.2.1)

   e. While there is a potential for impingement of aquatic organisms at the intake structure, the staff does not consider that serious impingement losses will occur. (Sect. 5.5.2.1)

   f. There exists no serious potential for ground-level fogging and icing due to operation of the cooling towers. Drift effects on terrestrial ecosystems are considered to be minimal. (Sect. 5.1.1.1)

   g. The risk associated with accidental radiation exposure is very low. (Sect. 7.1)

   h. No significant environmental impacts are anticipated from normal operational releases of radioactive materials. The total annual dose to the U.S. population (total body plus thyroid) from operation of the plant is 210 man-rems which is less than the normal fluctuations in the background dose this population would receive. The occupational dose is approximately 1400 man-rems/year. (Sect. 5.4.2.5)

4. Principal alternatives considered were:

   a. Purchase of power

   b. Alternate energy systems

   c. Alternate sites

   d. Alternate heat dissipation methods

5. The following Federal, State, and local agencies were asked to comment on the Draft Environmental Statement issued in March, 1975:

   - Advisory Council on Historic Preservation
   - Department of Agriculture
   - Department of the Army, Corps of Engineers
   - Department of Commerce
   - Department of Health, Education, and Welfare
   - Department of Housing and Urban Development
   - Department of the Interior
   - Department of Transportation
   - Energy Research and Development Administration
   - Environmental Protection Agency
   - Federal Energy Administration
   - Federal Power Commission
   - State of South Carolina Clearing House
   - Chairman, Board of Commissioners, Cherokee County, Gaffney, South Carolina

   Comments on the Draft Environmental Statement were received from the following:

   - Department of the Army, Corps of Engineers
   - Department of Agriculture, Agricultural Research Service
   - Department of Agriculture Soil Conservation Service
   - Department of Interior
   - Energy Research and Development Administration
   - Department of Commerce
   - Department of Agriculture, Forest Service
   - Department of Health, Education and Welfare
   - Department of Transportation
   - State of South Carolina

Wildlife and Marine Resources Department
State Land Resources Conservation Commission
Department of Archives and History
Public Service Commission
Department of Health and Environmental Control

- State of North Carolina Department of Administration

- Duke Power Company

- Environmental Protection Agency

- Federal Power Commission

Copies of these comments are appended to this Final Environmental Statement as Appendix A. The staff has considered these comments, and the responses are located in Section 11.

6. This Environmental Statement was made available to the public, to the Council on Environmental Quality and to other specified agencies in October, 1975.

7. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical, and other benefits of Cherokee Nuclear Station, Units 1, 2, and 3, against environmental and other costs and considering available alternatives, it is concluded that the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of a construction permit for the facility subject to the following conditions for the protection of the environment:

   a. The applicant shall take the necessary mitigating actions, including those summarized in Sect. 4.5 of this Environmental Statement, during construction of the station, associated transmission lines, and railroad spur to avoid unnecessary adverse environmental impacts from construction activities.

   b. The applicant will be required to submit a detailed erosion control plan prior to initiation of construction activities. The plan must identify those areas where serious erosion could occur as a result of clearing and construction, and it must describe in detail, for each of these areas separately, actions that will be taken to impede the erosion (Sect. 4.3.1).

   c. Because the staff's analysis indicates that there is doubt that the present discharge system can meet state thermal standards under all conditions, the applicant is required to develop alternate discharge arrangements or procedures so that state standards are met. (Section 5.3.1)

   d. In view of the superior environmental aspects of either of the alternative blowdown discharge methods and locations, the staff will approve the proposed discharge method and location only if the applicant will commit to meet a chlorine design objective of total residual chlorine of not more than 0.1 mg/l and not discharge blowdown containing total residual chlorine when leakage through the dam is the only flow in the river downstream of the dam. (Sections 5.3.1, 5.5.2.2 and 9.2.3)

   e. Before engaging in a construction activity not evaluated by the Commission, the applicant will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in this Environmental Statement, the applicant shall provide a written evaluation of such activities and obtain prior approval of the Director of Reactor Licensing for the activities.

   f. The applicant shall establish a control program which shall include written procedures and instructions to control all construction activities as prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of environmental conditions. The applicant shall maintain sufficient records to furnish evidence of compliance with all the environmental conditions herein.

   g. If unexpected harmful effects or evidence of serious damage are detected during facility construction, the applicant shall provide to the staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

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FOREWORD

This environmental statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (staff) in accordance with the Commission's regulation, 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

The NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of the NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR 51, the NRC Office of Nuclear Reactor Regulation prepares a detailed statement on the foregoing considerations with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or a full-power operating license, the applicant submits an environmental report to the NRC. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing, and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Section 102(2)(C) of the NEPA and 10 CFR 51.

This evaluation leads to the publication of a draft environmental statement, prepared by the Office of Nuclear Reactor Regulation, which is then circulated to Federal, State and local governmental agencies for comment. A summary notice is published in the Federal Register of the availability of the applicant's environmental report and the draft environmental statement. Interested persons are also invited to comment on the draft statement.

After receipt and consideration of comments on the draft statement, the staff prepares a final environmental statement, which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final benefit-cost analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether--after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered--the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license, or its appropriate conditioning to protect environmental values.

Single copies may be obtained as indicated on the inside front cover. Dr. Robert A. Gilbert is the NRC Environmental Project Manager for this statement. Should there be questions regarding the contents of this statement, Dr. Gilbert may be contacted at the following address:

Division of Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
(301) 443-6990

Effective January 19, 1975, activities under the U.S. Atomic Energy Commission regulatory program were assumed by the U.S. Nuclear Regulatory Commission in accordance with the Energy Reorganization Act of 1974. Any references to the Atomic Energy Commission (AEC) contained herein should be interpreted as Nuclear Regulatory Commission (NRC).

1. INTRODUCTION

1.1 THE PROPOSED PROJECT

Pursuant to the Atomic Energy Act, as amended, and the U.S. Atomic Energy Commission's regulations in Title 10, Code of Federal Regulations, an application with an accompanying Environmental Report was filed on March 29, 1974 by Duke Power Company (hereinafter referred to as the applicant) for construction permits for three generating units designated as the Cherokee Nuclear Station, Units 1, 2, and 3 (Docket Nos. STN 50-491, 50-492, and 50-493), each of which is powered by a pressurized water reactor (PWR) and is designed for initial operation at approximately 3817 MWt with a net electrical output of 1280 MWe. Condenser cooling will be accomplished through the use of circular mechanical-draft cooling towers. Makeup water for the cooling towers will be obtained from the Broad River, and the tower discharge (blowdown) will be returned to the Broad River. The proposed facilities will be located on the applicant's 2263-acre site in Cherokee County, South Carolina, about 21 miles east-northeast of Spartanburg and about 8 miles southeast of Gaffney.

Integration of the power from CNS will be accomplished by three double-circuit 230-kV lines folded into the Cherokee switchyard. This will require the construction of approximately 20.5 miles of 230-kV circuit transmission lines into existing electrical systems. A 230-kV switchyard will be located on the Cherokee site in proximity to the generating units and will constitute the terminus of the 230-kV circuits over which the output of the station will be delivered to the load centers.

1.2 BACKGROUND

10 CFR Part 51 requires that the NRC analyze the applicant's Environmental Report and prepare a detailed statement of environmental considerations. It is within this framework that this Environmental Statement related to the construction of the Cherokee Nuclear Station, Units 1, 2, and 3, has been prepared by the Division of Reactor Licensing (staff) of the Nuclear Regulatory Commission.

Major documents used in the preparation of this statement were the applicant's Environmental Report (ER), and supplements thereto, and the applicant's Preliminary Safety Analysis Report (PSAR). In this Environmental Statement, the ER[1] is cited extensively and the PSAR[2] is cited a number of times; however, their full titles and documentation are given only in the list of references for Sect. 1. Elsewhere in this statement, references to these two documents will appear as the abbreviations ER and PSAR, respectively, followed by the number(s) of specific sections, pages, tables, figures, and appendices.

Independent calculations and other sources of information were also used by the staff as a basis for the assessment of environmental impact. In addition, some of the information was gained from visits by the staff to the site, the Town of Gaffney, and the surrounding areas in August 1974. Members of the staff also had discussions with representatives of the South Carolina State Environmental Health and Safety Commission, State Wildlife and Marine Resources Commission, local officials of the Town of Gaffney and Cherokee County, South Carolina, and local conservation officers.

As a part of the Commission's safety evaluation leading to the issuance of construction permits and operating licenses, it makes a detailed evaluation of the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal conditions and potential accident conditions, including the effects of natural phenomena on the facility. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated environmental effects are repeated in this Environmental Statement.

Copies of this Environmental Statement and the applicant's Environmental Report are available for public inspection at the Commission's Public Document Room, 1717 H Street, NW, Washington, D.C., and at the local Public Document Room, Gaffney Library, Gaffney, South Carolina.

1.3 STATUS OF REVIEWS AND APPROVALS

The applicant has provided a status listing of environmentally related permits, approvals, and licenses required from Federal, State, regional, and local agencies in connection with the proposed project (ER, Sect. 12). The staff has reviewed this listing and has consulted with some of the appropriate agencies in an effort to identify any significant environmental issues of concern to the reviewing agencies. As a result of this effort, no potential non-NRC licensing problems have been identified.

REFERENCES FOR SECTION 1

1. Duke Power Company, *Environmental Report, Cherokee Nuclear Station, Units 1, 2, and 3*, Docket Nos. STN 50-491, 50-492, and 50-493, March 29, 1974, Amendment No. 1, September 20, 1974.

2. Duke Power Company, *Preliminary Safety Analysis Report, Cherokee Nuclear Station, Units 1, 2, and 3*, Docket Nos. STN-50-491, 50-492, and 50-493, March 29, 1974.

2. THE SITE

2.1 LOCATION

The proposed construction site of Cherokee Nuclear Station (CNS) lies in eastern Cherokee County, South Carolina, about 21 miles east-northeast of Spartanburg and 8 miles southeast of Gaffney. The center reactor is to be located at 35° 02' 12" north latitude and 81° 30' 43" west longitude about 1000 yd west of the Broad River. Figure 2.1 (ER, Fig. 2.1-1) shows the cities, towns, major roads, and other nuclear installations within 50 miles of the site.

The site is bordered on the north and east by the Broad River and is directly west of Ninety-Nine Islands Hydro Station, which impounds the Broad River contiguous to the site. Details of present site usage and site development plans are given in the applicant's Environmental Report (ER, Sect. 2.1).

2.2 REGIONAL DEMOGRAPHY, LAND AND WATER USE

2.2.1 Regional demography

The proposed site is located in an area of relatively low population density; only about 500-600 residents live within a 2-mile radius. The estimated 1970 population within 10 miles of the station was 31,877. Within a 50-mile radius, the 1970 population was estimated to be 1,308,327 as indicated in Fig. 2.2. The nearest towns of any size are Blacksburg, with a population of $\sim$ 2000, and Gaffney, the Cherokee County Seat, with a population of $\sim$13,000. Draytonville Elementary School, approximately 4.3 miles west of the site, is the only school within a 5-mile radius. The nearest public hospital (164 beds) is located in Gaffney about 8 miles west-northwest of the site.

Although there are no major industries within 5 miles of the site, the nearest industry is Burlington Industries (250 employees) in Cherokee Falls about 3 miles northwest of the site. However, there are a number of industries, ranging in size from 3 to 1000 employees, within 10 miles of the site.

The applicant determined the population within 5 miles of the site by a house count in Cherokee County (made in November 1973) and from tax assessor records in York County. Beyond that point, the applicant used 1970 census data. Population projections for the years 1984 and 2024 were based on extrapolations of projections made by Region IV, Environmental Protection Agency.[1] The staff's review and assessment of census data are in agreement with the applicant's census data. More detailed treatment of the local and regional demography is found in the applicant's Environmental Report (ER, Sect. 2.2).

2.2.2 Land use

The area surrounding the near vicinity of the site (within a 5-mile radius) is rural and lightly populated. Both counties adjoining the site, York and Cherokee, are largely rural in character. However, both counties demonstrate a pattern of industrial development adjacent to the major transportation routes. The towns of Gaffney and Blacksburg are the major urban areas in Cherokee County. Most of the industries in Cherokee County are located in or adjacent to these urban areas.

The major cultivated (farming) areas of Cherokee County lie west of the Broad River with row crops and orchards, as well as cattle farms, predominating. The pountry industry, the largest agricultural income producer in the area, is concentrated in the eastern part of Cherokee County.

While there are no wildlife preserves within a 5-mile radius of the site, there are several areas to the south and southeast within 3-5 miles of the site that have been donated to the South Carolina Game Management Program. These areas can be hunted by the public after acquisition of a permit. For further details of land use, see the applicant's Environmental Report (ER, Sect. 2.2).

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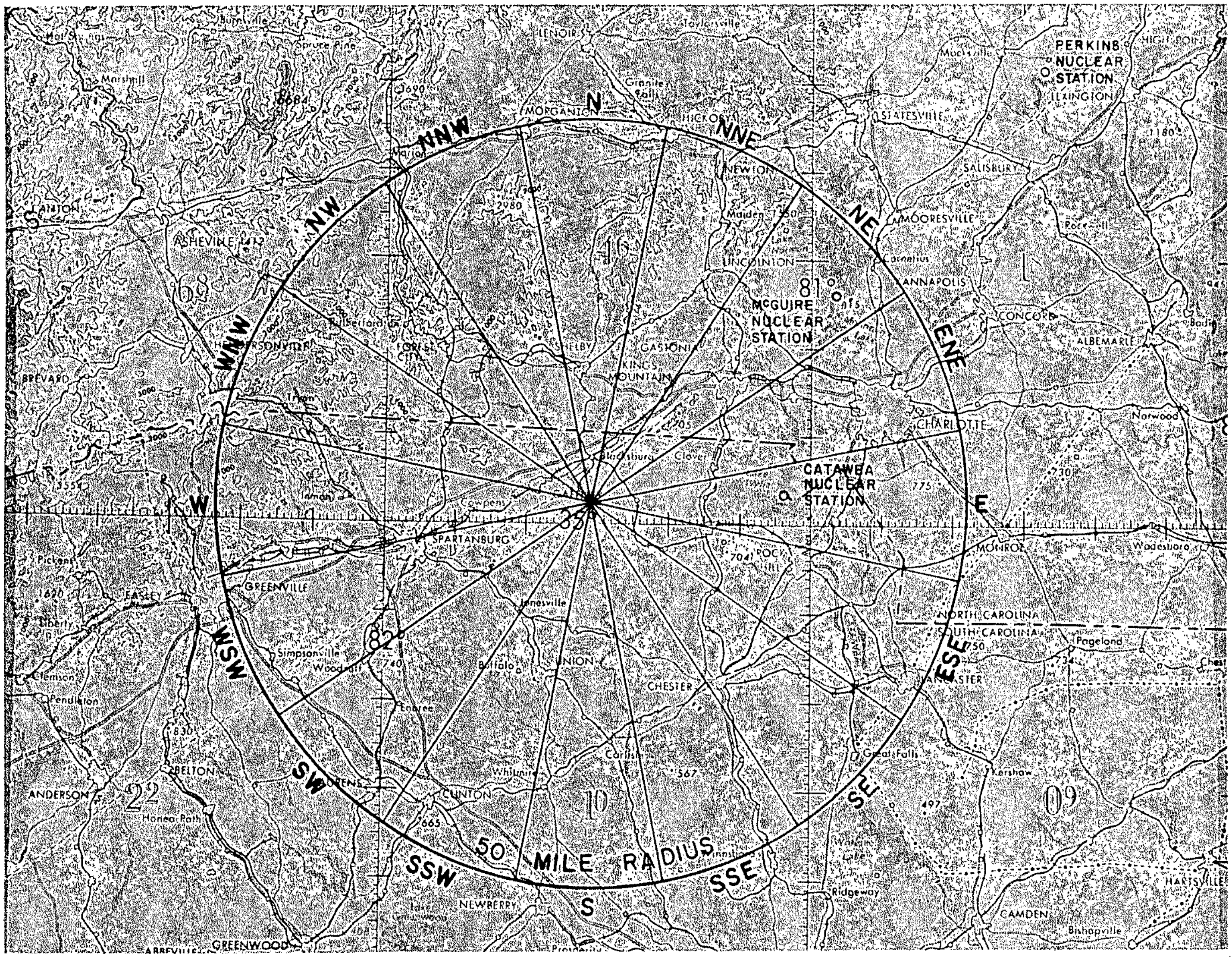

Fig. 2.1. Region surrounding the Cherokee Nuclear Station. Source: ER, Fig. 2.1-1.

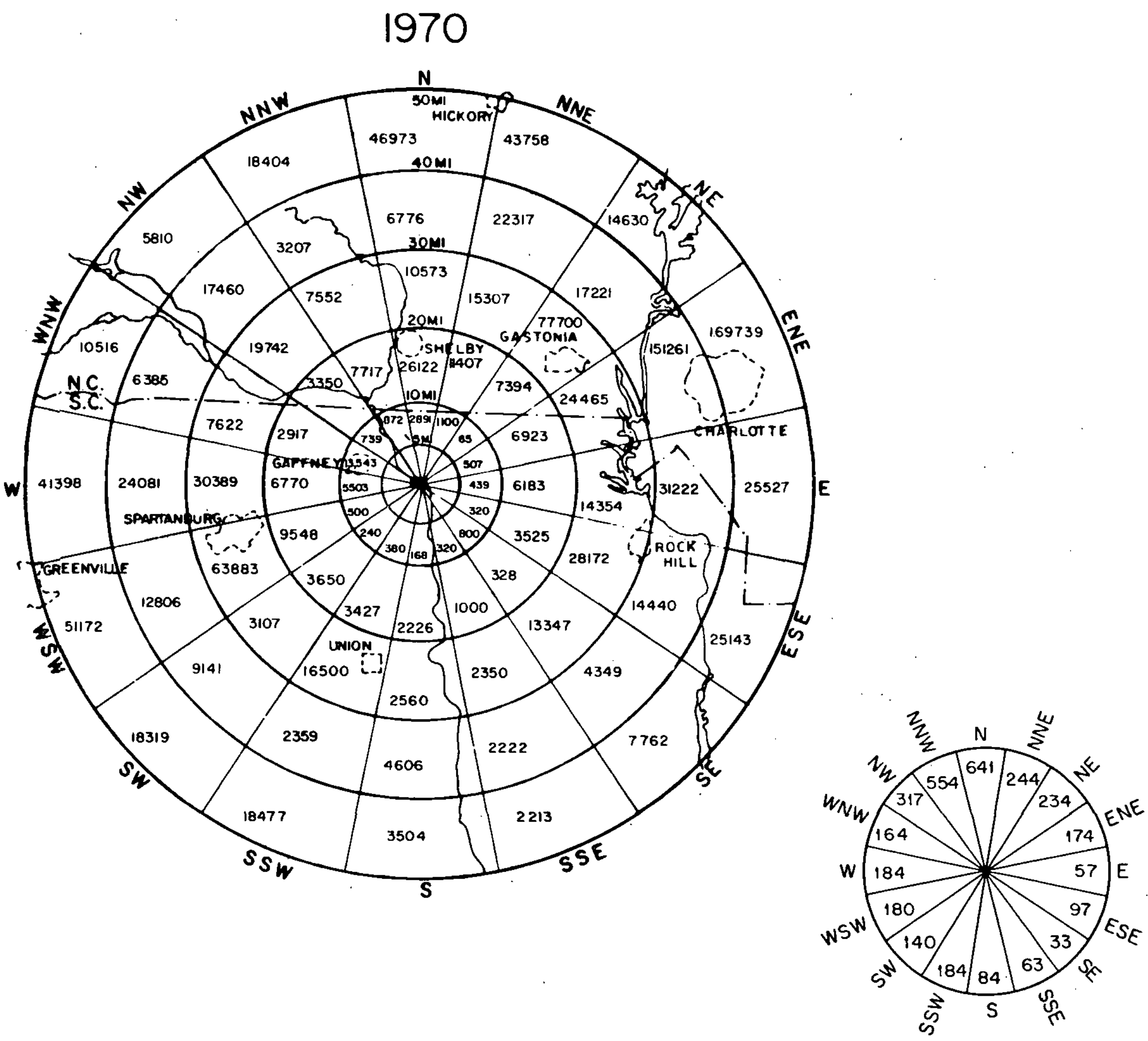

Fig. 2.2. Population within 50 miles of site. Source: ER, Fig. 2.2.1-5.

2.2.3 Water use

2.2.3.1 Surface water

In the vicinity of the site, the Broad River is the major source of water supply. The nearest downstream municipal intake is about 21 miles downstream and has a capacity of 3.5 Mgd. There are approximately 13 other water intakes on the Broad River or its tributaries within a 50-mile radius of the site. However, the only other downstream intakes on the Broad River in this area are for industrial usage and have a combined capacity of approximately 3.64 Mgd.

2.2.3.2 Groundwater

Within a 20-mile radius of the site, there are approximately 51 wells or groups of wells that serve industrial and public uses. The nearest location to the site is a group of five wells (0.03 Mgd capacity) used by Burlington Industries about 3 miles northwest of the site. The applicant's Environmental Report covers this subject in greater detail (ER, Sect. 2.2.2.5).

2.3 HISTORICAL AND ARCHAEOLOGICAL SITES AND NATURAL LANDMARKS

2.3.1 Historical sites

There are two places within 20 miles of the site listed in the National Register of Historic Places. They are Kings Mountain National Military Park (10 miles northeast) and Cowpens National Battlefield near Chesnee, South Carolina, about 18 miles west of the site. There are, however, a number of historic sites and buildings in Cherokee County. Among these are the Adams Goudelock House near Thicketty, Fort Thicketty, the Cherokee Iron Works, Austels' Grist Mill, and Limestone College in Gaffney. None of these will be directly affected by plant construction or operation and none are on the site property.

2.3.2 Archaeological sites

The applicant has not identified any specific archaeological sites in the area. However, the Institute of Archaeology and Anthropology of the University of South Carolina has, at the request of the applicant, conducted an archaeological site survey of the proposed site area. The results of this survey indicate that no significant sites are endangered by the proposed project.[2]

2.4 GEOLOGY AND SEISMOLOGY

2.4.1 Geology

The geology of the site is discussed only to the extent necessary to provide background for potential environmental impact. The staff analysis related to site safety will be presented in the Safety Evaluation Report. More detail is given by the applicant (ER, Sect. 2.4; PSAR, Sect. 2.5).

The site is located in the Piedmont physiographic province, which extends in a belt 80 to 120 miles wide from New York to Georgia. It is bordered on the northwest by the Blue Ridge province and on the southeast by the coastal plain.

Most of the site is underlain by felsic gneiss, although mafic gneiss, felsic schist, and quartzite have been located throughout the site. No active faults have been located within the general site location, but several inactive faults appear in published maps and literature. Weathering action on the rocks has created a soil overburden that is classified as being a silt to silty sand composition.

2.4.2 Seismology

The Piedmont (and the southeastern United States in general) is an area of infrequent earthquakes of only moderate intensity. Two major earthquakes have occurred in the area. The Charleston, South Carolina, earthquake of 1886 had an epicentral intensity on the Modified Mercalli scale of IX (heavy destruction) and an estimated intensity of VI-VII at the site, 175 miles away. The New Madrid, Missouri, earthquake of 1811-1812 had an epicentral intensity of XII (total destruction) and an estimated intensity at the site (450 miles away) of VI. Altogether, 11 earthquakes (with a maximum epicentral intensity of V or more) have probably been felt at the site during historic times. The nearest to the site was the Union County, South Carolina, earthquake of 1913, with an epicenter 20 miles from the site and an intensity of VI.

The applicant has proposed 0.15 g as the earthquake acceleration for safe shutdown in the PSAR. The staff has this proposal under review, and the subject will be addressed in its Safety Evaluation Report.

2.5 SURFACE WATER AND GROUNDWATER

2.5.1 Surface water

The dominant source of surface water in the area of the site is the Broad River, which is about 185 miles long and has a drainage area of approximately 5240 sq miles. The river is generally shallow with width/depth ratios varying from about 50 to 150. It also carries a large bedload of material composed mainly of sand.

The river typically attains its periods of lowest flow during the months of July, August, and September. The mean annual flow measured at a point 5 river miles above the site is 2472 cfs, while the lowest ten-year seven-day average flow ($7\ Q_{10}$) at the same point is 470 cfs. The maximum flow on record is 119,000 cfs.

The average temperature of the river ranges from approximately 41 to 82°F. The lowest temperatures occur during January and February, and the highest occur during July and August.

The applicant discusses the river hydrology in the Environmental Report (Sect. 2.5).

2.5.2 Groundwater

Groundwater in the area of the site is derived almost entirely from local precipitation. The applicant has conducted a well survey of the area within about a 2.5-mile radius of the site (ER, Sect. 2.5.4.3). The data presented indicate that most of the 39 wells and four springs surveyed are generally shallow (less than 150 ft deep) and have a small flow (median flow rate of 7 gpm). Of the wells surveyed, no known wells are currently in use on the site proper, although the nearest spring in use is about 0.4 mile northwest. The applicant has presented a survey of the wells in the area and has presented data from about 60 test borings in the immediate area of the site (ER, Sect. 2.5.4).

2.6 METEOROLOGY

2.6.1 Regional climatology

The climate of the Cherokee site is typical of continental climates in southern areas and is characterized by cool winters and relatively long, warm summers. Cold air moving southward into the area from Canada is modified by crossing the Appalachian Mountains and descending the eastern slopes.

2.6.2 Local meteorology

Climatological data from Charlotte, Greenville-Spartanburg Airport (about 40 miles west of the site), Greenville Airport, Spartanburg Airport, and available onsite data have been used to assess local meteorological characteristics of the site.

Mean monthly temperatures at the site may be expected to range from about 40°F in January to about 79°F in July.[3,4] A record maximum temperature of 104°F was reported at Charlotte in September 1954,[3] while the record minimum temperature for the area was -6°F, reported at Greenville-Spartanburg in January 1966.[4]

Annual average precipitation in the site area is about 46 in.[4] The maximum mean monthly precipitation of about 4.9 in. occurs in July, while the minimum mean monthly precipitation of about 2.6 in. occurs in November. Annual average snowfall averages about 5 in.[3]

Wind data[5] from the 33-ft level at the Cherokee site for the period September 11, 1973, through September 11, 1974, indicate a prevailing wind direction from the southwest (11.9%) and from the northwest (11.0%). Winds from the south-southeast occurred least frequently at less than 2%. Calms occurred about 5.5% of the time. The average wind speed at the 33-ft level for the same period was about 3.6 mpg. Due to the complex topography of the site area, only onsite data can be used to truly represent the site. The onsite wind rose for the 33-ft level for the period September 11, 1973, through September 11, 1974, is presented in Fig. 2.3(*a*).

Wind data from the 135-ft level at the Cherokee site for the same one-year period of record also indicate a prevailing wind direction from the southwest (13.3%), although the remainder of the 135-ft wind rose is more uniform than the 33-ft wind rose. Winds from the east-southeast occurred least frequently at less than 3%. Calms occurred only 0.2% of the time. The average wind speed for this period at the 135-ft level was about 6.5 mph. The onsite wind rose for the 135-ft level for the period September 11, 1973, through September 11, 1974, is presented in Fig. 2.3(*b*).

2.6.3 Severe weather

The Cherokee site may be affected by thunderstorms, tornadoes, tropical storms, and hurricanes.

Thunderstorms can be expected to occur about 42 days per year, being most frequent from June through August.[3]

During the period 1955-1967, only four tornadoes were reported in the latitude-longitude square containing the site, giving a mean annual frequency of 0.3.[6] The computed recurrence interval for a tornado at the plant site is 4400 years.[7]

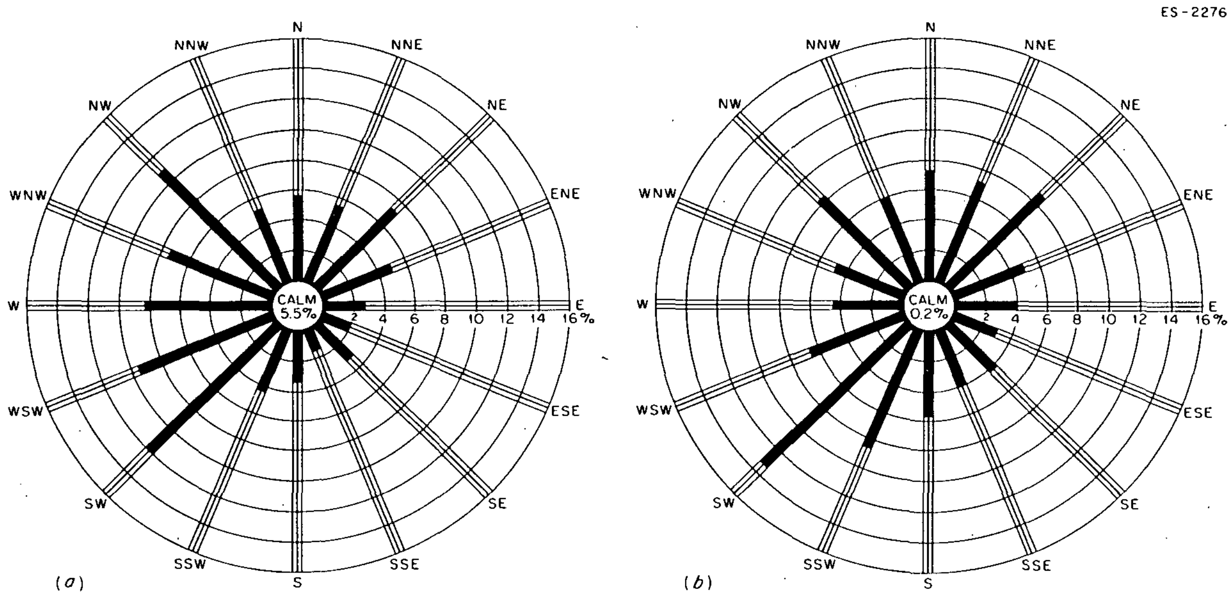

Fig. 2.3. Wind roses for the Cherokee site (a) 33-ft level and (b) 135-ft level from September 11, 1973, to September 11, 1974.

In the period 1871-1971, 27 tropical storms, hurricanes, and depressions passed within 50 miles of the site.[8]

The "fastest mile" wind speed recorded at Greenville Airport was 79 mph (ER, Table 2.6.1-1, Amendment 3).

In the period 1936-1970, there were about 84 atmospheric stagnation cases totaling about 325 days reported in the site area.[9] The maximum monthly frequency occurs in October.

2.7 ECOLOGY OF THE SITE AND ENVIRONS

2.7.1 Terrestrial ecology

2.7.1.1 Physical characteristics

The site is located near the center of the Piedmont physiographic province on the west bank of the Broad River. The topography of the site is similar to that along much of the river in the area and consists mostly of gentle slopes, with steep slopes in some areas. The center of the exclusion area is located on a rise surrounded, for the most part, by outward radiating ridges and ravines that lead toward the river and two of its smaller tributaries. Soils on both uplands and valley slopes belong to the Hapludults (Red-Yellow Podzolic) great soil group and are identified by the Soil Conservation Service as the Tatum series — a deep, well-drained Piedmont soil. Tatum soils have moderate permeability, moderately slow infiltration, medium available moisture capacity, low natural fertility, and low content of organic matter. Alluvial soils occur along the river bottoms.

2.7.1.2 Vegetation

The site is almost entirely forested, although no virgin forest is present. The exclusion area is largely uncleared, except for a few roads, a power line right-of-way, and the meteorological tower site. Outside of the exclusion area there is some cleared farm land in the southeastern and western portions of the Duke-owned property.

The combined effects of topographic variations and resultant soil drainage characteristics, past land use practices, and dynamics of the Broad River have led to the establishment of several vegetation types. The types and their general locations on the site are given in Table 2.1.

The applicant has provided data on plant species composition of forests found on the Cherokee site (ER, Tables 2.7.1-4 through 2.7.1-11). The data indicate that the forests are similar to widespread forests that would be expected to occur in the Piedmont area of South Carolina.[10,11] The American beech-mountain laurel community (ER, Table 2.7.1-7), however, is an interesting variant not mentioned by publications[10,11] that include this geographic area (see discussion of this community in Sect. 4.3.1.1). The forest types and their acreages (staff estimates from ER, Fig. 2.7.1-2 supplement) exist within the 450-acre exclusion area on the site as follows: pine forest, 228 acres; oak-hickory, 141 acres; mixed mesic hardwood, 50 acres; and mountain laurel-hardwood, 7 acres. The single stand of laurel hardwood forest occupies only 0.2% of the total area mapped (3348 acres) and therefore may be considered a rare forest type on the site.

Table 2.1. Vegetation types of the Cherokee Nuclear Station site

Type[a]	Dominant species[b]	Location
Cattail marsh	*Typha latifolia*	Shore of Ninety-Nine Islands Reservoir
Alluvial forest (61, 63)	Boxelder, river birch	Adjacent to Broad River, on sandy silt
Alluvial thicket	Black willow, cottonwood, common elderberry	Low lying land between reservoir and river
Hardwood-Mountain laurel forest (44, 90)	Mountain laurel, American beech, American holly	Steep north-facing bluffs
Mixed mesic forest (76, 90)	American beech, sugar maple, American holly, red cedar, white oak	Lower slopes and valley sides on well-drained soils
Pine forest (75)	Shortleaf pine, red cedar	Soils of low fertility that have been timbered, cultivated, or burned
Pine scrub (79)	Virginia pine	On eroded sites that were originally pine forests or old fields
Oak-hickory forest (41, 52)	Scarlet oak, red oak	Upland slopes and ridge tops on well-drained soils

[a]Numbers in parentheses are forest type numbers of the Society of American Foresters, which the given forest types most closely resemble (Society of American Foresters, *Forest Cover Types of North America*, 1954, p. 67).

[b]Determined with dominance ratings; see ER, Table 6.1.4-1.

Succession in aquatic areas, leading to the establishment of terrestrial communities, occurs in the following sequence: floating aquatics, cattails, black willow, cottonwood, and finally Box elder-river birch-water oak. Successional stages on sand bars are forbs, willows, and the cottonwoods. The successional sequence on uplands, as on right-of-ways, is *Aster pilosus* and *Andropogaon virginicus*, scrub pine (skipped in plant succession on many areas of the site), shortleaf pine, and hardwoods.

Almost all the site has been, at one time or another, disturbed by man's activities. Because of clearing during early days of settlement and subsequent activities, virgin forests are completely absent from the site as well as from the entire Piedmont region.[12] The clear-abandon process has been repeated on many lands, resulting in forests of different ages and different stages of succession.

According to the applicant (ER, Sect. 2.7.1.1.5), nonextensive logging, mostly selective harvesting of pine species, is being conducted by local land owners on the proposed site. Pines are logged from pine plantations, mixed hardwood stands, and mesic pine woodlands, which tend to favor and accelerate the establishment of hardwood species on the site (ER, Sect. 2.7.1.1.5). Later information supplied by the applicant, however, states that there was no selective harvesting of pine but that all logging was general (ER, Question 2.7.22g). The applicant does not know the extent of cutting nor future plans.

Because most of the land is gradually to steeply sloping, existing vegetation plays an important role in preventing rapid runoff with resultant erosion, loss of soil, siltation of nearby aquatic habitats, flooding, and lowered replacement rates of groundwaters.

2.7.1.3 Fauna

The variety of plant species and types of vegetation present provide suitable habitat for numerous vertebrate and invertebrate species. Invertebrate species have not been surveyed but would be expected to include common species existing in eastern forests.

As determined from a report of probable mammalian species compiled for the Cherokee site (ER, Table 2.7.1-13) and scant data from a small amount of sampling (ER, Table 2.7.1-16), 19 mammalian species are known to occur on the site and have been observed, and 42 species are known to occur in the vicinity of the site. Population studies were too limited to allow comparisons of the abundance of mammals in different plant communities in the site, although large numbers of rice rats were captured in the cattail marsh and alluvial thicket. Smaller species captured (during December 10-16, 1973) include the white-footed mouse (1), shorttail shrew (1), eastern cottontail (1), and opossum (2). Feral housecats (3) and dogs (1) were also captured. Population data for the region surrounding the site is available in published literature.

The only endangered mammalian species that could occur on the site is the eastern cougar, but it would occur there so rarely that the site can be judged insignificant to the status of the cougar.

Of 241 species of birds that could potentially occur on the Cherokee site, 99 have been observed there by the applicant's consultants. Few data for breeding birds and summer populations are provided, but such data for the region are available in the literature. Three endangered avian species that could potentially occur on the site are the bald eagle, the peregrine falcon, and the red-cockaded woodpecker. The latter species is the only one that might reside on the site, but to date, no individuals have been observed. The staff has observed the forest on the site and did not find any habitat of mature park-like pine forest that would be suitable for red-cockaded woodpeckers. The other two species might occur along the Broad River during nonbreeding seasons, but the site is of no particular importance to them. Use of the river by waterfowl is light, and the site is of no particular importance to any waterfowl population.

Reptiles and amphibians include 64 species that could potentially occur on the site and 27 species that have been observed on the site. One rare species, the bog turtle, could occur on the site but has not been observed.

2.7.2 Aquatic ecology

The Broad River will be the primary source of cooling tower makeup water as well as the receiving stream for most liquid effluents released from CNS. The river, including Ninety-Nine Islands Reservoir, will therefore be the principal aquatic environment impacted by the construction and operation of CNS. Other aquatic environments that will be affected by CNS include the two onsite creeks that will be impounded to form the nuclear service water pond and the intake sedimentation basin (see Fig. 2.4). The applicant has initiated an ecological monitoring program of the CNS site and environs. Data collected during the interval from October 1973 through March 1974 are presented in the applicant's Environmental Report (ER, Sect. 2.7.2). Specific communities of the aquatic environment are discussed briefly in the following sections.

2.7.2.1 The Broad River

The Broad River originates in the western North Carolina mountains and flows southeasterly to a point near Gaffney, South Carolina. It then flows south to Columbia, South Carolina, where it is joined by the Saluda River to form the Congaree River.

The drainage area of the river above the proposed site is 1550 sq miles. The river has had a maximum flow of record near the site of 119,000 cfs and a lowest seven-day ten-year average flow ($7Q_{10}$) of 470 cfs. Mean annual flow is 2472 cfs. Maximum flows generally occur in March, while lowest flows occur from July through September (ER, Fig. 2.5.1-5). The average monthly river velocity for October 1973 through March 1974 ranged from 2.0 to 4.8 fps (ER, Sect. 2.5.1).

Excluding Ninety-Nine Islands Reservoir, the river can be characterized as being wide (80 m) and shallow (0.5 to 1 m). The bottom substrate is generally sandy, interspersed approximately every 1/4 mile by rocky shoals. The river carries a large bed load of sand and is generally quite turbid, with an average total suspended solids content of 135 mg/l (ER, Table 3.6.2-1).

The site of CNS is on the shore of Ninety-Nine Islands Reservoir, a run-of-the-river hydroelectric reservoir built about 1910. This reservoir retains few lake characteristics because it has been largely filled in with silt. The bottom sediments of the reservoir are silty loam (ER, Sect. 6.1.1.1). Moderately rapid river current is maintained in the main channel of the river throughout the reservoir. The only lentic (standing water) environments that remain from the original reservoir are several backwater areas (Fig. 2.4). The reservoir has virtually no remaining storage capacity.

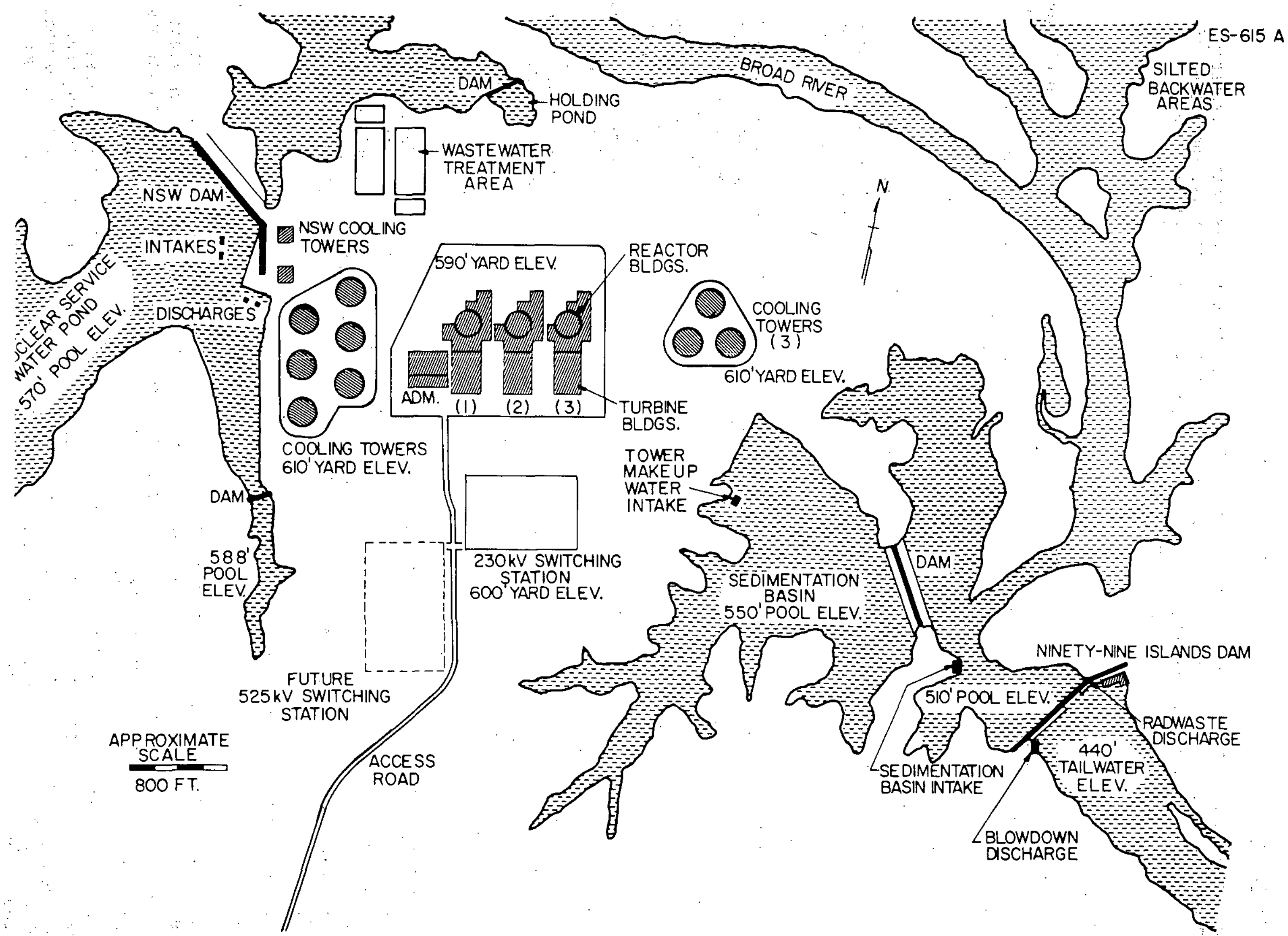

Fig. 2.4. Layout of principal features of Cherokee Nuclear Station.

Information on the limnology of the Broad River and Ninety-Nine Islands Reservoir is presented by the applicant (ER, Sects. 2.5.1 and 2.5.2).

2.7.2.2 Aquatic biota of the Broad River

Primary producers

The Broad River, due to its normally high turbidity, has a trophic structure that is probably based on allochtonous primary production.[13] Autochtonous primary production is, therefore, of lesser importance. Studies by the applicant have indicated that about 78% of the suspended organic material in the river is of terrestrial origin (ER, Sect. 2.7.2.1.1).

Aquatic macrophytes

Several marshy areas that exist in the backwaters of the reservoir support substantial populations of emergent hydrophytes, principally *Typha latifolia* and *Sagittaria latifolia* (ER, Table 2.7.1-4). The existence of other populations of aquatic macrophytes in the river and the reservoir is doubtful because of the high turbidity and changing water levels of the river.

Phytoplankton

True phytoplankton (euplankton) communities are not characteristic of turbid, fast-flowing rivers such as the Broad.[13] The planktonic flora recognized in collections made by the applicant have probably been derived from lentic and benthic populations that have been carried into the river current. Nearly all the periphyton species collected by the applicant were also found among the phytoplankton (ER, Table 2.7.2-16).

Phytoplankton densities in the river, exclusive of the backwaters of the reservoir, were generally low. Highest densities (∿500 cells/ml) were encountered in the spring and summer, while lowest densities (∿100 cells/ml) were found in the fall and winter. Numerically, diatoms dominated the phytoplankton throughout the year, while the bluegreens, though present in low numbers, generally dominated the total biovolume of the phytoplankton. These relationships generally held throughout the year except for the winter, when diatoms dominated both in numbers and biovolume. Green algae were occasionally abundant, generally in the late summer. The phytoplankton community of the reservoir was similar in composition and followed similar seasonal trends, as did the community of the river. Densities, however, were generally considerably higher. The highest densities encountered (∿5500 cells/ml) were found in October 1973. Bloom conditions have been occasionally reported (ER, Sect. 2.7.2.1.3). A list of the phytoplankton species collected from the CNS site area is presented in the ER, Table 2.7.2.1. Section 2.7.2.1 of the ER provides quantitative data on the phytoplankton of the river and the reservoir.

Periphyton

Sampling by the applicant indicated that the periphyton of the river is comprised largely of diatoms, with some blue-green algal taxa occasionally present. The instability of the site environs (changing water levels, scouring, and turbidity) made interpretation of data on productivity or densities of algae difficult, and no discernable patterns were elucidated. Additional data on the applicant's periphyton collections are presented by the applicant (ER, Sect. 2.7.2.3).

Consumers

Zooplankton. In lentic environments, zooplankton are a primary link between primary production and higher trophic levels. In lotic (flowing-water) environments, their role is less important and is replaced by benthic invertebrates.[13] Those zooplankters present are generally immigrants from lentic or benthic populations that have been washed into the river current.

The zooplankton community of rivers is often dominated by rotifers.[13] In the river, exclusive of the reservoir's backwaters, rotifers dominated the zooplankton throughout the sampling year except during the coldest months, when zooplankton populations were lowest. During this period, the copepods and cladocerans predominated. Zooplankton densities in the river usually ranged between 200 and 600 per cubic meter.

The zooplankton community of the reservoir differed substantially from the river community. Rotifers were not as abundant but still made up a major numerical component of the samples, especially in the fall and winter. Compared to river samples, zooplankton densities were generally higher in the reservoir. Since the reservoir community was comprised of a higher percentage of copepods and cladocerans, the biomass density of zooplankton was considerably higher than in the river. Densities ranged from as low as 170 per cubic meter in March to as high as 75,000 per cubic meter in June.

A list of the zooplankton taxa collected in the CNS area is presented in the ER, Table 2.7.2-4. Quantitative data on the zooplankton of the river and the reservoir are presented by the applicant (ER, Sect. 2.7.2.2 and Question 2.7.3).

Benthos

In a turbid river such as the Broad, the benthic invertebrate community is the principal link between primary production, detritus, and the higher trophic levels, primarily fish. The bottom substrate of a river, along with water quality, largely determines the benthic community that will develop.

The benthic fauna of those areas of the river having a sandy substrate was dominated by chironomids, principally nr. *Demicryptochironomus* sp. n. Other abundant taxa included the phantom midge, *Chaoborus punctipennis,* oligochaetes, and Gomphidae. The density of benthic organisms in samples from sandy areas ranged from 49 to 1000 per square meter.

No seasonal changes in the benthos species composition were discernable. Chironomids continued to dominate samples throughout the sampling year. In areas of rock substrate, such as exist occasionally above and below the reservoir, the trichoptera and ephemeroptera were more abundant, and they often dominated the samples. The most abundant taxa recognized were *Cheumatopsyche* sp., *Stenonema* sp., *Ameletus* sp., and *Demicryptochironomus* sp. Densities of benthos collected from rocky substrate areas were higher than from sandy substrate areas and ranged from 58 to 3741 per square meter. No seasonal trends were apparent.

The benthic community of the reservoir was similar in many respects to the sandy substrate community of the river except that the phantom midge *Chaoborus punctipennis* was the dominant taxon (56% of collections) while chironomids were next with 37% of the collections. Benthos densities were generally much higher in the reservoir than in the river, ranging from about 200 to 4500 square meter. No obvious seasonal trends in species composition were apparent. A species list of the benthos collected from the CNS site is presented in the ER, Table 2.7.2-11. Specific data on species composition and abundances are given by the applicant (ER, Tables 2.7.2.4 and 2.7.2-15).

Nekton

Broad River. A total of 24 fish species was collected by the applicant from the river proper. Cyprinids (minnows) were the dominant family in the collections, comprising nine species and 75% of all individuals collected. Centrarchids (sunfishes) were second in abundance (five species and 8% of individuals) followed by the clupeids (shad) (Table 2.2). Fishing in the river is primarily for white and channel catfish (*Ictalurus* spp.),[14] although only two specimens of one of these species (white catifsh) were collected by the applicant. A list of fish species and numbers collected from the river is presented in Table 2.2.

Ninety-Nine Islands Reservoir. Collections in the backwater areas of the reservoir revealed a more typical lake-type fish community than the river proper. A total of 15 species was collected. Centrarchids, including largemouth bass, bluegills, and crappie, were the numerically dominant species (67% of the total number) and, along with catfish, are the target of the fishing effort on the reservoir.[14] Abundant forage species collected from the reservoir included threadfin and gizzard shad (*Dorosoma* spp.) and the golden shiner (*Notemigonus crysoleucas*). The common carp and the quillback carpsucker (*Carpiodes cyprinus*), both categorized as "rough fish," comprised a large percentage of the total weight of fish collected, that is, 24% and 40%, respectively.

Ichthyoplankton

Data presented by the applicant indicate that the river has relatively few fish larvae compared to the lentic areas of the reservoir. The most common fish larvae taxa encountered in the river were catostomids (suckers) and shad. Maximum densities of catostomid larvae (68 per 1000 m^3) were collected in early May. Shad larvae (*Dorosoma* spp.) were collected primarily in June (up to 570 per 1000 m^3). Other taxa recognized were carp larvae and unidentified cyprinids.

The lentic areas of the reservoir had much higher numbers of fish larvae. Specimens were first caught in late April and continued to be found throughout May and June. Maximum densities encountered were 1330 per 1000 m^3 The most common taxa recognized were shad (*Dorosoma* spp.), crappie (*Pomoxis* spp.), and sunfish (*Lepomis* spp.).

Table 2.2. Occurrence and relative abundance of the fish species collected from the Broad River, Ninety-Nine Islands Reservoir, and tributaries near the CNS site, October 1973 through September 1974

Species	Stations: River stations 1, 2, 4, 7, 8, 15		Lake stations 9, 10, 12, 13		Onsite creeks stations 21, 23	
	n	%N	n	%N	n	%N
Clupeidae						
Dorosoma cepedianum	130	10.6	179	11.5		
Dorosoma petenense			19	1.2		
Cyprinidae						
Clinostomus funduloides						
Cyprinus carpio	19	1.6	70	4.5		
Hybognathus nuchalis						
Hybopsis hypsinota	2	0.2				
Hybopsis n. sp.	4	0.3				
Nocomis leptocephalus	51	4.1				
Notemigonus crysoleucas	16	1.3	17	1.1		
Notropis chloristius	302	24.5				
Notropis hudsonius	3	0.2				
Notropis niveus	460	37.4				
Notropis scepticus	65	5.3				
Semotilus atromaculatus					114	100.0
Catostomidae						
Carpiodes cyprinus			145	9.3		
Moxostoma anisurum	14	1.1	2	0.1		
Moxostoma robustum	7	0.6				
Ictauridae						
Ictalurus brunneus	8	0.6				
Ictalurus catus	2	0.2	23	1.5		
Ictalurus nebulosus	1	0.1	10	0.6		
Ictalurus platycephalus	3	0.2				
Poecilidae						
Gambusia affinis	42	3.4	44	2.8		
Centrarchidae						
Lepomis auritus	6	0.5				
Lepomis gibbosus	2	0.2	20	1.3		
Lepomis gulosus			5	0.3		
Lepomis macrochirus	79	6.4	861	55.4		
Micropterus salmoides	10	0.8	88	5.7		
Pomoxis annularis			29	1.9		
Pomoxis nigromaculatus	1	0.1	43	2.8		
Percidae						
Etheostoma flabellare	1	0.1				
Etheostoma thalasinum	3	0.2				
Total	1231		1555		114	

Rare or endangered fish species

Three rare or endangered fish species may exist in the river. An undescribed species of *Hybopsis* n. is occasionally found in the river, but its current status is undetermined. Two species of endangered darters are present in the area, *Etheostoma collis* and *E. thalasinum*; *E. thalasinum* has been collected regularly by the applicant in a tributary of the river, but *E. collis* has not been collected to date (ER, Sect. 2.7.2.6.8).

2.7.2.3 The biota of the site creeks

The two creeks present on the CNS site are very similar hydrolically and ecologically and therefore will be discussed together. Both have clear, cold water that flows down a moderate gradient through alternating pools and gravel riffles. Mean annual flows are approximately 1 cfs for the smaller creek and 3 cfs for the larger creek.

The trophic structure of most small forest streams is detritus-based.[13] A diverse periphyton flora was found in the streams and probably also contributes substantially to the energy inputs into the stream ecosystem. The periphyton were dominated by diatoms, principally *Achnanthes, Navicula,* and *Gomphonema* (ER, Table 2.7.2-16).

The benthic communities of the creeks were diverse and abundant. Numerically dominant were the Chironomidae, followed by the Trichoptera and the Ephemeroptera. Benthos densities ranged from 11 to 865 per square meter for the sampling period (ER, Question 2.7.3).

Only one fish species, the creek chub (*Semotilus atromaculatus*), has been collected from the creeks.

REFERENCES FOR SECTION 2

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3. U.S. Department of Commerce, Environmental Data Service, "Local Climatological Data, Annual Summary with Comparative Data — Charlotte, North Carolina," published annually through 1972.

4. U.S. Department of Commerce, Environmental Data Service, "Local Climatological Data, Annual Summary with Comparative Data — Greenville-Spartanburg, South Carolina," published annually through 1972.

5. Duke Power Company, *Environmental Report Cherokee Nuclear Station, Units, 1, 2, and 3,* Docket Nos. 50-491, 50-492, and 50-493.

6. SELS Unit Staff, National Severe Storms Forecast Center, "Severe Local Storm Occurrences, 1955-1967," ESSA Technical Memorandum WBTM FCST, 12, Office of Meteorological Operations, Silver Spring, Md., 1969.

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12. H. J. Oosting, "An Ecological Analysis of the Plant Communities of Piedmont, North Carolina," *Amer. Mid. Natur.* 28: 1-128 (1942).

13. H. B. N. Hynes, *The Ecology of Running Waters,* University of Toronto Press, Toronto, 1970.

14. B. Parkhurst, AEC Staff, memorandum to H. E. Zittel, AEC Staff, re: Trip Report — Cherokee Nuclear Station Site Visit, August 20, 1974, Docket Nos. STN 50-491, 50-492, and 50-493.

3. THE STATION

3.1 EXTERNAL APPEARANCE

The CNS will be located in hilly terrain about 1 mile west of the Ninety-Nine Islands Dam. The main structures for the power station will be located on elevated portions of the site, and they will be visible from several vantage points in the surrounding countryside (see Fig. 2.4).

One of the noticeable features of the station will be the three domed reactor buildings, each about 220 ft in diameter and standing about 160 ft above the finished grade level. The centerline distance between the reactor buildings is about 400 ft. Each of the three units will also have a separate turbine-generator building, about 300 ft x 400 ft x 110 ft high above finished grade level. Six cooling towers will be located on an 800- x 1400-ft graded site just west of the reactor buildings, and three cooling towers will be located east of the buildings on an equilateral-triangle-shaped plot, about 600 ft in major dimension. The 74-ft-high cooling towers will not, in themselves, be a particularly dominant feature, but the white plumes of water vapor that may at times rise above the towers and drift for long distances downwind will be visible for many miles, particularly on clear, cold days.

In addition to the reactor and turbine-generator building, each unit will be provided with an auxiliary building. An equipment building and an administration building will be shared by the three units.

The applicant states that the architectural style of the station will be contemporary (ER, Sect. 3.1). The reactor buildings will have a concrete exterior surface, and the turbine-generator building will have a masonry wainscot topped with colored siding. The station will be landscaped after construction is completed by using materials that are generally native to the area. The staff considers that the station will have a neat, functional appearance.

3.2 REACTOR AND STEAM-ELECTRIC SYSTEMS

The three units at CNS are identical and contain pressurized water reactors manufactured by Combustion Engineering, Inc., and turbine generators manufactured by General Electric Company. The reactor fuel is Zircaloy-clad uranium dioxide with a maximum enrichment of 2.9%. Each unit of the nuclear steam supply system has a guaranteed main steam flow of 17,185,000 lb/hr and a warranted output of 3817 MWt. The turbine generators have a gross rated electrical output of 1345 MWe and a "valve-wide-open" rated capacity of 1387 MWe. The cycle net heat rate is given as 9683 Btu/kWhr, which is a thermal efficiency of about 35.3%. The total net electrical output for the three-unit station is 3840 MWe.

3.3 STATION WATER USE

The station will use water from the Broad River for all purposes during normal operation. Water from the river will be pumped into the intake sedimentation basin from which water will be drawn for all station usage. The largest single usage will be makeup for the cooling towers, where the largest consumptive usage will occur. A diagram outlining the various water uses in the station is shown in Fig. 3.1 (ER, Fig. 3.3.0-1, Amendment 3) and attendant Table 3.1 (ER, Table 3.3.0-1). Detailed descriptions of the various systems and the quality of their effluents appear in Sects. 3.5, 3.6, and 3.7.

3.4 HEAT DISSIPATION SYSTEM

3.4.1 Cooling towers

Combined operation of the three units at CNS at rated capacity will result in the discharge of about 2.6 x 10^{10} Btu/hr to the environment. This heat will be dissipated primarily to the atmosphere through evaporation of water in wet mechanical-draft-type towers. As indicated in the diagram of the heat dissipation system in Fig. 3.2, makeup water for the cooling towers will be pumped from a sedimentation basin, which is supplied with water from the Broad River, and the

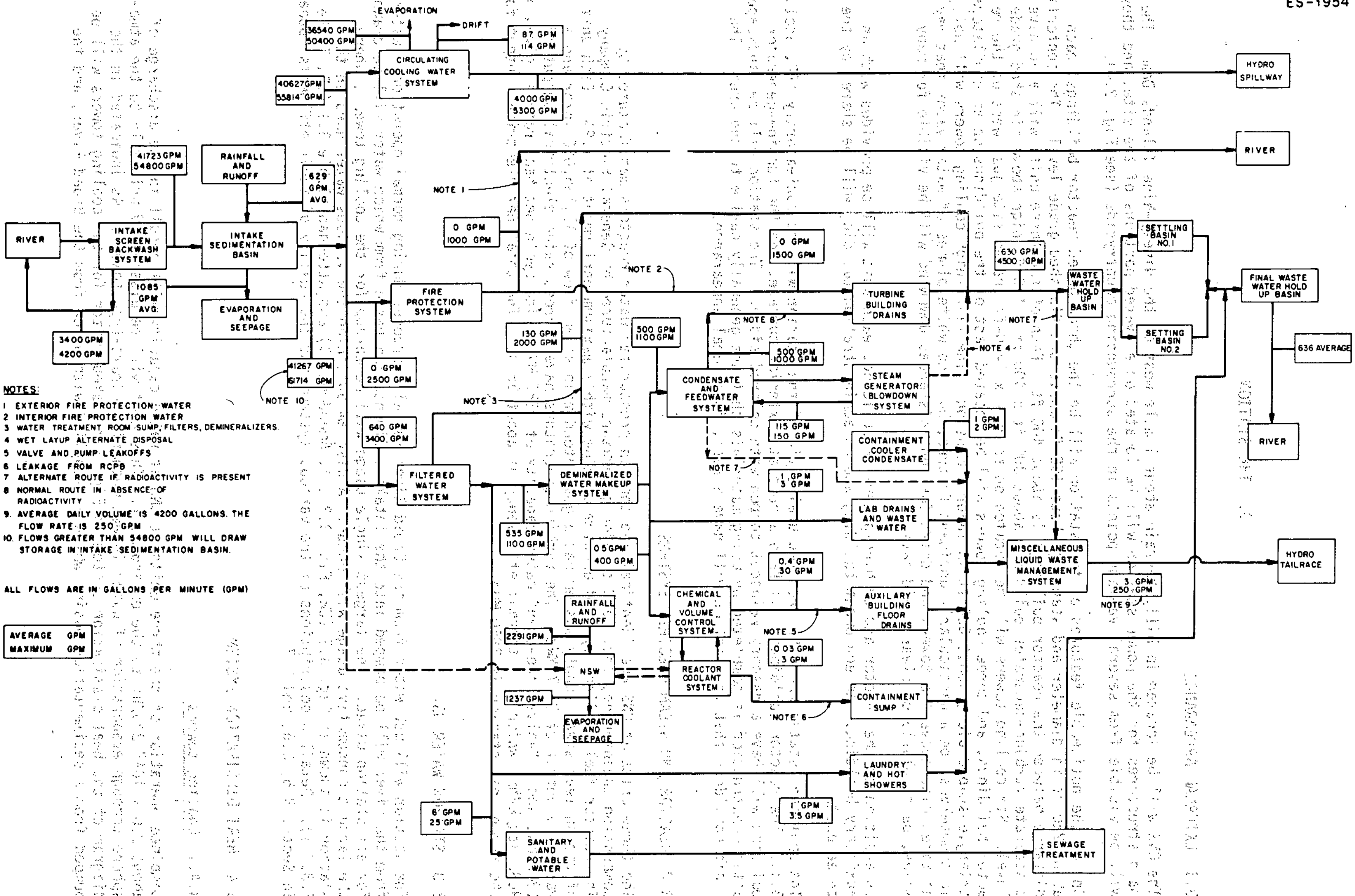

Fig. 3.1. Station water use. Source: ER, Fig. 3.3.0-1, Amendment 3.

Table 3.1. Cherokee Nuclear Station water use

	Flow	Average gpm	Maximum gpm
1	River water makeup	41,723	59,670
2	Rainfall and runoff to NSW pond	629	
3	Evaporation and seepage from NSW pond	1,085	
4	Cooling tower makeup	40,627	55,814
5	Cooling tower evaporation	36,540	50,400
6	Cooling tower drift loss	87	114
7	Cooling tower blowdown	4,000	5,300
8	Intake screen backwash	3,400	4,200
9	Exterior fire protection	0	1,000
10	Interior fire protection	0	1,500
11	Filtered water makeup	640	3,400
12	Filtered water waste	130	2,000
13	Demineralized water makeup	535	1,100
14	Secondary coolant makeup	500	1,100
15	Secondary system pump seals and leakage	500	1,000
16	Turbine building drains	630	4,500
17	Steam generator blowdown (after flashing)	115	150
18	Containment cooler condensate	1	2
19	Laboratory drains and waste water	1	3
20	CVCS makeup	0.5	400
21	Primary coolant leakage (see note 7)	0.4	30
22	Primary coolant leakage (see note 6)	0.03	3
23	Laundry and shower	1	3.5
24	Sanitary and potable water	6	25
25	MLWM system discharge	3	250
26	Waste water treatment system discharge	636	

blowdown will be discharged next to the spillway apron immediately downstream of the Ninety-Nine Islands Dam.

Each of the three units at the CNS will be provided with three cooling towers laid out as an equilateral triangle with a 453-ft side dimension for Units 1 and 2 and with a 381-ft side dimension for Unit 3 (ER, Fig. 3.4.1-1, Amendment 3). Six of the towers (for Units 1 and 2) will be located on an elevated portion of the site on an 800- x 1400-ft area to be leveled immediately west of the reactor buildings. The three towers for Unit 3 will be located east of the buildings on a triangular area about 600 ft in major dimension. The towers will be of a new circular mechanical-draft (CMD) type developed by The Marley Company. The design offers the promise of the lower costs and lower visibility (low height) usually associated with mechanical-draft towers, while at the same time providing plume buoyancy forces that approach those attained by the large-diameter plumes discharged from natural-draft cooling towers. A sketch of the CMD towers is shown in Fig. 3.3. Each tower for the station will be about 270 ft in diameter at the base, about 74 ft high overall, and will have thirteen 28-ft-diam fans arranged within a circle about 170 ft in diameter. At summer design conditions, over 90% of the heat dissipated by the towers is by evaporation of about 50,400 gpm (112 cfs) of water; the remainder is absorbed by heating the air that flows through the towers to an exit temperature of about 102°F. These and other cooling tower data, including that supplied by the applicant (ER, Response to Question 3.4.4-1), are given in Table 3.2.

An improved design for the drift eliminators is said by the applicant to limit the drift to less than 0.005% of the condensing water circulating rate. The drop-size distribution of the drift particles as furnished by the applicant (ER, Response to Question 3.4.4-1) is given in Table 3.2. Although prototype CMD towers have been operated, large-scale verification of drift and other performance data from first commercial operation in the spring of 1975 is awaiting evaluation of initial operating data.

Chlorination of the circulating water is expected to control algae and slime-forming micro-organisms in the cooling tower system. A free residual chlorine content of 0.5 ppm will be periodically maintained in each circuit for about 1 hr during cold weather. During the summer, the chlorine residual will be periodically maintained at 1 ppm for about one 1 hr. The three units at CNS may use a total of 1600-3200 lb of chlorine per day in the form of sodium hypochlorite fed into the system.

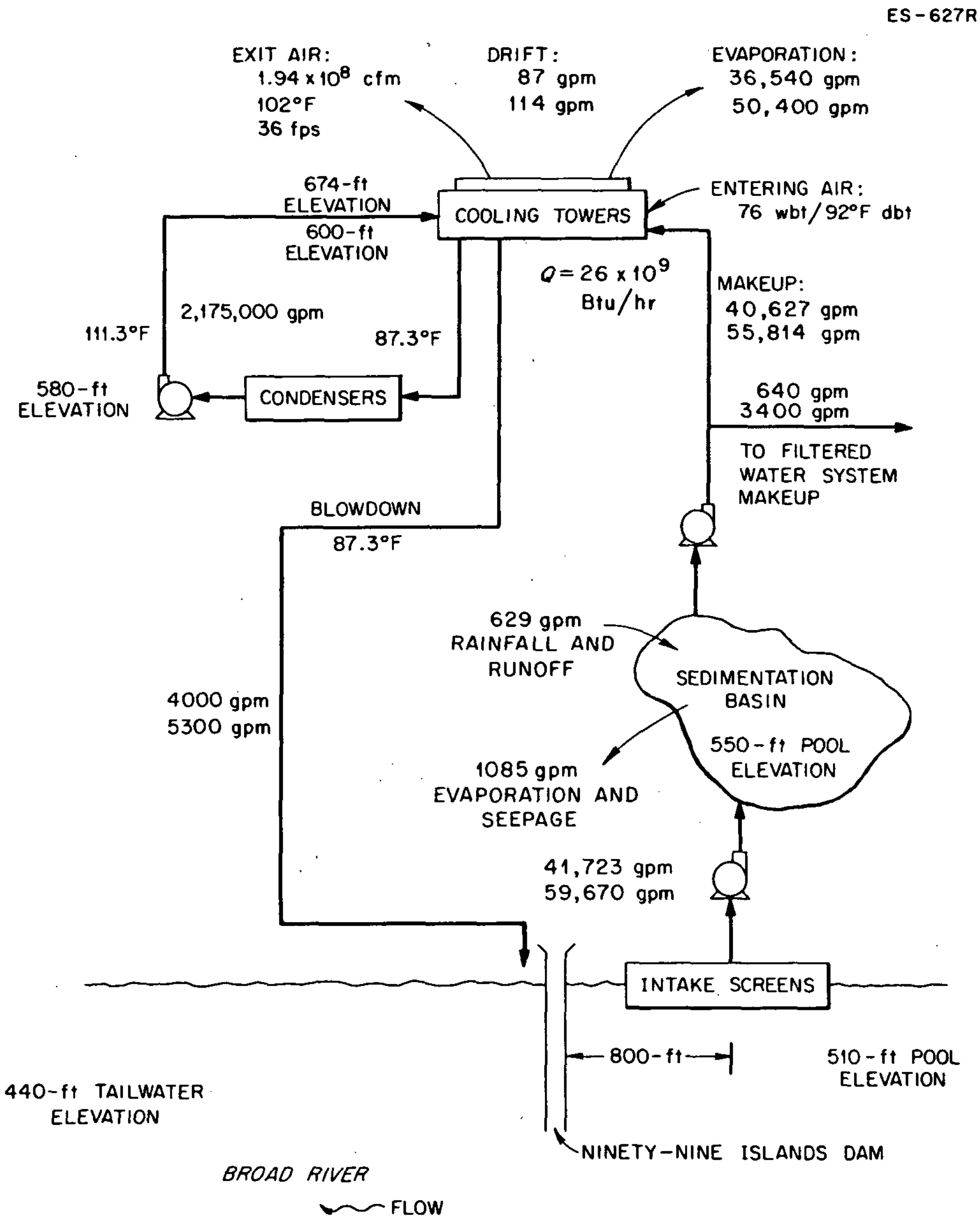

Fig. 3.2. Heat dissipation system for Cherokee Nuclear Station. All quantities are total for three units at station. Average and maximum flow rates are shown, where applicable; temperatures at cooling towers are at summer design conditions.

3.4.2 Intake structure

A maximum of about 59,670 gpm (133 cfs) of water will be pumped from the reservoir to the sedimentation basin. The water will first pass through an intake screen structure and then be held in a sedimentation basin to allow removal of a large part of the burden of silt and sand before the water is pumped into the cooling tower circulating systems. The design of the makeup water intake structure is shown in Fig. 3.4. The settling basin, or pond, will be impounded by the construction of a 1500-ft-long earth-fill dam between the two points of land shown on the site plan (ER, Fig. 2.1.2). The basin will have a storage capacity of about 3000 acre-ft. The water surface elevation in the reservoir is about 510 ft, and the pool elevation in the sedimentation basin will be about 550 ft. The makeup water intake structure on the sedimentation basin and the relative elevation of the various portions of the water intake system are shown in Fig. 3.5.

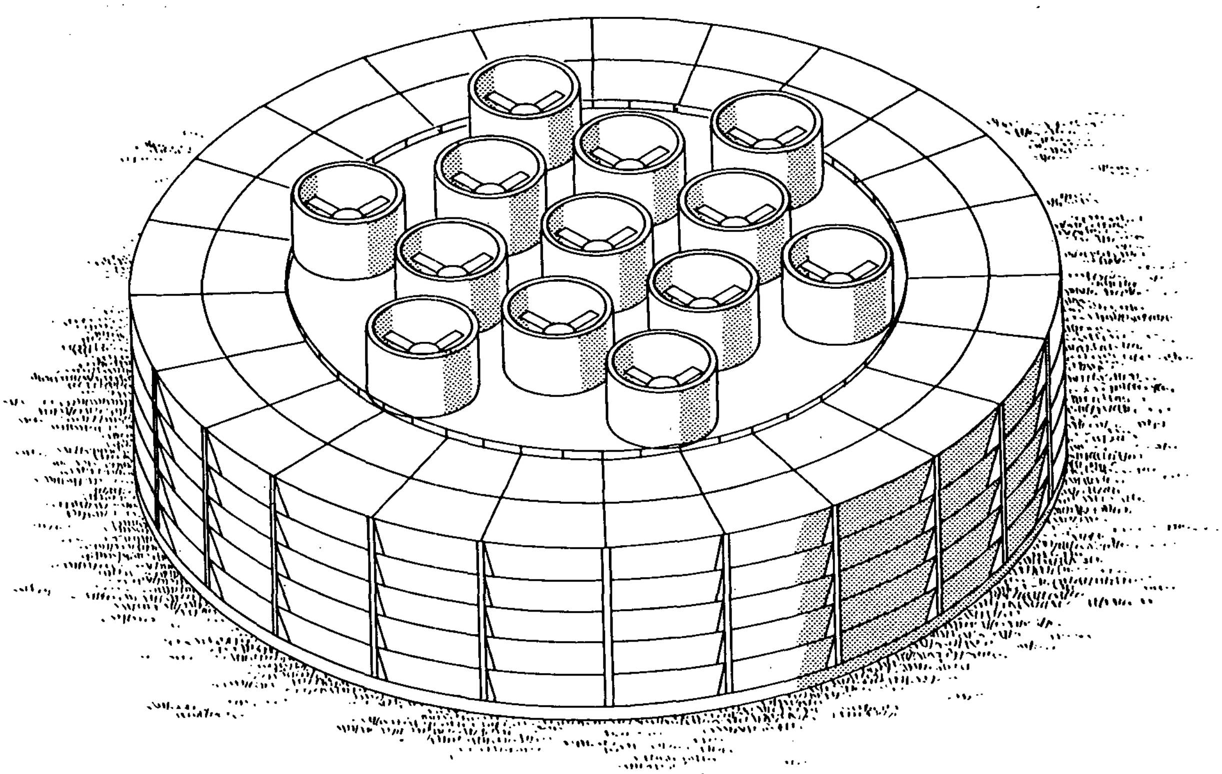

Fig. 3.3. Conceptual sketch of circular mechanical-draft cooling tower proposed for Cherokee Nuclear Station. (The tower is about 270 ft in diameter and 74 ft high.)

The water intake structure on the reservoir will be located about 800 ft upstream of the Ninety-Nine Islands Dam and near the base of the new earth-fill dam for the sedimentation basin, as indicated in the ER, Fig. 2.1.2. The 55-ft x 75-ft structure will be located at the shoreline and will house four makeup water pumps, each with a 12-ft-wide vertical traveling screen. A cross-sectional sketch of the intake structure is shown in Fig. 3.6. Trash racks, probably consisting of vertical bars set on 3- or 4-in. centers, will be located near the face of the structure and will extend vertically above the normal water surface level of 510-ft elevation. A concrete skimmer wall extends the remainder of the distance to the top of the structure to prevent floating trash from impinging on the traveling screens when the pool elevation is higher than normal.

Based on a 133-cfs makeup water flow rate and assuming that the traveling screens are the commonly used 3/8-in. mesh type with 60% free area for flow based on outside dimensions, the staff estimates that the maximum average face velocity at the screens would be about 0.7 fps.

3.4.3 Discharge structure

Approximately 5300 gpm (12 cfs) of cooling tower blowdown water at temperatures in excess of the river temperature of 10 to 15°F in the summer and 20 to 30°F in the winter will be discharged into the Broad River. The nine cooling towers will drain into a common 21-in.-diam pipe that will extend underground about 2 miles in a generally downhill and easterly direction to be discharged onto a rock outcropping on the west bank of the river immediately adjacent to the west abutment of the Ninety-Nine Islands Dam at a point about 50 ft above the tailwater elevation and about 135 ft southwest of the river shoreline. The blowdown will flow down the rock face, which has a drop of about 1 ft in 3 ft, onto the dam spillway apron below. The applicant states that the rocky character of the discharge arrangement is such that no provisions are needed to prevent scouring. The end of the blowdown discharge pipe will be anchored to the rock by a simple concrete headwall construction (ER, Fig. 10.3.2-1, Amendment 3).

Table 3.2. Cooling tower data

Type of tower		Circular mechanical-draft
Total number of towers		Nine
Number of towers per cluster[a]		Three
Distance between towers in cluster		138 m (453 ft)
Tower height		22.6 m (74 ft)
Base diameter		77 m (254 ft)
Equivalent radius of top		17.2 m (56.3 ft)
Approach temperature	11.3°F summer	29.5°F winter
Range	24°F summer	24°F winter
Design wet-bulb temperature	76°F summer	40°F winter
Design dry-bulb temperature	92°F summer	48°F winter
Design exit air temperature	102°F summer	85°F winter
Heat dissipated by towers[b]	1828.5 mg-cal/sec	(26.12 X 10^9 Btu/hr)
Air flow rate[b]	191.5 X 10^6 cfm	(815.81 X 10^6 lb/hr)
Air exit speed	10.82 m/sec	(35.5 fps)
Circulating water flow rate[b]	2,175,000 gpm	(4846.3 cfs)
Water/air ratio	1.44 lb/lb	
Evaporation rate, design[b]	50,400 gpm summer	
Blowdown rate[b]	5,300 gpm summer	5,300 gpm winter
Drift rate[b]	0.005% of circulating water flow	(114 gpm)
Makeup rate, maximum[b]	55,814 gpm	
Concentration factor for solids	10	
Dissolved solids in makeup	53 ppm (av)	98 ppm (max)
Drop size mass distribution in drift:		
0–60 μ, 50%	225–325 μ, 8%	
60–125 μ, 22%	325–425 μ, 6%	
125–180 μ, 5%	425–525 μ, 5%	
180–225 μ, 4%		

[a]For calculating multiple-plume effect.
[b]Total for all towers (nine) at station.

3.5 RADIOACTIVE WASTE SYSTEMS

During the operation of the Cherokee Nuclear Station Units 1, 2, and 3, radioactive material will be produced by fission and by neutron activation of corrosion products in the reactor coolant system. From the radioactive material produced, small amounts of gaseous and liquid radioactive wastes will enter the waste streams. These streams will be processed and monitored within the station to minimize the quantity of radioactive nuclides ultimately released to the atmosphere and to the river. The liquid, gaseous, and solid radioactive waste systems will be separate for each unit, with no subsystems or components shared with other units.

The waste handling and treatment systems to be installed at the station are discussed in the applicant's Preliminary Safety Analysis Report and Environmental Report, both dated May 24, 1974. In these documents, the applicant has prepared an analysis of the treatment systems and has estimated the annual radioactive effluents.

In the following paragraphs, the waste treatment systems are described, and an analysis is given based on the staff's model of the applicant's radioactive waste systems. The model has been developed from a review of available data from operating nuclear power plants, adjusted to apply over a 40-year operating life. The coolant activities and flows used in the evaluation are based on experience and data from operating reactors. As a result, the parameters used in the staff model and the calculated releases vary from those given in the applicant's evaluation. The resulting differences do not lead to adverse effects in the evaluation. The staff's evaluation was based on the parameters in USAEC Report WASH-1258 and the "Concluding Statement of Position of the Regulatory Staff, ALAP LWR Effluents" (with Attachment, "Draft Regulatory Guides for Implementation"), Docket No. RM-50-2, February 20, 1974. The staff's liquid and gaseous source terms were calculated by the PWR-GALE Code as described in "Draft Regulatory Guide 1.BB," which is a revised version of the ORIGEN and STEFFEG codes given in WASH-1258. The principal parameters used in the staff's source term calculations are given in Table 3.3.

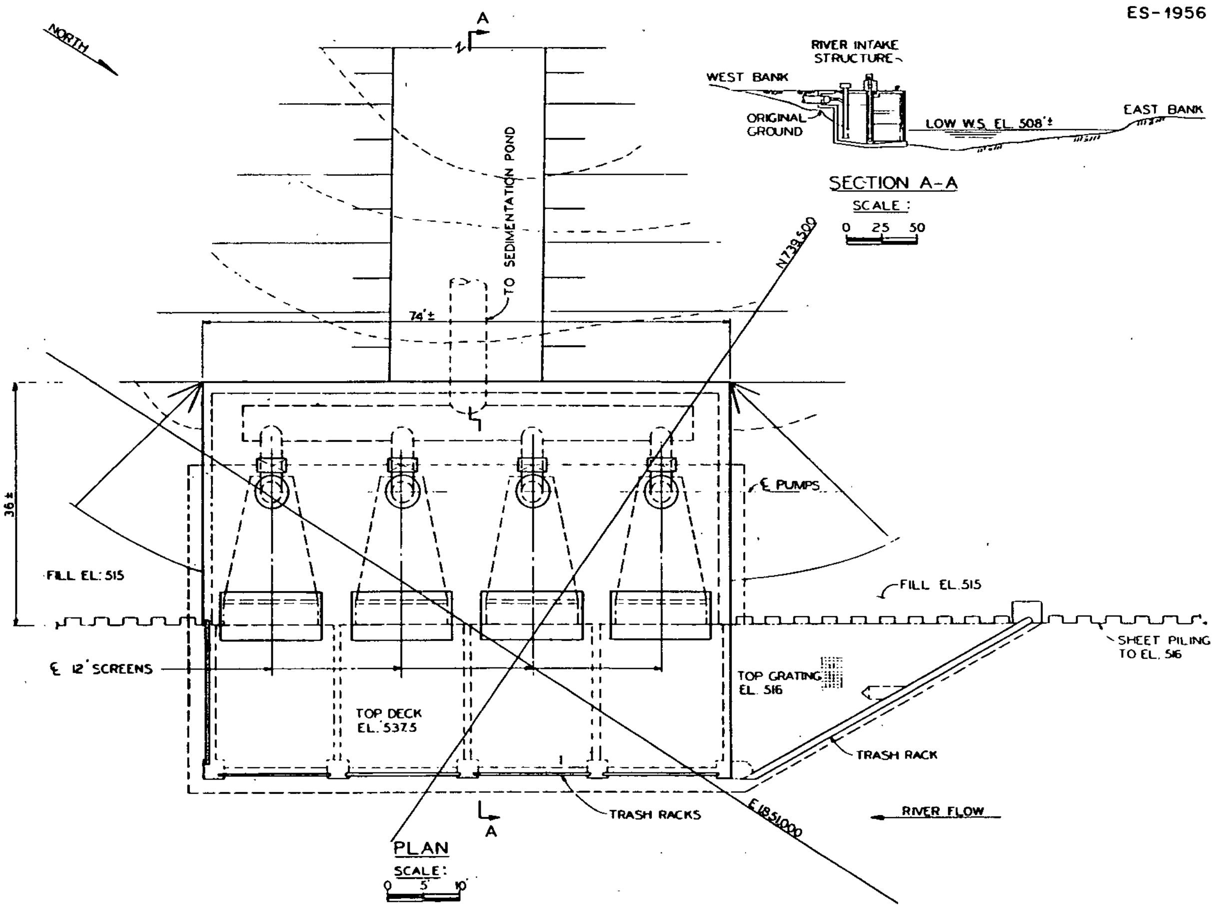

Fig. 3.4. Design of makeup water intake structure. Source: ER, Fig. 10.2.1-1, Amendment 3.

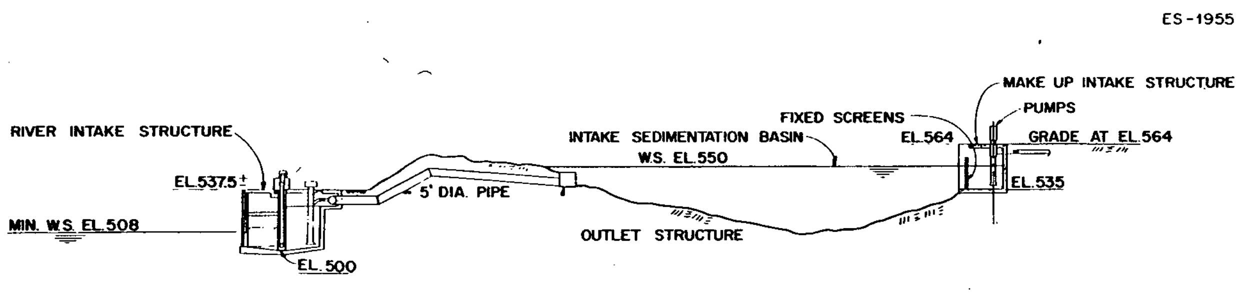

Fig. 3.5. Relative elevations of the water intake system.

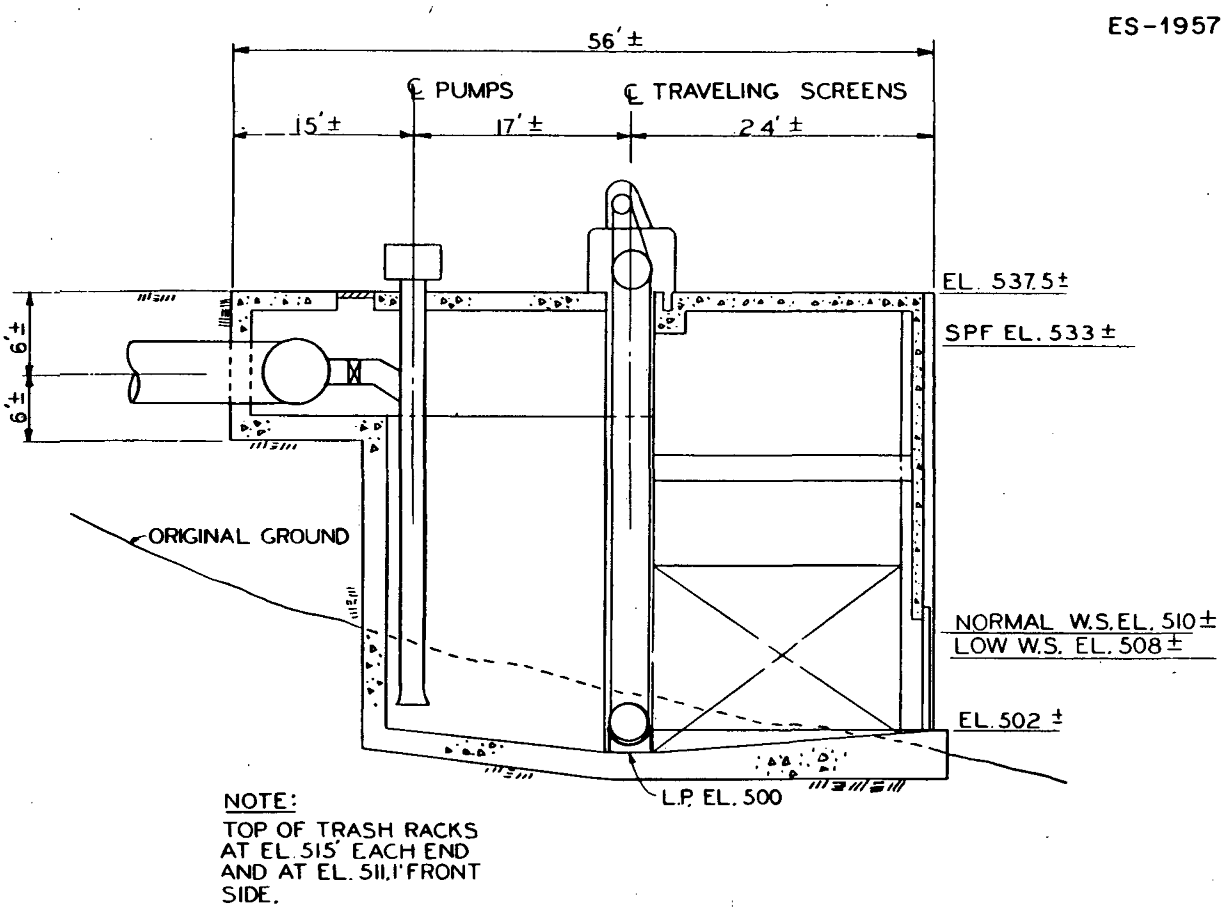

Fig. 3.6. Sketch of cross section through intake water structure on Ninety-Nine Islands Reservoir. Source: ER, Fig. 3.4.4-3, Amendment 3.

On April 30, 1975, the Nuclear Regulatory Commission announced its decision in the rule-making proceeding (RM-50-2) concerning numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as practicable" for radioactive material in light-water-cooled nuclear power reactor effluents. This decision is implemented in the form of a new Appendix I to 10 CFR 50. To effectively implement the requirements of Appendix I, the NRC staff is presently reassessing the parameters and mathematical models used in calculating releases of radioactive materials in effluents in order to comply with the Commission's guidance. In the interim, until such reassessment is completed and can be applied to the Cherokee Station, the staff has prepared upper bound estimates of the potential effect on the estimated radiological environmental impact set forth in the FES. The dose estimates discussed in Sect. 5.4 used revised estimates of expected annual releases of radioactive materials in effluents from the Cherokee Station. The applicant has stated (Appendix B) that he does not intend to remove any presently proposed equipment or systems and will provide such additional equipment determined to be necessary to meet the requirements of Appendix I as a result of a detailed evaluation.

On the basis of information presently available on the technology to reduce radioactive effluent releases, the Cherokee Station can be designed to meet the requirements of Appendix I.

3.5.1 Liquid wastes

Liquid radioactive wastes will be processed on a batch basis to permit optimum control of releases. Prior to being released, samples will be analyzed to determine the types and amounts of radioactive materials present. Based on the results of the analysis, the wastes will either be

Table 3.3. Principal parameters and conditions used in calculating releases of radioactive material in liquid and gaseous effluent from Cherokee Nuclear Station Units 1, 2, and 3

Reactor power level (MWt)	3990
Plant capacity factor	0.80
Operating power fission product source term	0.25%
Primary system	
Mass of coolant (lb)	5.71×10^5
Letdown rate of CVCS (gpm)	84
Shim bleed rate (gpm)	3.1
Leakage rate to secondary system (lb/day)	110
Leakage rate to auxiliary building (lb/day)	160
Leakage rate to containment building (lb/day)	240
Frequency of degassing for cold shutdowns (per year)	2
Secondary system	
Steam flow rate (lb/hr)	1.72×10^7
Mass of steam/steam generator (lb)	1.81×10^4
Mass of liquid/steam generator (lb)	1.63×10^5
Secondary coolant mass (lb)	2.81×10^6
Rate of steam leakage to turbine building (lb/hr)	1.7×10^3
Dilution flow (gpm)	4.0×10^3
Containment building volume (ft^3)	3.3×10^6
Frequency of containment purges (per year)	4
Iodine partition factors (gas/liquid)	
Leakage to containment building	0.1
Leakage to auxiliary building	0.005
Steam leakage to turbine building	1
Steam generator (carryover)	0.01
Main condenser air ejector	0.0005

Decontamination factors (liquids)

	Boron recycle	MLWMS	SGB/VCC (condensate treatment)
I	1×10^5	1×10^4	1×10^2
Cs, Rb	2×10^4	1×10^5	1×10^1
Mo, Tc	1×10^5	1×10^6	1×10^4
Y	1×10^4	1×10^5	1×10^3
Others	1×10^6	1×10^5	1×10^2

	All nuclides except iodine	Iodine
Waste evaporator DF	10^4	10^3
BRS evaporator DF	10^3	10^2

	Cation[a]	Anion[a]	Cs, Rb
Mixed-bed demineralizer (Li_3BO_3)DF	10	10	2
Mixed-bed demineralizer (H^+OH^-)DF	10^2(10)	10^2(10)	2(10)
Cation demineralizer DF	10^2(10)	1(1)	10(10)
Anion demineralizer DF	1(1)	10^2(10)	1(1)
Powdex DF	10(10)	10(10)	1(10)

(Note: for two demineralizers in series, the DF for the second demineralizer is given in parentheses.)

Removal by plateout	Removal factor
Mo, Tc	10^2
Y	10

Containment building	Recirculation system
Flow rate	1.8×10^4 cfm
Operating period/purge	16 hr
Mixing efficiency	70%

[a]Does not include Cs, Mo, Y, Rb, Tc.

retained, recycled, and reprocessed or released under controlled conditions to the Broad River. A signal from a radiation monitor will automatically terminate liquid waste discharges if radiation measurements exceed a predetermined level in the discharge line. A simplified diagram of the liquid radioactive waste treatment systems is shown in Fig. 3.7.

The liquid waste management systems will be divided into two principal systems: the boron recovery system (BRS) and the miscellaneous liquid waste management system (MLWMS). The BRS will process high-grade water from the reactor coolant system, which will normally be recycled for reuse in the plant after treatment. The BRS consists of holdup tanks, mixed-bed demineralizers, a gas stripper, an evaporator, and a distillate demineralizer for processing. The MLWMS will process water from equipment drains, building sumps, and laundry wastes. Some of these wastes will be discharged after treatment, and some will be reused. The MLWMS will consist of holdup tanks, an evaporator, and a distillate mixed-bed demineralizer for processing.

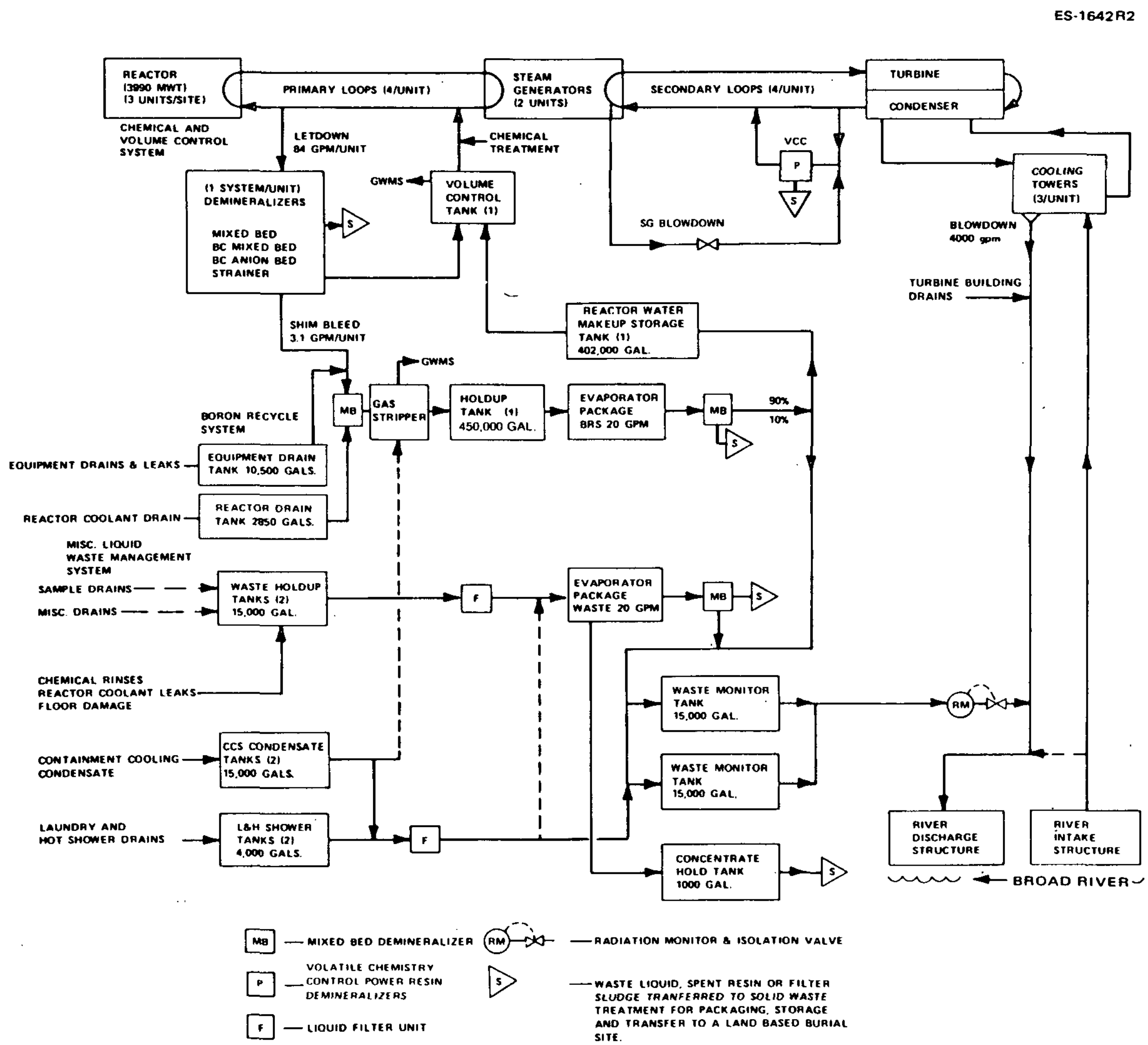

Fig. 3.7. Liquid radioactive waste system, Cherokee Nuclear Station, Units 1, 2, and 3.

In addition to the preceding systems, the chemical and volume control system (CVCS) is considered in the evaluation. The CVCS will process reactor grade water through mixed-bed and anion demineralizers to maintain boron control and reactor coolant purity and will be the principal input to the BRS. Liquid leakage to the turbine building will be collected in the turbine building floor drain system and will be released without treatment.

The boron recycle system (BRS)

Primary coolant will be withdrawn from the reactor coolant system at approximately 84 gpm and processed through the CVCS. The letdown stream will be cooled and reduced in pressure, then filtered and processed through one of two mixed-bed demineralizers, and sent to the volume control tank. The second mixed-bed demineralizer will be used intermittently for lithium and cesium control. Boron concentration will be controlled during core life by feed and bleed operation to the BRS, and at the end of core life it will be controlled by anion deborating demineralizer in the CVCS. Radionuclide removal by the CVCS was evaluated by assuming 84-gpm letdown flow at primary coolant activity (PCA) through one mixed-bed demineralizer. Deaerated hydrogenated equipment drain wastes in the reactor containment will be collected in the 2850-gal reactor drain tank. High purity liquid wastes outside the reactor containment will be collected in the 10,500-gal equipment drain tank. The drain wastes from these tanks will be combined with the shim bleed from the CVCS letdown stream and routed to a mixed-bed demineralizer and a gas stripper, where fission product gases and hydrogen will be removed. The stripped liquid will then be collected in the 450,000-gal holdup tank for decay and will be processed through a 20-gpm evaporator and a mixed-bed demineralizer. The staff calculated the shim bleed input activity by applying the decontamination factor (DF) for the mixed-bed demineralizers to the shim bleed stream, assuming a 30-gpm shim bleed flow and CVCS output activity. The combined reactor drain tank and equipment drain tank input flow to the BRS was assumed to be 240 gpd at PCA. Radioactive decay during collection in the holdup tanks was calculated in the PWR-GALE code. The collection time was calculated to be 38 days assuming the 450,000-gal holdup tank will be filled to 80% capacity using the combined shim bleed and reactor equipment drain flow rate of 4720 gpd. Radionuclide removal by the BRS was based on the parameters in Table 3.3 for an evaporator and the mixed-bed demineralizers in series. Additional credit for radioactive decay during processing was based on transferring the holdup tank liquid at the evaporator flow capacity (20 gpm). In its evaluation, the staff assumed that equipment downtime, anticipated operational occurrences, and tritium control will result in approximately 10% (138,000 gpy) of the evaporator condensate stream being discharged to the river. The applicant also assumed that a portion of the BRS stream will be discharged for primary coolant tritium control.

Miscellaneous liquid waste management system (MLWMS)

Aerated radioactive wastes will be collected in one of two equipment and floor drain waste tanks, one of two laundry drain tanks, and one of two containment cooler condensate tanks. Liquid wastes from these tanks will be processed through an evaporator and a mixed-bed demineralizer. Based on staff parameters and information supplied by the applicant, the staff calculated the liquid waste flow to be approximately 1375 gpd at 0.08 PCA.

By assuming that one of the two 15,000-gal waste tanks will be filled to 80% capacity, the staff calculates the collection time to be nine days. Radionuclide removal by the liquid waste system was based on the parameters in Table 3.3 for an evaporator and a mixed-bed demineralizer. Additional credit for radioactive decay during processing was based on transferring the tank liquid at the evaporator flow capacity (20 gpm) and holdup in one of the two 15,000-gal waste condensate tanks. The staff's evaluation, like the applicant's, assumes that all of the processed waste liquid will be discharged to the environment.

Wastes from laundry and contaminated showers will be collected in one of two 4000-gal laundry drain tanks for analysis. Normally, these wastes will be of low activity and will be filtered and discharged to the environment. They may be processed by the evaporator-demineralizer in the liquid waste system if the activity is above a predetermined value. Based on its parameters, the staff assumed that the laundry and shower tank activity will be approximately 10^{-4} $\mu Ci/cm^3$ and that the release rate will be 450 gpd.

Two 4000-gal containment cooler condensate tanks will be provided to collect condensation from humidity in the containment ventilation system. Because this liquid will normally be of low activity, it will be filtered and discharged to the environment. If the activity is above a predetermined level, liquid will be processed by the liquid waste system. Based on staff parameters and information supplied by the applicant, the containment cooler condensate tank input stream flow was calculated to be approximately 315 gpd at 0.005 PCA.

Blowdown from the steam generators will be treated and recycled through the secondary loop condensate polishing demineralizers. Four of these five nonregenerated, powdered resin demineralizers will provide volatile chemistry control for the U-tube steam generators and filtration for the blowdown stream. The staff's evaluation, like the applicant's, assumed that the blowdown rate will be approximately 10% of the main steam rate with no blowdown waste release and that the condensate polishing demineralizers will process 65% of the secondary loop flow rate. Spent resins from these demineralizers will be transferred to the solid waste system.

Turbine building floor drains

Waste collected by the turbine building floor drain system will contain radioactive materials from secondary system leakage as well as leakage from nonradioactive cooling systems. The applicant has indicated that these wastes will not be treated prior to discharge. The staff assumes that the activity discharged through the turbine building floor drain system will be due to secondary system condensate leakage at a rate of 5 gpm. The quantity of activity released through this path will be approximately 0.04 Ci/year. The staff concludes that the release of the turbine building floor drain wastes without treatment is acceptable.

Liquid waste management system summary

Based on the staff's evaluation of the waste treatment systems using the parameters in Table 3.3, the release of radioactive materials in the liquid wastes discharged to the Broad River was calculated to be 0.4 Ci/year per reactor, excluding dissolved gases and tritium (see Table 3.4).

Table 3.4. Liquid radioactive source term (Ci/year/unit) for Cherokee Nuclear Station, Units 1, 2, and 3

Radionuclide	Ci/year	Radionuclide	Ci/year
Br-82	0.00009	Ba-139	0.00005
Br-83	0.0001	Ba-140	0.0002
Rb-86	0.00005	La-140	0.0001
Sr-89	0.0002	Ce-141	0.00003
Sr-91	0.00008	Ce-143	0.00001
Y-91*m*	0.00003	Pr-143	0.00003
Y-91	0.0001	Ce-144	0.00007
Zr-95	0.00003	Pr-144	0.00002
Nb-95	0.00003	Nd-147	0.00001
Mo-99	0.0004	Na-24	0.0001
Tc-99*m*	0.0004	P-32	0.00003
Ru-103	0.00002	P-33	0.0001
Rh-103*m*	0.00002	Cr-51	0.0004
Te-125*m*	0.00001	Mn-54	0.00008
Te-127*m*	0.0001	Mn-56	0.001
Te-127	0.0002	Fe-55	0.0004
Te-129*m*	0.0006	Fe-59	0.0002
Te-129	0.0004	Co-58	0.004
I-130	0.0005	Co-60	0.0005
Te-131*m*	0.0007	Ni-65	0.00003
Te-131	0.0001	Nb-92	0.00008
I-131	0.18	Sn-117*m*	0.00003
Te-132	0.01	W-185	0.00002
I-132	0.01	W-187	0.0006
I-133	0.1	Np-239	0.0002
I-134	0.00009		
Cs-134*m*	0.00004		
Cs-134	0.01	All others	0.0001
I-135	0.02	Total (except tritium)	0.4
Cs-136	0.007		
Cs-137	0.01		
Ba-137*m*	0.01	H-3	350
Cs-138	0.00003		

Note: Isotopes with discharges less than 10^{-5} Ci/year/unit are not identified but are included in the "All others" term.

Based on previous experience at operating reactors, the staff estimates the tritium releases to be 350 Ci/year. The applicant has estimated the normal releases to be approximately 0.1 Ci/year per reactor, excluding dissolved gases and tritium, and 77 Ci/year per reactor of tritium, based on an operating fission product source term of 0.1%, as compared to the staff's value of 0.25%.

The radioactivity in liquid effluents from Units 1, 2, and 3, exclusive of tritium and dissolved noble gases, will be less than 5 Ci/year per reactor. The whole-body and critical-organ doses will be less than a total of 5 millirems/year from the three units at the site.

3.5.2 Gaseous waste

The gaseous waste treatment and ventilation systems will consist of equipment and instrumentation necessary to reduce releases of radioactive gases and airborne particulates from equipment and building vents. The principal source of radioactive gaseous waste will be gases stripped from the primary coolant in the CVCS and BRS. Additional sources of gaseous wastes will be main condenser air ejector exhausts, ventilation exhausts from the auxiliary and turbine buildings, and gases collected in the reactor containment building. The principal system for treating gaseous wastes will be the gaseous waste management system (GWMS). The GWMS will collect and store gases stripped from the primary coolant in a cover gas nitrogen loop containing a recombiner, compressors, and three pressurized storage tanks. Each reactor will have its own GWMS.

The auxiliary building ventilation exhausts, fuel handling area, and containment purge exhausts will be processed through HEPA filters and charcoal adsorbers prior to release. In addition, the containment atmosphere will be recirculated through HEPA filters and charcoal adsorbers prior to purging. The main condenser air ejector exhausts will be processed through charcoal adsorbers. Noncondensible substances from the steam generator blowdown will be vented to the main condenser. Ventilation exhausts from the turbine building will be released without treatment. The gaseous waste treatment system is shown in Fig. 3.8.

Gaseous waste management system (GWMS)

The GWMS will collect and process gases stripped from the primary coolant. It will contain an initial inventory of nitrogen that will be continuously replaced by nitrogen as a cover gas transporting radioactive gases removed from the primary coolant. Hydrogen cover gas from the volume control tank and reactor coolant drain tank, gases stripped in the BRS stripper and evaporator, and gases purged from the sample system will enter the GWMS 20-ft^3 gas surge tank. The cover gas will carry with it small amounts of hydrogen gas removed from the primary coolant. The hydrogen will be combined with oxygen in the recombiner and will be removed as water vapor. The remaining radioactive gases will have a negligible effect on the overall gaseous inventory. The nitrogen and radioactive gases will be alternately collected and stored in one of three 700-ft^3 (design pressure of 380 psig) pressurized storage tanks. The storage tanks will collect, store, and release gases in rotation to allow short-lived radionuclide decay. After holdup, the nitrogen, containing long-lived radionuclides, may be reused as cover gas in the primary loop. In this manner, short-lived radionuclides will decay during storage, and long-lived radionuclides will accumulate in the system. The system is designed to hold up gases for long-term storage. However, the applicant has estimated periodic releases to avoid buildup of long-lived isotopes and has estimated releases based on a one-year holdup. The staff based its calculations on release after 90-days' holdup, which will leave Kr-85 (10.7 y half-life) as the predominant radionuclide. The staff assumed gas stripping of the BRS to be 3 gpm, based on information provided by the applicant. The staff calculated the GWMS releases to be 456 Ci/year per reactor for noble gases and negligible for iodine. Waste gases displaced from aerated tanks, demineralizers, and BRS and waste evaporators will exhaust to the gas collection header and will be directed to the plant vent for monitoring and release without treatment. The staff considered these waste gases as infrequent exhausts and included the releases in the auxiliary building releases. The applicant calculated gas releases from the plant based on a higher gas stripping rate (up to 140 gpm) and estimated the combined GWMS and waste gas release to be 3300 Ci/year per reactor of noble gases and negligible amounts of iodine.

Containment purges

Radioactive gases will be released inside the reactor containment when primary system components are opened or when leaks occur in the primary system. The gaseous activity will be sealed within the containment during normal operation but will be released during containment purges. Prior to purging, the containment atmosphere will be recirculated through HEPA filters and charcoal adsorbers (18,000 scfm) for particulate and iodine removal. Following recirculation, the containment will be purged through HEPA filters and charcoal adsorbers to the atmosphere. The airborne activity was calculated based on the parameters for primary coolant leakage to the containment in Table 3.3. Radionuclide removal was based on 16 hr of recirculation system operation,

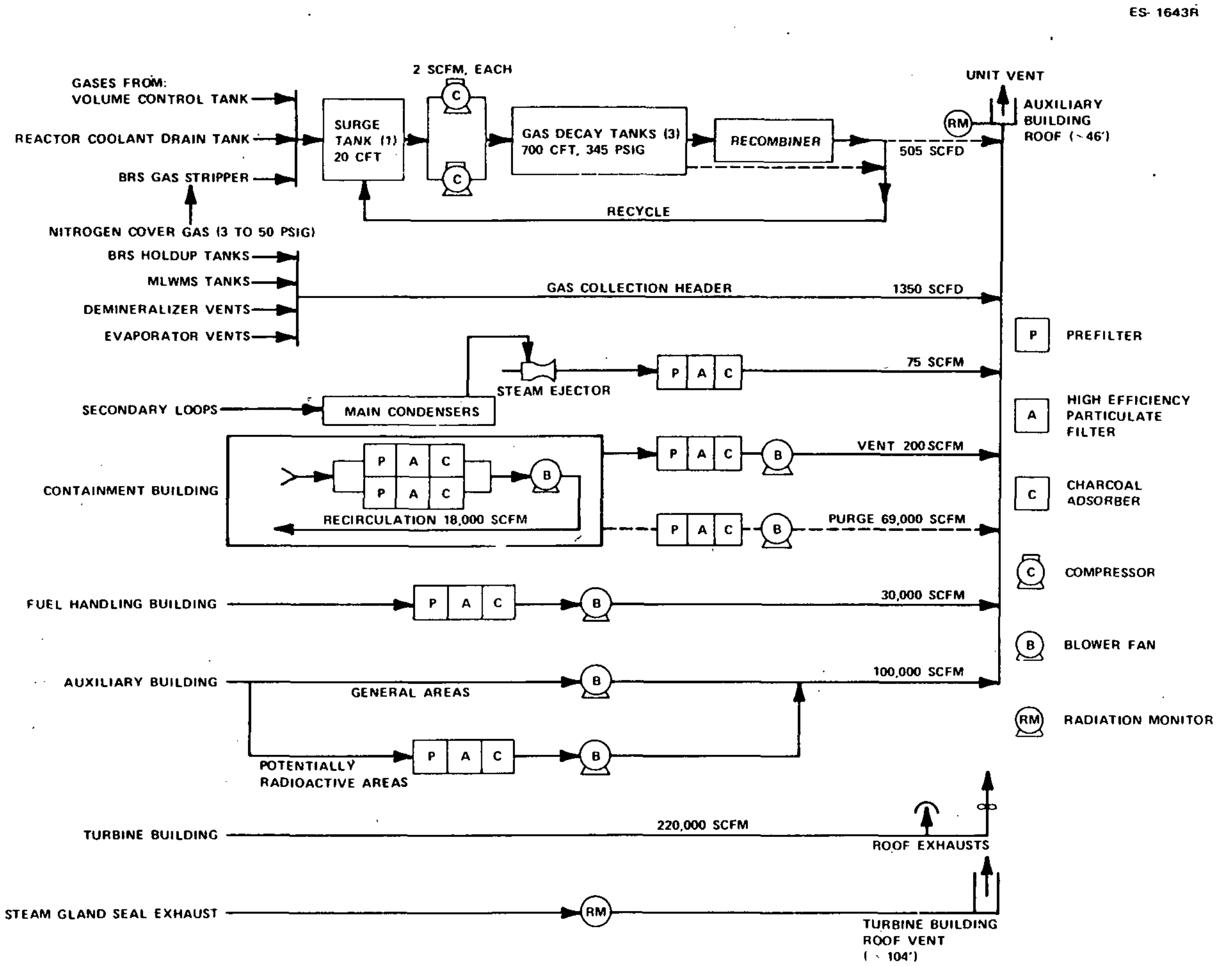

Fig. 3.8. Gaseous radioactive waste system, Cherokee Nuclear Station, Units 1, 2, and 3.

70% mixing efficiency, and a DF of 10 for the recirculation charcoal adsorber. The staff assumed four containment purges annually and calculated the containment purge releases to be approximately 9200 Ci/year of noble gases per reactor and 0.017 Ci/year of I-131 per reactor. The applicant did not provide a separate estimate of these releases.

Auxiliary, turbine, and fuel handling area releases

Radioactive gases will be released to the auxiliary building due to leakage from primary system components. The ventilation systems will be designed to ensure that air flow will be from areas of low potential to areas having a greater potential for the release of airborne radioactive material. Ventilation air from the fuel handling area and from potentially radioactive areas will be passed through HEPA filters and charcoal adsorbers. Ventilation air from other auxiliary building areas will be monitored and discharged to the environment through the plant vent without treatment. The staff's calculated releases were based on the auxiliary building leakage rate and iodine partition factor listed in Table 3.3. Based on these parameters, the staff calculates the auxiliary building and fuel handling area releases to be 335 Ci/year of noble gases per reactor and 0.042 Ci/year of I-131 per reactor. The applicant estimated the auxiliary building releases alone per reactor to be 320 Ci/year of noble gases and 0.001 Ci/year of I-131.

Radioactive gases will be released to the turbine building due to secondary system steam leakage. The turbine building releases are not filtered and will go directly to the atmosphere. The staff's calculated release values are based on 1700 lb/hr per reactor of steam leakage to the turbine area, assuming that all of the noble gases and iodine remain airborne, as specified in the parameters. On this basis, the turbine area releases were calculated to be less than 1 Ci/year per reactor for noble gases and 0.006 Ci/year per reactor for I-131. The applicant estimated the turbine building releases to be 7.7 Ci/year per reactor for noble gases and 0.002 Ci/year per reactor for I-131.

Steam releases to the atmosphere

The turbine bypass capacity to the condenser will be 55%. The staff analysis indicates that steam releases to the environs due to turbine trips and low-power physics testing will have a negligible effect on the calculated source term.

Main condenser air ejector exhausts

The main condenser air ejector exhausts will contain radioactive gases resulting from primary to secondary system leakage. Iodine will be partitioned between the steam and liquid phases in the steam generators and between the condensing and noncondensibles phases in the main condensers and air ejectors. Air ejector exhausts will be passed through charcoal adsorbers to the plant vent. Based on the parameters listed in Table 3.3, the staff considered 110 lb/day per reactor of primary to secondary leakage and partition factors of 0.01 and 0.005 for iodine in the steam generators and main condenser air ejectors respectively. The staff considered a DF of 10 for the charcoal adsorbers in its evaluation. The staff calculates the main condenser air ejector releases to be approximately 218 Ci/year per reactor for noble gases and 0.003 Ci/year per reactor for I-131. Based on the higher gas stripping rate of the primary coolant, the applicant estimated this release to be 300 Ci/year per reactor for noble gases and 0.002 Ci/year per reactor for I-131.

Gaseous waste summary

Based on the parameters given in Table 3.3, the staff calculates the total radioactive gaseous releases to the environment through the plant vent on top of the containment building to be approximately 10,200 Ci/year of noble gases per reactor and 0.068 Ci/year of I-131 per reactor. The principal sources and isotopic distribution are given in Table 3.5. The applicant has calculated an overall release of approximatley 3950 Ci/year of noble gases per reactor and 0.004 Ci/year of I-131 per reactor. The applicant has assumed a DF of 100 vs the staff's DF of 10 for charcoal adsorbers in the auxiliary building, containment purge, and containment recirculation system releases, resulting in a lower I-131 release estimate.

Table 3.5. Gaseous radioactive source term (Ci/year/unit) for Cherokee Nuclear Station, Units 1, 2, and 3

Radionuclide	Reactor building	Auxiliary building	Turbine building	Air ejector	Decay tanks	Total
Kr-83*m*	*a*	*a*	*a*	*a*	*a*	*a*
Kr-85*m*	9	3	*a*	2	*a*	14
Kr-85	40	1	*a*	*a*	453	494
Kr-87	2	1	*a*	*a*	*a*	3
Kr-88	11	5	*a*	3	*a*	19
Kr-89	*a*	*a*	*a*	*a*	*a*	*a*
Xe-131*m*	51	2	*a*	1	3	57
Xe-133*m*	95	4	*a*	3	*a*	102
Xe-133	8910	310	*a*	200	*a*	9420
Xe-135*m*	*a*	*a*	*a*	*a*	*a*	*a*
Xe-135	56	8	*a*	5	*a*	69
Xe-137	*a*	*a*	*a*	*a*	*a*	*a*
Xe-138	*a*	1	*a*	*a*	*a*	1
I-131	0.017	0.042	0.006	0.003	*a*	0.068
I-133	0.011	0.061	0.004	0.004	*a*	0.080
H-3						760
C-14						8
Particulates						0.06

[a] Less than 1 Ci/year/unit noble gases, less than 10^{-4} Ci/year/unit iodine.

3.5.3 Solid waste systems

Solid waste containing radioactive materials will be generated during station operation. Wet solid wastes will consist mainly of demineralizer resins collected in the 5000-gal spent resin storage tank, evaporator concentrates collected in the 5000-gal evaporator bottoms holdup tank, and miscellaneous chemical reagent wastes. These wastes will be mixed with a solidifying agent, transferred to a shipping container for onsite storage, and then shipped to an NRC burial ground. The staff considers these wastes to be stored for 180 days for radioactive decay prior to shipment offsite.

Dry solid wastes will consist of ventilation air filters, contaminated clothing and paper, and miscellaneous items, such as tools and laboratory glassware. Dry solid wastes will be compressed into 55-gal drums by using a baling machine. Noncompressible solid wastes will be packaged for offsite shipment. Because dry solid wastes will contain much less activity than wet solid wastes, the staff did not consider the need for onsite storage of dry solid wastes in the evaluation.

The staff's estimates that approximately 600 drums of wet solid waste containing approximately 10 Ci/drum and 450 drums of dry solid waste containing a total of less than 5 Ci will be shipped offsite annually per reactor. Greater than 90% of the radioactivity associated with the solid waste will be long-lived fission and corrosion products, principally Cs-134, Cs-137, Co-58, Co-60, and Fe-55. The applicant estimates that approximately 4440 ft^3 of solidified evaporator bottoms totaling approximately 380 Ci, 324 ft^3 of demineralized resins with a total of 8800 Ci, 1500 ft^3 of compressible dry solid wastes, 120 ft^3 of chemical reagent wastes, and 70 filter cartridges will be shipped offsite annually per reactor.

Solid waste summary

All containers will be shipped to licensed burial sites in accordance with NRC and DOT regulations. The solid waste system will be similar to systems that have been evaluated and found to be acceptable in previous license applications. Therefore, the staff finds this solid waste system to be acceptable.

3.6 CHEMICAL AND BIOCIDAL EFFLUENTS

Operation of CNS will result in the discharge of chemical wastes into the Broad River. The chemical wastes result from (1) the concentrating effect on the dissolved solids in the intake water due to cooling tower evaporation and subsequent blowdown and (2) the addition of chemicals to the various systems during reactor operation, which eventually are dumped into the effluent stream.

A summary of chemicals discharged to the environment is given in Table 3.6. A partial water analysis of the Broad River (intake water) and the results of the concentration effected by the cooling towers are given in Table 3.7. The relative magnitude of the chemicals discharged from the station may be judged by using these tables.

All nonradioactive waste water from the station, except the cooling tower blowdown, will be discharged to the waste water treatment system (WWTS). This system, a series of four basins (total surface area about 6.2 acres), will consist of an initial holdup basin, two settling basins, and a final holdup basin. The discharges to the river from this system will average 636 gpm. The pH of the effluent will be maintained between 6.0 and 9.0, and the discharge structure will be equipped with an oil trap.

The operation of this waste facility must be conducted in compliance with all State of South Carolina regulations on the discharge of chemicals, oil, and other wastes. The staff concludes that the system, as proposed, can comply with these regulations.

Table 3.6. Chemicals added to liquid effluent during station operation

Parameter	Maximum total added (lb/day)	Maximum concentration[a] in effluent (mg/l) (blowdown or WWTS discharge)	Incremental increase in Broad River (mg/l)[b]
Sodium hydroxide (NaOH)	3,742	283 (Na^+)	0.9
Sulfuric acid (H_2SO_4)	4,584	582 (SO_4^{3-})	1.8
Cyclohexylamine ($C_6H_{11}NH_2$)	99[c]		
Morpholine (C_4H_9NO) (alternative)	493[c]		
Hydrazine (N_2H_4)	49[c]	3.9[d]	0.04
Lithium hydroxide (LiOH)	0.1		
Boric acid (H_3BO_3)	165		
Sodium triphosphate (Na_3PO_4)	12,946[e]	15 (PO_4^{3-})	0.05
Polyacrylate polymer	192	3	0.07
Aminomethylene phosphonate, AMP (as PO_4^{3-})	165	2.6	0.06
Chlorine (Cl_2)	3,390		
Free residual		0.3	0.01
Chlorine reaction products		50	1.2
Dodecylguanidine			
Hydrochloride (alternative)	617	10	0.25
Polyelectrolyte	100	13	0.04
Ammonia	10	0.3	0.004
Liquid detergent	1,145[e]	2.3	0.007

[a]Based on 636-gpm flow from WWTS and 5300-gpm blowdown from cooling towers.
[b]Based on river flow of 470 cfs.
[c]Yearly total divided by 365.
[d]Based on layup maximum discharge only.
[e]Total used per unit prior to startup only.

Table 3.7. Increase in chemical effluent concentration due to cooling tower blowdown

Parameter	Maximum intake concentration (mg/l)[a]	Cooling tower blowdown concentration (mg/l)[b]	Incremental increase in Broad River (mg/l)[c]
pH	7.8		
BOD_5	8	82	1.8
Hardness ($CaCO_3$)	14	144	3.2
Calcium (Ca)	3.8	39	0.9
Magnesium (Mg)	1.5	15	0.3
Sodium (Na)	6.6	68	2.4[d]
Potassium (K)	1.7	18	0.4
Iron (Fe)	0.18	1.9	0.04
Manganese (Mn)	0.1	1.0	0.02
Ammonia (NH_3)	0.3	3	0.7
Nitrate (NO_3)	0.2	2	0.04
Phosphate (PO_4)	0.45	4.6	0.1[d]
Chloride (Cl)	8.3	86	1.8
Fluoride (F)	0.2	2	0.04
Silica (SiO_2)	16	164	3.6
Sulfate (SO_4)	5.6	58	3.1[d]
Aninomethylene phosphonate (as PO_4)		2.6	0.06
Polyacrylate polymer		3	0.07
Dodecylguanidine			
Hydrochloride (alternative)		10	0.25
Chlorine			
Free residual		0.3	0.01
Chlorine reaction products		50	1.2
Total dissolved solids (TDS)	98	980	22

[a]Source: ER, Table 3.6.2-1.
[b]Assuming 55,814 gpm makeup, 114 gpm drift, and 5,300 gpm blowdown.
[c]At a Broad River flow of 470 cfs.
[d]Include added chemicals from WWTS.

3.6.1 Condenser cooling system

Makeup water for the cooling towers will be supplied from the sedimentation basin (see Fig. 3.1) at a maximum rate of about 55,814 gpm. Evaporation and drift will consume about 50,514 gpm of this amount, and the blowdown will be about 5300 gpm. Because of the concentrating effect of the evaporation, the cooling tower water and, consequently, the blowdown will have a dissolved solids concentration about ten times that of the intake water. Because of the high sediment burden of the Broad River, the makeup water will be processed through a sedimentation basin (see Fig. 2.4) where 60-70% of the suspended solids are removed. The remaining solids and precipitates will be stabilized as sols by use of organic corrosion and deposit inhibitor mixtures of a short chain polyacrylate polymer and aminomethylenephosphonate. This inhibitor will be used at a 30-ppm concentration to permit system operation at a pH of 7.8 to 8.25.

Organic growth and chemical scaling in the condenser tubing will be partially controlled by use of a mechanical system of cleaning. Sponge rubber balls, slightly larger in diameter than the condenser tubing, will be recirculated through the condenser tubing to control fouling of condenser heat-transfer surface. The condenser cooling tubes will be stainless steel, which is highly resistant to water corrosion. Therefore, no significant amounts of corrosion products are expected to be released to the river.

Various other chemicals will be added to the cooling tower circulating water system. For control of biological growth, a biocide will be added once a day to the cooling tower basin outlets. The applicant proposes the application of 533-1066 lb of chlorine (as sodium hypochlorite) daily per unit (1600-3200 lb/day total) over a period of 1 hr to obtain a free chlorine residual of 1 ppm during warm months and 0.5 ppm in cold weather. The units are to be chlorinated sequentially. The free residual chlorine in the cooling tower water will decay to essentially zero in a matter of hours, but because of the large ratio between the volume of water being chlorinated and the blowdown volume, the concentration of the added chlorine and its reaction products (chloride ion, chloramines, organic chloramines, and chlorophenols) will build up in the circulating water to an essentially steady state of $\sim$50 ppm. The exact composition of this steady state cannot be accurately estimated, although the staff agrees that a large fraction of it will be chloride ion. Blowdown will not materially decrease this concentration between chlorinations; therefore, the blowdown from each unit will contain this average concentration at all times. For each chlorination, the resultant concentration in the circulating water effluent (blowdown to river) will initially consist of up to a maximum of 0.3 ppm free residual chlorine and 50 ppm of the reaction products of chlorine. After several hours, the free residual chlorine will decay, leaving only the chlorine reaction products. Since some of the reaction products may be toxic (chlorophenols and chloramines), the applicant is required to restrict the discharge of total residual chlorine from this source to not more than 0.1 mg/l.

If chlorine-resistant organisms require control, the applicant proposes the use of an organic biocide, such as dodecylguanidine hydrochloride. This biocide will be applied in the 10-30 ppm concentration range resulting in a 3-10 ppm concentration in the effluent.

3.6.2 Filtered water treatment

Water for station use, other than the condenser cooling system, will be obtained from the sedimentation basin. Because this water will contain clay-type colloidal materials, a 2100-gpm water treatment unit, combining usage of a polyelectrolyte coagulant approved for use in potable water, prechlorination, and three filters of the deep-bed-upflow type, will be used to treat the water taken from the sedimentation basin. The applicant estimates that 38-190 lb of chlorine and 20-75 lb of polyelectrolyte will be required daily in this process. The wastes from this system will be routed to the WWTS.

3.6.3 Demineralizer regeneration

To provide the necessary reactor makeup water, a system composed of granulated-activated carbon filters just ahead of two mixed-bed demineralizers, with a capacity of 700 gpm each, will be used. These beds will be periodically regenerated with sodium hydroxide and sulfuric acid. The elutant will be routed to the WWTS and neutralized to a pH not exceeding 9. The staff estimates that the demineralizer process will result in the daily maximum use of 3742 lb of sodium hydroxide and 4584 lb of sulfuric acid.

3.6.4 Reactor coolant chemicals

The chemicals added to the reactor primary coolant system will be present in any effluent only as the result of leakage or letdown for processing. Because the primary coolant will contain radioactive material, any leakage will be processed through the liquid radioactive waste system (Sect. 3.5). Daily use is estimated to be 0.1 lb of lithium hydroxide and 165 lb of boric acid.

3.6.5 Secondary coolant feedwater

The applicant will use hydrazine as an oxygen scavenger and amines for control of pH in the secondary system. The annual use of these substances will amount to 18,000 lb of hydrazine and 36,000 lb of cyclohexylamine (or 180,000 lb of morpholine). Little release is expected from this source since hydrazine reacts chemically to form nitrogen and water. The other amines follow the same waste routes as the hydrazine. During shutdown, the secondary side of the units will be blanketed with nitrogen and/or filled with condensate quality water containing 200 ppm hydrazine and 10-15 ppm ammonia.

3.6.6 Miscellaneous

Prior to station startup, about 850 gal of liquid detergent will be used during the construction period for degreasing and spray-cleaning of pipe assemblies. This waste will be processed through the temporary sewage system (Sect. 3.7.1). Also, prior to startup, hot trisodium phosphate solution will be used for degreasing and cleaning of condensers. The applicant estimates that about 36,000 lb of trisodium phosphate ($Na_3PO_4 \cdot 12H_2O$) and 138 gal of liquid detergent per unit will be used for this purpose. About 720,000 gal of water containing this waste will flow to the WWTS and will be discharged to the river after dilution and neutralization.

3.7 SANITARY WASTES AND OTHER EFFLUENTS

3.7.1 Temporary sewage

During the period of plant construction, the applicant will treat sewage waste in prefabricated extended aeration-type sewage treatment plants that have a combined capacity of 36,000 gpd and use up to 6 lb of chlorine (as hypochlorite) per day in chlorine contact chambers. Sewage solids will be digested by extended-aeration treatment, leaving a chlorinated liquid with a minimum of 0.5 to 1.0 ppm free residual chlorine. This liquid will be pumped to a holding pond — where waste stabilization will be completed during the normal retention period — and ultimately to the river.

3.7.2 Permanent sewage

Domestic sewage from the plant, estimated at 8000 gpd, will be collected in a sand filter with tertiary treatment. The effluent from the underdrains of the filter will be treated in a chlorine contact chamber using up to 1.5 lb of chlorine (as hypochlorite) per day. The effluent from the chamber, which has a minimum residual free chlorine concentration of 0.5 to 1.0 ppm, will be pumped to the WWTS and, after stabilization, it will ultimately be pumped to the river.

Both the temporary and permanent sewage treatment systems will meet all applicable standards of the State of South Carolina.

3.7.3 Auxiliary heating systems

The plant heating boiler, used prior to unit startup, will be electric-fired and, consequently, there will be no gaseous emissions.

The diesel generators, used for emergency power only, will be started and tested for an hour at least once every two weeks. The exhaust gases will pass through a silencer before being discharged. The fuel to be used is fuel oil that has a cetane rating of 37-47, 0.6% sulfur, 0.01% ash, and 0.15% carbon residue. The staff concludes that the emissions from this source would be within the limits set in State regulations.

3.8 TRANSMISSION SYSTEMS

3.8.1 Switching station

The 230-kV switching station is located about 800 ft south of the powerhouse and encompasses an area of approximately 17 acres. Approximately 19 acres are reserved for a proposed 525-kV switching station adjacent to the 230-kV station on the south side. Power from each unit is transmitted via two separate overhead transmission lines connecting to the 230-kV switching station. Initially, the 230-kV switching station will interconnect with the Duke Power Transmission Network by three lines (fold-ins), each having two three-phase double-circuit overhead lines (Fig. 3.9). Provisions for two additional double-circuit 230-kV transmission lines are included in the design for CNS, plus space requirements for a future 525-kV switching station.

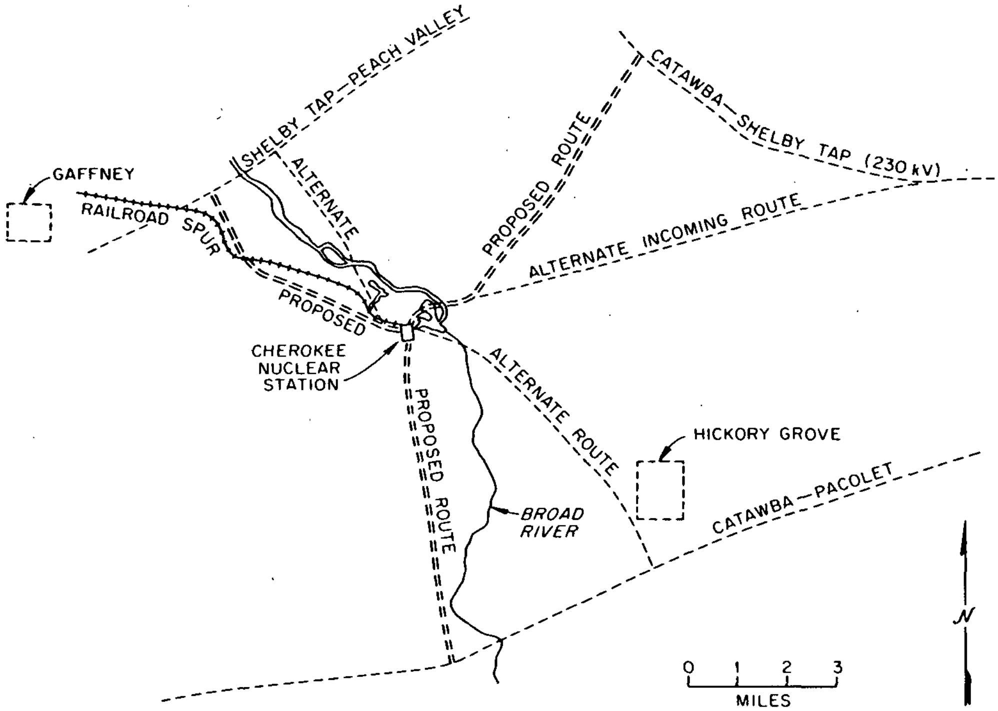

Fig. 3.9. Proposed transmission line and rail spur rights-of-way routes.

3.8.2 Transmission routes

Transmission lines proposed for connection of CNS with the existing distribution system are illustrated in Fig. 3.9. To connect CNS with Duke Power Company's existing transmission system, three double-circuit 230-kV lines are folded into the Cherokee switchyard.

Cherokee Station to Shelby Tap-Peach Valley 230-kV line

One double-circuit 230-kV line is constructed over a 270-ft-wide, 5.2-mile corridor (169.4 acres) that leads from CNS to a juncture with the Shelby Tap to Peach Valley 230-kV line. Towers are spaced approximately 1100 ft apart and are 110-175 ft high. Minimum wire clearance to the ground at any point is 35 ft. Of the total 169.4 acres of right-of-way, approximately 81% is forest land, 6% is pasture, and 12% is active and inactive agricultural land.

Cherokee Station to Catawba-Pacolet 230-kV line

One double-circuit 230-kV line is to be constructed over a 270-ft-wide, 6.9-mile corridor (226.4 acres) that leads from CNS to a juncture with the Catawba to Pacolet 230-kV line. Tower specifications and wire clearance are the same as above. Of the total 226.4 acres of right-of-way, approximately 86% is forest land, 4% is pasture, and 10% is active and inactive agricultural land.

Cherokee Station to Catawba-Shelby Tap 230-kV line

One double-circuit 230-kV line is to be constructed over a 270-ft-wide, 1.2-mile corridor and then over a 251-ft-wide, 7.2-mile corridor leading from CNS to a juncture with the Catawba to Shelby Tap 230-kV line. Tower height and wire clearance are the same as above. Of the total 258.4 acres of right-of-way, approximately 84% is forest land, 9% is pasture land, and 7% is active agricultural land.

For all three fold-ins identified above, all forested land will be cleared. None of the proposed lines cross any existing railroads, and none require removal of any man-made structures, although some geodetic control survey monuments may be located in the proposed corridor. The proposed Catawba to Shelby Tap fold-in is the one line that will cross a body of water, and in this case, about 0.3 acre of water and wetlands is involved. The alternate routes proposed for the three lines would involve the following distances: Shelby Tap to Peach Valley fold-in, 4.4 miles; Catawba to Pacolet fold-in, 7.1 miles; and the Catawba to Shelby Tap fold-in, 10.5 miles. The existing land use along the alternate routes has not been supplied by the applicant; however, with the exception of two additional crossings of the Broad River, land use patterns are expected to approximate those stated for the preferred routing. Right-of-way width for alternate routes is likely to be identical to the preferred routing.

Existing lines will be modified to accommodate voltage output from the Cherokee Station. From the Shelby Tap Station to the Peach Valley Tie Station (about 34 miles of lines), 177 towers will be replaced. Between the Catawba Nuclear Station and the Pacolet Tie Station (about 42 miles of lines), a single conductor will be replaced by a two-conductor bundle at each phase, and 223 towers will be modified with heavier steel where necessary.

3.9 TRANSPORTATION CONNECTIONS

3.9.1 Railroad spur

The applicant has proposed construction of a railroad spur for use in transporting fuel, radioactive waste materials, and construction materials. A minimum 100-ft-wide right-of-way, including a total of about 83 acres, is required over the 7-mile spur that connects with an existing railroad at Gaffney, South Carolina (Fig. 3.9).

3.9.2 Access roads

One construction access road and one permanent access road to the station are proposed by the applicant for carrying truck and automobile traffic (ER, Fig. 4.1.1-2). Both roads will connect with County Road 13 south of the site. Three temporary access roads to the transmission lines of total length about 20.5 miles will be constructed on the rights-of-way of the three proposed lines.

3.10 CONSTRUCTION PLAN

The applicant expects construction activities (site preparation) to begin in November 1976, with pouring of the first permanent concrete foundations scheduled for September 1978. Commercial operation of Units 1, 2, and 3 is scheduled for January of 1984, 1986, and 1988, respectively. Construction manpower requirements are expected to peak at about 2600 during 1982; during the period 1979-1985, the average construction work force is not expected to drop below about 1100. Estimated average construction employment from 1977 through 1988 is given in Table 3.8. Further details of the preliminary construction schedule are given in Sect. 4 of the ER.

Table 3.8. Estimated average construction employment at Cherokee Nuclear Station

Year	Average construction employment
1976	20
1977	160
1978	540
1979	1190
1980	1840
1981	2510
1982	2590
1983	2590
1984	2290
1985	1940
1986	1530
1987	750
1988	180

Source: From the ER, Table 4.1.1-3.

4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND OF STATION AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 IMPACTS ON LAND USE

The total land area involved in the actual construction (both temporary and permanent facilities) of the CNS and related facilities will include 1488 acres as follows (all acreages given below are approximations):

	Acres
Station and facilities (including three access roads and three ponds)	751 (staff estimate from ER, Fig. 4.1.1-2)
Rights-of-way	
Transmission lines (including access roads and additional construction)	654
Railroad spur	83

The area included within the site boundary fence is 1272 acres (staff estimate from ER, Fig. 4.1.1-2), while the total site area is estimated by the staff to be 2263 acres (ER, Fig. 2.1-4).

4.1.1 Station site

A diagrammatic land use plan for the CNS is shown in Fig. 4.1, and the acreage to be affected by station facilities is given in Table 4.1. A total of about 751 acres (staff estimate from ER, Fig. 4.1.1-2) of possible wildlife habitat of forested and semiforested land will be completely cleared during construction. Almost all of the forest within the 450-acre exclusion area will be cleared. Of the three dominant land cover types within the exclusion area, 50% is pine forest (pine scrub and mesic pine forest), 31% is oak-hickory forest, and 11% is mixed mesic hardwood forest, with 8% miscellaneous (alluvial forest and water). The nuclear service water pond and the intake sedimentation basin (total of 280 acres) will flood 49% forest communities, 22% aquatic areas, 15% abandoned fields and transmission rights-of-way, and 14% thickets (ER, Question 1.13). All forested land to be covered by these ponds will be cleared by the applicant. Most of the other 1513 acres of the applicant's property could potentially be cut over, because the applicant has given timber rights to the previous landowners on 90% of the property. The applicant does not plan to monitor the amount of forests cleared by previous landowners. An additional acreage outside the applicant's 2263 acres may be cleared as more land is acquired by the applicant from private landowners and from U.S. Plywood and Champion Papers, Inc. The disposition of merchantable timber that the applicant himself will clear has not been stated, but it should be placed on the market since it may be important to the local economy.

Excavations for building foundations and installation of intake and discharge structures will provide substantial amounts of fill material. Excavation will be confined almost entirely to cleared areas (i.e., most of the area within the exclusion boundary and the acreage covered by the intake sedimentation basin and the nuclear water service pond). Grading and site excavation will involve the following estimated quantities of earthwork and dredging:

Waste water collection basin dam	34,000 yd^3 fill
Nuclear service water pond dam	625,000 yd^3 fill
Intake sedimentation basin dam	520,000 yd^3 fill
Station yard (including plant yard,	9,340,000 yd^3 excavation
cooling tower yard, and switchyards)	6,700,000 yd^3 fill

The total fill required amounts to 7,879,000 yd^3 compared to the 9,340,000 yd^3 for excavation. The excess excavation will be used as compacted fill in adjacent low areas to serve as construction yard space and as storage area for equipment. Excavation to depths below the existing water table will require dewatering for placement of foundations and substructures. The applicant has estimated the maximum production rate of dewatering effluents to be 450 gpm (ER, Question 1.10)

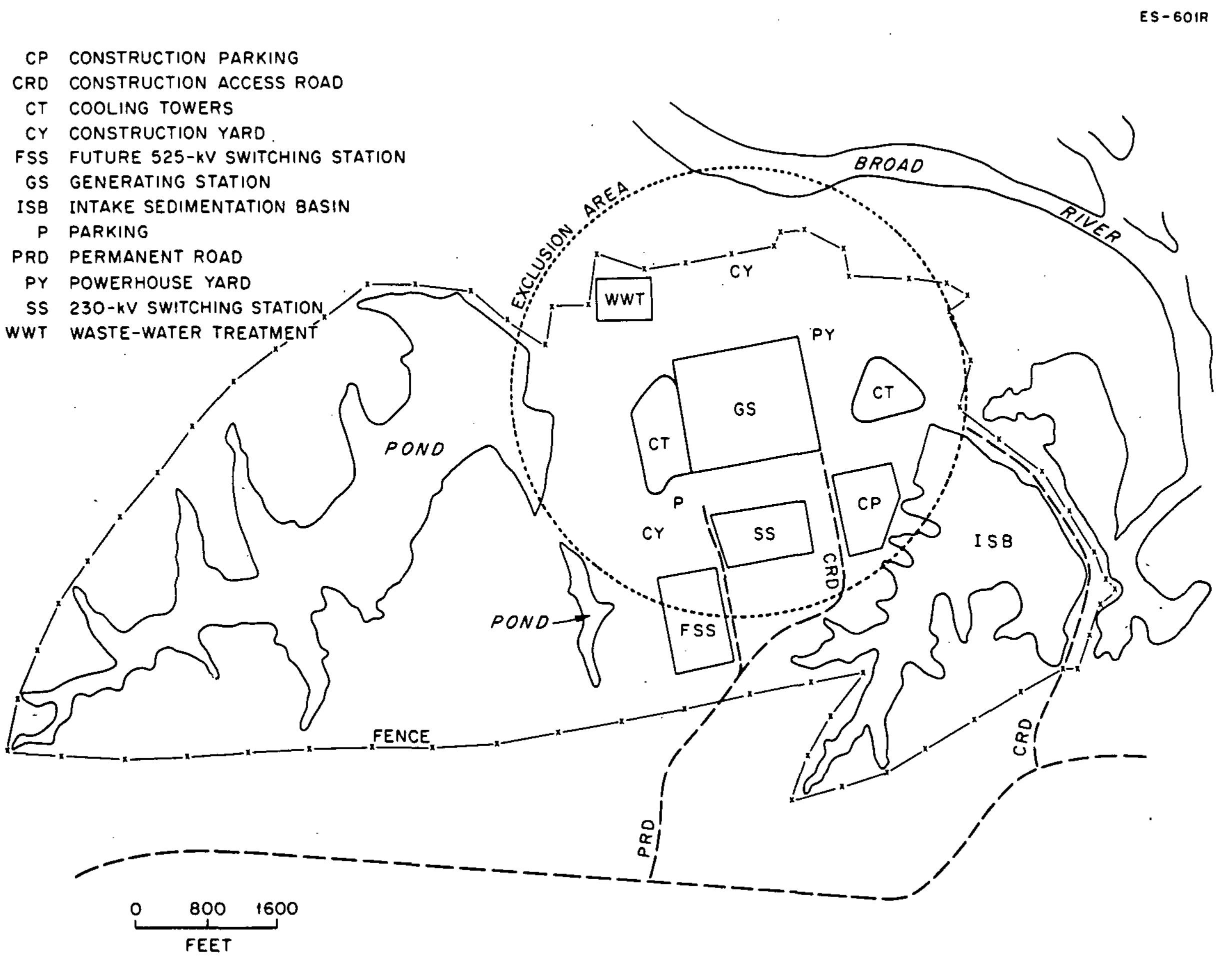

Fig. 4.1. Land use plan.

and has stated that the groundwater table is lowered only within the site (ER, p. 4.1-6). The effluent will be detained in detention ponds, thereby protecting the adjacent streams and river from construction-related sediment (ER, Question 4.1.10).

Table 4.1. Land area requirements for Cherokee Nuclear Station

Description of facility	Land area (acres)
Generating station	46[a]
Cooling towers	37[a]
230-kV switching station	17[b]
525-kV switching station	19[b]
Waste water treatment	7[a]
Intake sedimentation basin	96[a]
Nuclear service water pond	184[a]

[a]Staff estimate based on the site plan blueprint.
[b]From the ER.

A total of 17 homes (16 family and 1 recreational) will be displaced as a result of land acquisition and plant operation.

Of the 2263 acres of the applicant's property, the area within the site boundary fence will be removed from access by the general public (ER, Question 2.2.12). This action involves 1272 acres (staff estimate from ER, Fig. 4.1.1-2) instead of 736 acres, as stated by the applicant (ER, Question 2.2.12). The applicant did not state how much recreation would be allowed on its 991 acres outside the boundary fence. Recreation within the exclusion area will be limited to occasional boating and fishing on Ninety-Nine Islands Reservoir. Therefore, noise during construction should have no significant impacts on normal land use in the surrounding area, which is mostly forested and sparsely populated.

The applicant expects that noise levels at the boundary of the exclusion area will fall within the range 45-73 dB (A) during operation of large earth-moving equipment (ER, Sect. 4.1.2). The nearest offsite residence will be at least 4000 ft away from the loudest noise source.[1]

4.1.2 Intake sedimentation basin

The intake sedimentation basin will occupy 96 acres including 10% abandoned fields and transmission line rights-of-way, 58% forest communities, and 32% aquatic areas.

4.1.3 Transmission lines

The applicant has outlined a proposed routing and an alternate routing for each of the three fold-ins that connect with other lines of the applicant's existing and proposed system (Fig. 3.8). Comparisons of alternate and proposed routings are given in Sect. 9.2.4. None of the transmission line corridors cross any lakes; marshland; wildlife refuges; scenic, historic, or recreational areas; national forests; designated wilderness areas; or national register properties. Land that will be permanently removed from productive agricultural use is only that land immediately under the transmission towers; land use on other areas is not expected to change. If any geodetic control survey monuments are located in the transmission line routes, the National Ocean Survey requires not less than 90 days' notification in advance of construction activity in order to plan for their relocation.

Visual impact of the three fold-ins is expected to be light, since they cross strictly rural areas. None of the lines cross any major highways, and only one comes within visual distance of a small town.

In terms of actual construction of lines proposed for CNS, the principal impact on present land use will be the conversion of 550 acres of forested land to low-growing grass, herbs, and brush. Impact on remaining lands (104 acres), active and inactive croplands and pasture, will be limited to that from grading and other actions associated with tower siting and stringing of high tension lines. Except for areas occupied by tower bases and access roads, these lands will be allowed to revert to their former uses following construction. The temporary construction roads on each right-of-way will be seeded to impede erosion and to return the land to suitable wildlife habitat.

4.1.4 Railroad spur line

The principal impact associated with construction of the railroad spur described in Sect. 3.9 (Fig. 3.8) will be the permanent removal of about 83 acres of land from other uses. It is expected that approximately 10 acres of agricultural land will be lost, while the remainder (73 acres) to be affected consists of forest and an existing unused 33-kV right-of-way. The acreage of forest and of right-of-way to be used will depend on the suitability of the right-of-way for the spur; where the right-of-way is not suitable, forests adjoining the right-of-way will have to be cleared for the spur. The staff requires the applicant to construct the spur on the existing right-of-way as far as practicable (Sects. 4.5 and 9.2.5).

4.1.5 Access roads

A total of 2.3 miles of two access roads, one temporary construction and one permanent, will remove roughly 23 acres from present land use outside the exclusion area (based on staff estimates from the ER, Fig. 4.1.1-2, Amendment 3). Judging from the site aerial photograph (ER, Fig. 2.1-5), both roads may utilize portions of existing roads. The staff recommends that the applicant use existing road as much as possible for access to the site.

4.1.6 Makeup and blowdown pipelines

Impacts of the construction of the makeup pipeline were included in Sect. 4.1.1. The blowdown pipeline will require additional clearing outside the exclusion area, amounting to probably less than 5 acres (acreage estimates were not provided by the applicant). Where the line passes down the slope to the Broad River, the staff recommends that the applicant exercise all reasonable precautions to minimize erosion and siltation of the river.

4.1.7 Conclusion and summary of land use impact

A total of 1373 acres of forest will be cleared for the station site (750 acres), transmission line rights-of-way (550 acres), and railroad right-of-way (73 acres). This total acreage cleared will reduce the total forested acreage (36,725) within a 5-mile radius by 3.7% (staff estimate from aerial photographs). Small portions of the cleared acreage on the station site proper may be allowed to undergo natural succession to forest, but for comparative purposes, the staff assumes that at least 1373 acres will be removed from productive forest status. Additional forested acreage will be cleared for the construction of mobile home parks and other living accommodations for personnel involved in Cherokee site preparation and construction (ER, Question 4.1.6b); however, this acreage has not been estimated.

The relative impact of the above changes in land use may be compared with previous land use changes in Cherokee County for the period 1958-1967 (Table 4.2). The conversion of 1373 acres of forest to other uses will reduce the 1967 inventoried forest acreage (land at least 10% stocked with trees, land with forest reduced to less than 10% but not developed for other uses, and land planted with trees, except U.S. Forest Service land) by 1.0% (0.01% statewide). The conversion of 550 acres (transmission line rights-of-way) of forest to other uses and 823 acres (station site and railroad spur) of forest to noninventory status involves increases of 8.6% and 4.2%, respectively, of 1967 acreages in these two categories. These two figures are only slightly less than the total increases in these two categories from 1958-1967. Of note are the large changes in acreage for cropland (-12,711 acres), forest (+5359 acres), and pasture (+5211 acres) during these years. The increase in urban and built-up areas has been much less than that experienced in other counties.

4.2 IMPACTS ON WATER USE

4.2.1 Surface water

The major potential impact on water use will be the increased turbidity in the Broad River (Ninety-Nine Islands Reservoir), which will result from activities associated with construction of the river intake and discharge structures. During site preparation, there will also be some increase in turbidity due to runoff during rainstorms from the site. River uses that could be affected by an increase in turbidity are fishing and other water-related forms of recreation. There are no agricultural, domestic, or metropolitan water withdrawals from the river near

Cherokee (Sect. 2.2). The staff agrees with the applicant (ER, pp. 4.1-5 and 4.1-6) that, if proper erosion controls are implemented in the site area, there will be no appreciable impact on the water quality of the river.

Table 4.2. Land use inventory for Cherokee County, South Carolina, as compared with land use for all counties 1958–1967[a]

	Acres		Change 1958–1967	
	1958	1967	Acres	Percent
Total inventory[b]	234,200 (17,471,086)	232,459 (17,154,441)	−1,741 (−316,645)	−0.7 (−1.8)
Cropland	78,500 (4,540,500)	65,789 (3,865,413)	−12,711 (−675,087)	−16.2 (−14.9)
Pasture	24,000 (940,200)	29,211 (1,037,685)	+5,211 (+97,485)	+21.7 (+10.4)
Forest (less USFS)	125,700 (11,090,400)	131,059 (11,427,073)	+5,359 (+336,673)	+4.3 (+3.0)
Other land	6,000 (900,000)	6,400 (824,270)	+400 (−75,730)	+6.7 (−8.4)
Noninventory[b]	17,800 (1,902,874)	19,541 (2,183,828)	+1,741 (+280,954)	+9.8 (+14.8)
Federal noncropland	1,000 (1,036,542)	1,000 (1,042,667)	+(6,125)	(+0.6)
Urban and built-up	15,500 (777,335)	16,899 (1,031,000)	+1,399 (+253,665)	+9.0 (+32.6)
Small water area[c]	1,300 (88,997)	1,642 (110,161)	+342 (+21,164)	+26.3 (+23.8)

[a]Totals for all counties are shown in parentheses.

[b]Noninventory land is the land excluded from farming purposes.

[c]Small water area includes ponds and lakes less than 40 acres and streams less than 1/8 mile wide; acreages attributable to larger bodies of water have been subtracted from total land areas.

Source: "South Carolina Soil and Water Conservation Needs Inventory," Soil Conservation Service, USDA, Columbia, S.C., 1970.

4.2.2 Groundwater

The groundwater environment at the site will be substantially changed by the proposed construction. During construction, dewatering of the various excavations will cause the groundwater table to be lowered (ER, p. 4.1-6). The applicant also states (PSAR, Sect. 2.4.13.2) that the groundwater in the area moves toward the river, which acts as a groundwater sink for the site and the surrounding area. Because the nearest well is outside the effective zone of influence of such dewatering, the staff considers that construction will have no effect on adjacent wells. However, the staff recommends that the applicant monitor the nearest well (Sect. 2.5.2) and, if any effect is noted, take remedial steps.

4.3 EFFECTS ON ECOLOGICAL SYSTEMS

4.3.1 Terrestrial

In general, all mitigative activities of the applicant should focus on maintaining the productivity of natural systems, which is especially critical as the demands for foodstuffs, renewable natural resources (e.g., lumber), and recreational opportunities increase. A major key to maintaining maximal productivity of terrestrial systems is to maintain soil fertility. Therefore, operational procedures that maintain a productive topsoil should be utilized. Such procedures will, in general, involve restriction of grading, leveling, and bulldozing operations; saving and replacing topsoil where such operations must occur; and preventing erosion through rapid and efficient revegetation programs.

4.3.1.1 The site

Vegetation

Clearing for construction and site development constitutes an unavoidable disturbance to the immediate environs. The bulk of clearing and site preparation will occur in upland pine, oak-hickory, and mixed mesic hardwood forests, which comprise 93% of the exclusion area. It is expected that 228 acres of pine forest (five stands), 141 acres of oak-hickory forest (four stands), 50 acres of mixed mesic hardwood forest (three stands), and seven acres of mountain laurel-hardwood forest (one stand) will be cleared within the 450-acre exclusion area. The remaining acreage within the exclusion area is mostly surface water and transmission line right-of-way. Within the security fence, a total of about 750 acres of forest will be cleared.

Some areas cleared during construction will be allowed to undergo natural succession, thus reverting, after many years, to their original condition. For succession to proceed normally on slopes, however, topsoil on cleared and graded or eroded areas should be replaced and quickly stabilized with vegetation; otherwise, the reestablishment of vegetative cover will be slow, the soil would further erode, and wildlife populations would receive little benefit from the areas.

The single stand of mountain laurel-hardwood lies in the southwestern portion of the site and is near or on areas to be cleared (ER, Fig. 4.1.1-2). The community vegetation is dominated by American beech in the overstory and mountain laurel in the shrub layer. Several factors indicate that this community type is infrequent or rare. This combination of beech and laurel forms a vegetation type that is not discussed in publications describing the forest types of this area (Sect. 2.7.1.2), and this community occupies only 0.2% of the 3348 acres on which vegetation on the site and vicinity was mapped. The staff has conferred with professional botanists or plant ecologists in South Carolina, who state that communities dominated by a laurel-beech combination occur in other areas besides the Cherokee site but that they are infrequent or rare. Both American beech and mountain laurel are common widespread species. Thus, while the species are not rare, the stand is unique because beech and laurel occur as dominant species in the same community. Therefore, if the stand were lost during construction, no serious impacts would occur on the species populations of beech and laurel. However, because this community type is infrequent or rare, the staff recommends that the applicant preserve it if such preservation is not too costly and does not seriously compromise other environmental concerns on the site.

The intake sedimentation basin and the nuclear service water pond will account for most of the land to be cleared outside the exclusion area. The intake sedimentation basin will cover 96 acres (Table 4.1), 10% of which is abandoned fields and transmission line right-of-way and 58% of which is forest land, consisting mainly of oak-hickory, pine, and mixed mesic hardwood. The nuclear service water pond will cover 184 acres, 20% of which is abandoned fields and transmission line right-of-way and 68% of which is thickets and forest. The percentages of each forest type to be covered by the ponds were not given by the applicant. Roads and the future 525-kV switching station account for other acreage to be cleared outside the exclusion area.

Erosion problems

Erosion on the site could have serious effects on terrestrial systems on the site and in the immediate vicinity of the site and on nearby aquatic systems, especially during a construction project of this size and duration. Because the loss of topsoil and siltation of streams through erosion would cause reductions in the productivity of both terrestrial and aquatic communities, possible erosion problems on the site should be assessed.

Several construction buildings and the cleared area in the north and northeast portions of the exclusion area will be close to or over relatively steep slopes leading down into the Broad River bottoms (ER, Fig. 4.1.1-2). The staff recommends that, where possible, the planned cleared area and construction buildings be relocated toward the center of the exclusion area closer to the proposed generating station to minimize erosion of slopes and the movement of sediments into slope forests and the river below. For example, a 100-ft-wide strip of forest could be left at the tops of the slopes, located on land with grades of less than 10%. The staff also suggests that more land be left uncleared along the northwest shore of the intake sedimentation basin and that the applicant restrict clearing by previous landowners along the shores of both the intake sedimentation pond and the nuclear service water pond. The applicant should take special precautions to ensure that forests on the steep slopes of McGowan Mountain southwest of the exclusion area are not subjected to any clearing, which could result in rapid erosion and siltation of the nuclear service water pond. The applicant in his comments on the DES (page A-20) has indicated several factors which will restrict the implementation of the staff's above recommendation.

The applicant plans to limit runoff according to EPA standards.[1] To minimize erosion into the river, the applicant will provide detention ponds and berms during early construction in order to detain sediment-laden water and provide settlement of sediment prior to discharge into the receiving streams. A permanent drainage system will be installed as soon as practical to prevent excessive erosion from overland travel of rainfall runoff. At the earliest practical time, all areas not paved will be seeded to obtain a stand of vegetation that will minimize runoff. All paved areas will be sloped and drained to minimize erosion of nonpaved areas (ER, Question 4.1.1.11).

Clearing of the three forest types dominant within the exclusion area should not have a serious effect on regional productivity and other environmental factors, as long as appropriate practices are followed during construction and land not covered by structures is quickly revegetated after construction. The applicant has stated that landscaping and restoration of habitats are to occur as construction progresses (ER, Sect. 4.1.3 and Question 4.1.11). Final grading, replacement of topsoil, and seeding with grasses and herbaceous plants will be done to stablize construction areas. Filling and seeding of settling basins and spoil sites will restore these areas as well.

The applicant will clear forested land totaling about 750 acres, and previous landowners will clear an undetermined amount. The staff assumes that no extra acreage of forested land will need to be cleared.

Fauna

Because the site is a minute portion of the total area occupied by each species, no species' overall population should be seriously affected. Impacts upon local fauna include killing and displacement of numerous animals, which will result in a reduction of the populations of the species involved. Numerous less mobile forms, including invertebrates, amphibians, reptiles, small and medium-sized mammals, and juvenile birds (during spring and summer) will be killed during clearing, excavating, grading, and filling. Larger mammals and adult birds will disperse from the site as dictated by construction activities. It must be assumed that the populations (or potential populations) of species that breed in forests will be permanently reduced in proportion to the number of forest acres cleared. Individuals of these species cannot simply leave the site being cleared and form breeding populations elsewhere because other suitable habitats in the area are already occupied and can support only a certain number of individuals. In other words, all habitats have their respective carrying capacities and cannot sustain populations greater than certain given densities. The reduction of suitable habitat is, thus, equivalent to reduction of the animal populations involved. For example, the clearing of 750 acres of pine and hardwood forests can be expected to reduce total bird populations on this acreage and in the region by 2280 individuals or 152 pairs per 100 acres (staff estimate using data of Johnston and Odum).[2] Forest bird populations would be reduced by about 0.01% statewide, which is the percent reduction in forests statewide (Sect. 4.1.7).

Other species that can exist in lawns and shrubbery and around buildings will move back into the area after construction subsides and revegetation of the area begins. Such animals include many invertebrates, a few species of lizards and small snakes, certain amphibians if ponds and streams are available, and several species of birds and mammals. Other species that require woodlands for existence may, with time, disperse back into areas that are allowed to undergo natural succession and revert to their original forested condition, although this process would take several decades. Successional stages of vegetation, however, are important to several species, including game species that inhabit ground level strata of vegetation (e.g., white-tailed deer, bobwhite quail, cottontail rabbit). An area of lawns, shrubbery, and scattered groves of trees, as might exist on the landscaped site, can support fairly dense populations of certain species, such as mockingbirds, robins, brown thrashers, cottontail rabbits, and squirrels, and can be an attractive area for migrating species of birds.

The intake sedimentation basin and the nuclear service water pond are expected to receive only light use by waterfowl during any particular season, unless resident populations are artificially established and feeding areas are provided.

Increased traffic can be expected to cause an increase in road kills of mammals, amphibians, reptiles, birds, and invertebrates, but the impact of such deaths on the populations involved should be small.

4.3.1.2 Transmission facilities

Cherokee transmission facilities are discussed in Sect. 3.8. The staff has examined proposed and alternate routings for the three fold-ins (Sect. 9.2.4) and feels that the proposed routings are slightly more desirable than the alternatives.

Vegetation

Clearing for the construction of transmission facilities constitutes an unavoidable disturbance to the immediate environs as a result of the establishment of an electrical power plant. The three fold-in transmission lines of the Cherokee project will cover 654 acres consisting of 84% forests, 6% pasture, and 10% active and inactive agricultural land. The vegetation in pasture and agricultural land is not expected to be seriously affected, and those land uses will be able to continue after the construction of the power lines. Approximately 550 acres of forest, however, will be cleared and permanently lost and replaced by earlier successional stages of vegetation, such as grasses, herbs, shrubs, and small trees. Most of the forest vegetation to be cleared will probably be pine forest and oak-hickory forests, although the applicant has not supplied data on the amount of each forest type in the transmission line corridors. Rough estimates of the proportions of the different forest types involved in the clearing operations may be made by assuming forest composition to correspond to the general pattern for commercial forest lands within the Piedmont region of South Carolina (72% pine and oak-pine and 28% miscellaneous hardwoods).[3] Thus, roughly 396 acres of pine forest (including oak-pine) and 154 acres of predominantly oak-hickory forests will be cleared.

The removal of these acreages of forests is not expected to seriously affect overall plant productivity in the area and will not seriously affect the population of any plant species. Clearing of 550 acres of forest for the transmission lines will reduce the total acreage of forest (36,725 acres) within a 5-mile radius of the station site by approximately 1.5% (staff estimate based on aerial photographs).

Plant species that require open areas with abundant sunlight will benefit from clearing of the forests because they will be able to invade the right-of-way as allowed by maintenance activities after initial construction operations. The clearing of corridors through extensive solid forests for rights-of-way may function in a way similar to that of extensive forest fires in the past (i.e., in causing a diversity or mosaic of successional stages to exist within large regions),[4] and it may also increase the diversity of plant and animal life in the area while successional stages exist on the transmission line rights-of-way. However, forests in the Cherokee site area are already considerably broken up by fields, roads, rights-of-way, etc.

Erosion problems

Erosion problems will occur on transmission line rights-of-way because the corridors will pass through country with gently rolling topography and with a total of five nonspanable slopes greater than 34% (i.e., slopes on which a 100-ft horizontal movement results in a vertical movement of 34 ft or more). Thus, some towers will necessarily be placed on slopes greater than 34%, and construction access roads, which will follow the rights-of-way, will cut across the slopes. The applicant did not state what would be done on steep slopes to minimize erosion.

The transmission line rights-of-way will cross streams in several places, and the applicant has stated that low-growing vegetation will not be disturbed along the banks so that soil stability can be maintained and aquatic life will not be affected (ER, Sect. 3.9.3, p. 3.9-3). Provided that towers are set back from the edges of the river and disturbances to vegetation along the banks are minimal, no significant environmental damage is anticipated from the one proposed river crossing.

The applicant's plans for clearing and reclamation operations are as follows: (1) initial clearing of rights-of-way will involve hand labor and such equipment as necessary, (2) no herbicides, growth retardants, or sprays will be used in the clearing operations, and (3) all slash and unmerchantable timber will be removed, buried, or otherwise disposed of in accordance with local regulations (ER, Sect. 4.2, p. 4.2-1). The staff recommends that the applicant study possibilities of using slash in impeding erosion and enhancing wildlife populations. After clearing, the rights-of-way will be planted with 50 lb of Fescue #31 per acre, and Sericea lespedeza will be used in rough areas such as steep slopes. In other places, German millet will be planted along with the fescue to provide cover and protection until the grass becomes established. Access roads are to be seeded and maintained in the same manner as the rest of the right-of-way. The staff recommends that the applicant consult with local authorities to develop seeding mixtures and schedules for wildlife and erosion control.

The staff suggests that the applicant consider breaking up the road surface before seeding in order to accelerate the growth of vegetation that would impede erosion. On slopes, much care would have to be taken to prevent erosion; the road should be broken up at a time of year when rains are not sudden and heavy, and structures should be provided to impede erosion.

The staff emphasizes that to prevent erosion, all bare areas including access roads should be given immediate attention. If erosion occurs initially, revegetation will be very slow without replacement of topsoil, and increased erosion could be a serious problem for the life of the transmission lines. For a long period of time, increased erosion would cause reduced levels of plant production reduced levels of terrestrial wildlife via reduction in food and cover, and reduced levels of aquatic life via siltation of streams.

The staff recommends that bulldozing be limited to the extent necessary for preparation of the access roads and placement of towers.

Fauna

The impact of the preparation of rights-of-way and the construction of transmission lines on the fauna will result almost entirely from the clearing of forest communities. The impact on fauna will thus involve mainly a permanent reduction of certain woodland species and a concomitant increase in other species that utilize woodland edges and successional stages of vegetation. Conversion of forest to forb-grass-shrub habitats is expected to reduce the bird population from a density of 152 pairs per 100 acres to a density of 66 pairs per 100 acres (staff estimate using data of Johnston and Odum[2]). Over 550 acres of this conversion would therefore cause a net reduction of the bird population by 946 individuals. This decrease may be partially offset by an increase in the numbers of birds that frequent woodland edges. The successional stages of vegetation on the rights-of-way should provide more food for deer, quail, and rabbits than would be provided in solid woodland.

The clearing of 550 acres of forested land in narrow belts (270 ft wide) is not expected to seriously reduce or affect the regional populations of any animal species. In the areas surrounding the proposed transmission line corridors, there are several forests of the same types that will be cleared; so the effect of clearing 550 acres is not serious to any of the populations requiring these forest types.

4.3.1.3 Conclusion to effects on terrestrial ecological systems

In view of the potential for serious erosion on the Cherokee site, as described in preceding sections, the staff requires that the applicant formalize its procedures for control of drainage effluents and submit a detailed erosion control plan for staff review prior to undertaking construction activities with potential for serious soil erosion. The plan must consider both the station site proper and transmission line rights-of-way. The plan must identify all areas where serious erosion could occur as a result of clearing and construction and must describe in detail for each of these areas separately, actions that will be taken to impede the erosion. All drainage effluents must conform to EPA regulations on turbidity (see *Federal Register* of October 8, 1974).

The staff also recommends that the applicant consult with appropriate state agencies to develop and submit a plan for maximizing the productivity of vegetation and wildlife on all areas subjected to clearing or other modifications.

4.3.2 Aquatic ecology

The adverse effects of nuclear power plant construction on the aquatic environment result primarily from three categories of impacts: (1) increased turbidity, (2) chemical effluents, and (3) destruction of aquatic habitats.

4.3.2.1 Increased turbidity

Increases in turbidity or total suspended solids (TSS) in the Broad River and Ninety-Nine Islands Reservoir will result from: (1) the construction of the two site ponds, (2) construction of intake and discharge structures, and (3) erosion and runoff from the disruption of ground cover.

Construction of the site ponds

The dredging, filling, and disruption of ground cover that will occur during the construction of the two site ponds will lead to substantially high turbidities in the ponds and in adjacent waters. A quantitative estimate of the turbidities that will be encountered is difficult to predict. It will depend primarily on meteorological and hydrological conditions prevailing during construction. Increases may be substantial because of the amount of construction activity that will take place directly in the waters of the reservoir (Fig. 2.4). The areas that will be affected by increased turbidity include the reservoir on the CNS side of the river and the Broad River itself. About 50% of the total area of the reservoir will be affected to some degree.

Construction of intake and discharge structures

The water intake structure will be constructed approximately 1000 ft above Ninety-Nine Islands Dam on the main channel of the river (Fig. 2.4). Construction activities will result in disruption of the river bank. Since the river bank is steep at the site, the potential for severe river bank erosion exists. In addition, the construction of the intake structure will require a temporary cofferdam. Dewatering of the cofferdam will be required, and the effluent will be discharged directly into the river. The discharge structure will be constructed immediately below the dam (Fig. 2.4). Although at this point the river bank is also steep, the potential for stream bank erosion is considerably less since the slope is largely composed of rock.

Turbidity in the river will be increased by the construction of these two structures, although it is impossible to predict the extent. Much will depend on meteorological conditions and river flows during the construction period. In any case, the areas affected will be relatively small, and the effects will only be temporary and localized.

Storm drainage runoff

Due to the hilly terrain and the soil characteristics of the CNS site, storm drainage runoff from areas of disrupted ground cover could carry off large quantities of soil. The applicant has estimated that a maximum of 751 acres at the site could be devoid of ground cover as the result of construction activities if erosion is not carefully controlled. The applicant has further estimated that this reduction in ground cover could result in the entrance of approximately 120 tons per acre of soil per year into the Ninety-Nine Islands Reservoir and the Broad River compared to 4.5 tons per acre per year under existing conditions (ER, Sect. 4.1.3.1).

As pointed out in Sect. 4.3.1, the applicant will be required to submit a plan to control erosion and runoff from the site, which, if properly implemented, should substantially reduce inputs of suspended solids derived from storm drainage runoff into the reservoir and river. It should do little, however, to prevent suspended solids washed from the impoundment dams and discharge and intake structure sites from entering the reservoir. The net result will be that TSS levels will be substantially increased in the backwater areas of the reservoir on the west side of the river. Total suspended solids increases will be less in the river proper due to the small area on the river involved in construction and due to the dilution of runoff with river water.

The effects of increased turbidities on aquatic organisms are well documented and include reduction of light penetration and photosynthesis;[5-7] impairment of respiratory and feeding functions; filling in of interstitial spaces of bottom substrates; smothering of benthos, spawning sites, and demersal fish eggs;[5,6,8] alterations in species composition;[5] and lower fish production.[9]

The average annual TSS in the river proper is 135 mg/l (ER, Table 3.6.2-1). Total suspended solids levels are probably lower in the lentic backwaters of the reservoir where suspended solids would have tended to settle out. The applicant recorded TSS levels in the river above the dam ranging from 20-136 mg/l for the period September 1973 to February 1974 (ER, Table 2.7.0-10). Maximum TSS levels of 75-100 mg/l are considered critical for successful spawning of largemouth bass and bluegills, two of the major fish species found in the reservoir (Table 2.2). Total suspended solids levels above 100 mg/l can severely restrict their spawning success.[9] If TSS levels are increased substantially above 100 mg/l during the critical spawning period for turbidity-intolerant species such as the bluegill and largemouth bass, the spawning success of these species could be diminished. If this occurred for several consecutive years, a change in the species composition of the reservoir could result. The most noticeable change would be a qualitative shift in the fish species composition from the present dominance of Centrarchidae (sunfishes) to a dominance of more turbidity-tolerant and less desirable species such as the carp, quillback carpsucker, and catfish. A decrease in fish productivity would also be expected.[9]

Any changes in species composition that occurred as a result of increased turbidity would not be permanent. Restoration of vegetation to disrupted ground cover and appropriate erosion control measures should eventually reduce TSS levels to near preconstruction levels. Thereafter, the biota of impacted areas should slowly revert back to approximately their former composition. After soil stabilization takes place and erosion is reduced, the nuclear service water will have TSS levels considerably below those of the river because it will be completely isolated from the river and will receive water only from the site creek drainage (Fig. 2.4).

The sedimentation pond will continue to have TSS levels near ambient even after construction is completed since it will function as the pond for sedimentation of cooling tower makeup water pumped from the river.

4.3.2.2 Construction effluents

Two categories of construction effluents resulting from CNS that could have adverse impacts on the aquatic environment of the site are: (1) chemical effluents, mainly chlorine and various nutrients from treated domestic sewage, and (2) spillages of harmful liquids.

Chemical effluents

During construction, domestic sewage will amount to a maximum of 36,000 gpd. These wastes will be treated in a prefabricated, extended aeration-type sewage treatment plant. All wastes will be treated with hypochlorite. The resultant effluent will be pumped to either the NSW or sedimentation ponds and then ultimately released to the reservoir after stabilization. Total residual chlorine will be present in the effluent at levels well below those toxic to aquatic biota.

The effluent will be released into a backwater of the reservoir where the rate of flow of water to the river is slow except during times of floods (ER, Sect. 2.5.2.2). Nitrates and phosphates will build up in this area of the reservoir with the result that primary production will be stimulated. During times of low TSS levels, blooms of undesirable bluegreen algae could result. The extent to which blooms will occur will depend on ambient TSS levels and the flushing rate of the water from the backwater area out into the river proper. Increased TSS levels resulting from CNS construction may tend to inhibit primary production.

The impact of these nutrients on the biota of the river proper will be minor due to the large dilution with river water that will occur. Average incremental increases will amount to 0.043 mg/l of nitrates and 0.013 mg/l of phosphates (ER, Table 3.6.2-1).

Spillage of harmful liquids

Spillages of environmentally injurious liquids (e.g., gasoline and oil) are a possibility. However, the distance from most construction areas to open water, plus the presence of the applicant's storm drainage runoff system, will minimize the possibility of spillages that will directly reach open water. Treatment and cleanup of spills could be managed after the liquids have entered the site ponds.

4.3.2.3 Destruction of aquatic habitats

Construction of CNS will result in the destruction of aquatic habitats from (1) sedimentation of suspended solids derived from CNS construction activities and (2) the filling and dredging associated with the construction of the two site dams and the discharge structure.

Sedimentation

Suspended solids eroded from the CNS construction site will tend to settle out upon entering the lentic waters of Ninety-Nine Islands Reservoir on the CNS side of the river. The result will be an accelerated loss of the remaining backwater areas of the reservoir. A large part of the original backwater area of the reservoir has already been completely filled in from sediments carried into the reservoir by the river (ER, Sect. 2.5.2.1). Much of the remaining backwater areas are very shallow (ER, Fig. 2.5.2-1). The quantity of sediment that CNS construction may contribute to the reservoir is difficult to predict but potentially could reach a maximum of about 90,120 tons/year (751 acres x 120 tons per acre per year). The areas most adversely impacted by sedimentation will be the shallow littoral areas and their associated biota, especially benthos and fish. Littoral areas had among the highest densities of benthos in sampling done by the applicant (ER, Table 2.7.2-11). The dominant game and forage fish species collected from the reservoir were littoral species, the Centrarchidae (sunfishes) and Cyprinidae (minnows). The applicant is committed to limiting the TSS of all effluents and runoff to EPA standards (50 mg/l), which will help retard this loss of aquatic habitat.[1]

Construction activities

Construction of the dams for the two site ponds will permanently separate 36 acres or about 12% of the full-pond backwater area of Ninety-Nine Islands reservoir from the remainder of the reservoir (Fig. 2.4). The areas to be separated and impounded were found by the applicant to have relatively high abundances of fish larvae and, therefore, these areas are probably sites of concentrated spawning activity (Sect. 2.7.2.4). Construction of the impoundments will not destroy these areas, and each pond will eventually develop its own distinct aquatic community. Since the sedimentation pond will be receiving continuous inputs of river water, it will be quite turbid. The biota that becomes established in the pond will probably be very similar to what are now present in the backwaters of the reservoir (Sect. 2.7.2). The NSW pond will not receive any inputs of river water; therefore, its waters should eventually become quite clear. The aquatic communities that develop will consist of species present in Ninety-Nine Islands Reservoir that thrive in clearer water and will include such fish as largemouth bass, bluegills, various small cyprinids, and shad (*Dorosoma* spp). The productivity of the NSW pond should obviously be substantially greater than that of the sedimentation pond.

The loss of about 12% of the backwaters of the reservoir should have a negligible effect on the fish and other aquatic organisms in the remaining backwaters of the reservoir because the areas to be impounded are in no respect substantially different. The loss of 12% of the reservoir should not affect species composition, per unit area productivity, or trophic structure.

Only one fish species, the creek chub (*Semotilus atromaculatus*), inhabits the two site creeks that will be partially impounded. No rare or endangered species are known to be present (Sect. 2.7.2.4). The formation of the two ponds will eliminate this species from impounded areas of the creeks; however, viable populations should continue to exist in unimpounded sections above the ponds.

4.3.2.4 Summary of the impacts of construction on the aquatic environment

Construction of CNS will adversely affect the aquatic environment through increases in TSS, releases of construction effluents, and destruction of aquatic habitats.

Increases in turbidity caused by construction activities will exert the greatest impact on the backwater areas of Ninety-Nine Island Reservoir on the west side of the river, affecting about 50% of the total backwaters area of the reservoir. The most noticeable and significant effect would be a change in the fish species composition from a dominance of sunfishes to a dominance of turbidity-tolerant species such as carp, quillback carpsuckers, and catfish. These changes will largely be temporary. The biota of the impacted areas will probably revert back to their former composition after TSS levels have returned to preconstruction levels.

Releases of nutrients from the wastewater treatment system will tend to stimulate primary production and could produce blooms of bluegreen algae in the receiving waters of the reservoir. The impact will probably be minor due to the inhibitory effects of the high TSS levels that will be present during CNS construction.

All construction activities at the CNS site will result in the permanent destruction of at least 15 acres of aquatic habitat in the reservoir and the separation of 36 acres of aquatic habitat from the rest of the reservoir. In addition, increased sedimentation resulting from increased TSS levels in the reservoir will accelerate the filling in of the few remaining backwater areas of the reservoir.

If proper construction procedures are followed, the impacts of CNS construction on the river will be relatively insignificant. The dilution of effluents and runoff with the river water will minimize potential adverse impacts.

The applicant is committed to limiting the TSS of construction runoff to the EPA limit of an average of 50 mg/l. The staff considers that compliance with this limit would be adequate to protect the aquatic biota of the area.

The impacts of CNS construction on the aquatic environment are summarized in Table 4.3.

4.4 IMPACT ON PEOPLE

4.4.1 Physical impacts

The noise and dust from construction activities will not be a major impact to the human environment since the site is quite remote and is in a relatively sparsely settled area. The applicant will comply with all OSHA requirements for noise and dust levels.

The applicant reports that a total of 17 families will be displaced from the Cherokee site; 11 families had already been displaced by August 1974 (ER, Response to Question 1.1.9). The number of families that will be displaced as a consequence of railroad spur connection is not currently known (ER, Response to Question 4.1.5).

The construction will result in an increase in vehicular traffic on local roads. The ER does not address the quality of existing roads, the expected required maintenance, the traffic density, or the expected impact on local residents of such increase in traffic. The staff, during the site visit, made a visual inspection of the road systems surrounding the site and concluded that the roads from Gaffney to the site (principally South Carolina Route 13) are, at present, inadequate

Table 4.3. Summary of environmental impacts due to construction

Potential impact	Applicant's plans to mitigate	Expected relative significance	Corrective actions available and remarks
Increased turbidity			
Pond construction	None	Significant increases in TSS could produce changes in the species composition of the backwaters of the reservoir from less turbidity tolerant species (sunfishes) to more turbidity tolerant species (carp, quillback carpsucker, catfish). The biota probably will revert back to its former composition after TSS levels have decreased to ambient levels.	Applicant must submit a detailed errosion control plan and must limit TSS levels of all effluents and runoff to meet EPA standards.
Intake and discharge construction	None		
Storm drainage runoff	Storm drainage runoff plan.		
Construction effluents			
Chemical effluents	Sewage will be treated and chlorinated in a prefabricated unit and put into the waste collection basin.	Impact of effluent nutrients and chlorine on the reservoir and river will be insignificant.	Effluent composition must meet state standards.
Spillages of harmful liquids	Proper handling procedures will be followed.	Insignificant, except if there is a very large spill.	No pathways should be allowed to exist which would permit spillages from reaching Ninety-Nine Islands Reservoir or the Broad River.
Loss of aquatic habitat			
Construction of the two site ponds	None	Locally significant. 36 acres of backwaters of the reservoir will be separated from the rest of the reservoir. Filling and dredging will destroy 15 acres of remaining back-waters of the reservoir.	None. Species composition of remaining parts of reservoir should not be affected.
Sedimentation	Applicant's storm drainage runoff control plan.	Possibly significant. Increases in TSS will accelerate filling in of remaining back-waters of the reservoir.	Applicant must limit the TTS of all effluent and runoff to a daily average of 50 mg/l.

for heavy traffic. The applicant has acknowledged this conclusion and has stated that remedial action between the State of South Carolina and the applicant is planned. The staff estimates that usage of these roads by several thousand additional cars and trucks per day will result from construction of the proposed installation. However, the staff's opinion is that such an added traffic burden will not cause undue inconvenience to the local traffic.

4.4.2 Population growth and construction worker income

The applicant has indicated (ER, Response to Question 4.1.6) that, based on its prior construction experience, only about 13% of the construction work force is expected to move into the vicinity as new residents. This percentage would translate into the influx of several hundred new families into the area with a concomitant increase in the population.

The total construction payroll for this project is expected to be over $424 million (ER, Sect. 8.1.2.3), of which a large fraction is expected to be spent in the area. The staff expects the decline in construction payroll at the completion of construction to result in a localized economic letdown.

4.4.3 Impact on community services

The applicant has not addressed the impact of station construction on community services in a specific manner. The staff has met with local authorities[10] and has discussed possible areas of concern with them. Since the Cherokee installation will provide its own potable water, sanitary sewage disposal facilities, and security personnel, its impact on existing community services will be negligible.

4.4.4 Impact on local institutions

The applicant has not addressed this concern in a specific manner but, as stated previously, the staff has met with local authorities to identify and assess areas of possible impact. Both waste facilities and the school system are either being enlarged or undergoing plans for enlargement. The local authorities feel that these enlargements will be sufficient to accommodate the influx of new residents due to construction of CNS. The staff considers that since most of the workers will commute, the area institutions will not be severely impacted.

4.4.5 Impact on recreational capacity of the area

While the increased turbidity of Ninety-Nine Islands Reservoir due to construction of CNS will temporarily have an adverse affect on fishing and canoeing, the staff does not consider that construction of CNS will have a major negative impact on the recreational capacity of the area.

4.4.6 Radiation exposure to construction personnel

During the period between the startup of the Cherokee Nuclear Station Unit 1 and the completion of Cherokee Units 2 and 3, the construction personnel working on Units 2 and 3 will be exposed to sources of radiation from the operation of Cherokee Unit 1.

The applicant has estimated the integrated dose to construction personnel to be 60 man-rems. This estimate is based on 5 million man-hours of exposure while Unit 1 is in operation and an additional 3 million man-hours of exposure during operation of Units 1 and 2. Estimated values for other LWRs have ranged from 10 to 30 man-rems.

4.5 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

4.5.1 Applicant commitments

Following is a summary of the commitments made by the applicant to limit adverse effects during construction of the proposed station.

1. Only the minimum necessary amount of clearing will be carried out for construction preparation. (See ER, Fig. 4.1.1-2, for areas that may be cleared of all vegetation.)

2. Excavation, filling, and spoiling will be done only within the cleared areas.

3. Areas not needed for permanent plant facilities will be restored to blend with the natural terrain by seeding and restoration planting as soon after construction as possible.

4. Dust generated by vehicular traffic will be controlled by dry weather wetting and paving of the more heavily traveled construction roads.

5. Erosion in the construction area and the resulting sedimentation will be controlled by providing piped drainage systems, intercept and berm ditches, and ground cover where necessary to control the flow of surface water. Construction runoff will be limited according to EPA standards.

6. Spoiled materials will be deposited in a controlled manner so that water transport of such material to the adjacent Ninety-Nine Islands Reservoir is negligible.

7. Construction noises will be reduced to acceptable levels. Motor powered equipment will be equipped with noise reducing equipment.

8. Smoke and other undesirable emissions to the atmosphere will be controlled. Local and state air pollution control regulations will be adhered to, and permits and operating certificates will be obtained as required.

9. Wastes such as chemicals, fuels, and bitumens will not be deposited on the natural watershed. Solid construction waste will either be burned, buried or transported offsite to an approved landfill.

10. Temporary buildings and usage areas will be maintained in a neat manner.

11. As much of the site as possible will be cleaned up and appropriately landscaped as expeditiously as possible after construction.

12. No herbicides, growth retardants, or sprays are to be used in clearing operations.

13. After clearing, the rights-of-way for transmission lines will be planted with suitable cover where necessary for soil stabilization.

14. Selective clearing will be performed adjacent to highways and areas of high visual exposure along transmission corridor rights-of-way.

15. Temporary roads will be built on transmission rights-of-way for access to construction equipment. After construction is completed, these temporary roads will be seeded and returned to suitable wildlife habitat.

4.5.2 Staff evaluation

Based on a review of the anticipated construction activities and the expected environmental effects, the staff concludes that the measures and controls committed to by the applicant when supplemented by those identified below are adequate to ensure that adverse environmental effects will be at the minimum practicable level.

1. The railroad spur will be constructed on an existing transmission line right-of-way as far as practicable.

2. Plans for adequate clarification of drainage effluents beyond those included in the applicant's present plans must be implemented so that the turbidity of waters discharged from holding basins will not exceed EPA guidelines.

3. The applicant will monitor the nearest well while dewatering is in process to ensure that no adverse effect on either the quality or the quantity of the well water is obtained as the result of such dewatering.

4. A control program shall be established by the applicant to provide for a periodic review of all construction activities to assure that those activities conform to the environmental conditions set forth in the construction permit.

5. The applicant should preserve the unique mountain-laurel hardwood stand described in Sect. 4.3.1.1.

REFERENCES FOR SECTION 4

1. W. H. Owen, Duke Power Company, letter to W. H. Regan, NRC Staff, July 1, 1975, regarding Duke Power Company responses to South Carolina Department of Health and Environmental Control and U.S. Environmental Protection Agency comments on Cherokee DES, Docket Nos. STN 50-491, 50-492, and 50-493.

2. D. W. Johnston and E. P. Odum, "Breeding Bird Populations in Relation to Plant Succession on the Piedmont of Georgia," *Ecology* 37: 50–62 (1956).

3. W. H. B. Harris, *Forest Statistics in the Piedmont of South Carolina–1967*, U.S. Department of Agriculture, U.S. Forest Service, Resource Bulletin SE-9, 1967.

4. H. E. Wright, Jr., and M. L. Heinselman, "Introduction: the Ecological Role of Fire," *Quaternary Research* 3: 319–328 (1973).

5. E. H. Hollis, J. G. Boone, C. R. DeRose, and G. J. Murphy, "A Literature Review of the Effects of Turbidity and Siltation on Aquatic Life," Staff Report, Department of Chesapeake Bay Affairs, Annapolis, Md., 1964.

6. A. J. Cordone and D. W. Killey, "The Influence of Inorganic Sediment on the Aquatic Life of Streams," *Calif. Fish and Game* 47(2): 189–228 (1961).

7. J. Cairns, "Suspended Solids Standards for the Protection of Aquatic Organisms," pp. 16–27 in *Proc. 22nd Indust. Waste Conf.*, Part 1, Purdue University Engr. Ext. Sir. No. 129, May 1967.

8. J. C. Ritchie, "Sediment, Fish and Fish Habitat," *J. Soil Water Conserv.* 27(3): 124–125 (1972).

9. D. H. Buck, "Effects of Turbidity on Fish and Fishing," pp. 249–261 in *Trans. 21st. N.A. Wildl. Conf.*, 1956.

10. H. E. Zittel, AEC Staff, letter to F. St. Mary, Aug. 20, 1974, regarding Cherokee Site Visit, Docket Nos. STN 50-491, 50-492, and 50-493.

5. ENVIRONMENTAL EFFECTS OF OPERATION OF THE STATION AND TRANSMISSION FACILITIES

5.1 IMPACTS ON LAND USE

The primary land use impact associated with the operation of the CNS will be the maintenance of about 1373 acres of potentially forested land in various other land cover types, including buildings at the station site, parking lots, lawns and shrubbery, permanently maintained successional stages of vegetation on rights-of-way, and small lakes. These areas involve 3.7% of the total forested area (36,725 acres, Sect. 4.1.7) within a 5-mile radius of the Cherokee Station. Additional potential forest acreage will be covered by mobile home parks and other living accommodations for personnel involved in Cherokee site preparation and construction.

5.1.1 Station operation

5.1.1.1 Cooling tower plumes

The plumes of moist air resulting from cooling tower operation (described in Sect. 5.3.2) are not expected to have any serious effect on land use. Negative impact on the use of South Carolina Highway 13 located 3000 ft south of the cooling tower yard should be slight because, according to the applicant, all ground-level plumes should undergo a "bouyant rise" within 1000 ft of the towers. Thus the plume emanating from the tops of the cooling towers at 674-ft elevation (600 ground elevation plus 74-ft tower height) should rise above South Carolina Highway 13, which ranges in elevation from 620-740 ft (average = 670 ft) south of the site. However, the effect that low-level inversions, which occur 20-30% of the time,[1] might have on fogging and icing on the highway is not known. The staff estimate of station-induced additional hours of fog per year for South Carolina Highway 13 and I-85 are less than 10 (Sect. 5.3.2).

When temperatures are sufficiently low, cooling tower plume can cause icing; that is, liquid droplets in the plume may freeze and fall to the ground, or condensation with subsequent freezing may cause icing on surrounding obstacles and surfaces, such as trees and roads. Few qualitative or quantitative observations of such icing have been reported for cooling tower operations. Because the applicant has estimated that fogging will not occur along any highways, the potential for dangerous driving conditions resulting from either icing or fogging of highways would appear to be low.

Airports within 20 miles of CNS are the Shelby Airport, the Cherokee Airport near Gaffney, and the York Airport. All three airports lie outside the 1% isopleths for cumulative frequencies of visible plume lengths (ER, Figs. 5.1.4-1 and 5.1.4-2), and the visible plumes are, therefore, not expected to interfere seriously with air traffic at these small airports. The Cherokee Airport is expected to experience less than ten additional hours of fog per year (staff estimate, Sect. 5.3.2).

5.1.2 Transmission lines and railroad spur

Operation of the transmission lines will cause fewer negative impacts than the construction phase, provided the rights-of-way are properly maintained. The presence of transmission lines across agricultural land is not expected to permanently alter the use of that land, except for the land immediately under the towers. The three fold-ins for CNS will require that 550 acres of forest be maintained in early successional stages; this involves 1.5% of the total forested area within 5 miles of the site (Sect. 4.3.1.2), which is not expected to seriously alter overall land use in this region. Properly maintained rights-of-way with successional vegetative stages can produce much food and cover needed by certain wildlife species. The extension of transmission lines over land zoned "rural-residential" will restrict development in the rights-of-way proper.

Aesthetic impacts associated with transmission lines are difficult to quantify but are present in the form of constant visual effects persistent over the lifetimes of the installations. Visual impacts associated with Cherokee lines are primarily linked with crossings of rural roads and a crossing of the Broad River.

With regard to present and future development along the proposed transmission lines, the applicant has contacted officials from Cherokee County who, according to the applicant, state that no historic sites listed or nominated to be listed in the *National Register of Historic Places* are located in or near the line routes and that no plans exist for any recreational or industrial sites along the planned corridors.

The railroad spur will permanently remove from productive use roughly 10 acres of harvested cropland or open pasture and 73 acres of forest and existing unused 33-kV transmission line right-of-way. The effect on land adjacent to the right-of-way is expected to be minimal, barring any unforeseen accidents or maintenance problems.

5.2 IMPACTS ON WATER USE

5.2.1 Surface water

The operation of CNS will result in a maximum consumptive use of 112 cfs of river water through evaporation and drift from the cooling towers. This loss of water is equal to 4.5% of the mean monthly flow of the river (2472 cfs), increasing to a maximum of 23.8% of the 7 Q_{10} flow (470 cfs). When river flows fall below 582 cfs, the applicant will release sufficient water from upstream reservoirs to completely compensate for consumptive cooling tower losses; therefore, operation of CNS will not contribute to reducing flows of the river at the site below 470 cfs (ER, Sect. 5.1.2.4).

The consumptive use of water by CNS will contribute to extending the duration of periods of low river flow and will also contribute to reducing the area of Ninety-Nine Islands Reservoir during periods of low river flow. This impact will not be large, however, since a consumptive loss of 112 cfs during low river flows (470 cfs) would cause a drop in the water level of the reservoir of only about 0.2 ft (ER, Sect. 5.1.2.4). The reservoir currently fluctuates between 175 and 325 acres, primarily due to releases of water by Ninety-Nine Islands Dam.

Some changes in the quality of river water will result from the operation of CNS, including slight increases in dissolved solids, biological oxygen demand, and total residual chlorine (Sect. 3.6). These changes will not be of sufficient magnitude to adversely affect the quality of river water.

5.2.2 Groundwater

The applicant estimates that salt deposition from cooling tower drift will produce an average increase in runoff salt concentrations of 13 ppm within a radius of 25,000 ft of the towers. Assuming no dilution or dispersion in the soil, groundwater salt concentration could also increase by 13 ppm (ER, Question 5.1.6). Because soils in the site area are relatively impermeable (ER, Question 2.2.7), increases in the salt concentration of groundwater should be considerably less and should not degrade the quality of the groundwater.

Because bottom elevations of the proposed structures are below the present water table, a permanent underdrain system will be installed in some locations to lower the water table below these elevations. The underdrain system will maintain the water level at an elevation about 10 ft above the bottom of the various structures (PSAR, Sect. 2.4). This will result in a permanent depression of the water table, with groundwater flow toward the reactor building area from all directions. The net effect will be to decrease the slope of the water table toward the river. Since such effects are estimated to be demonstrated only within about 300 ft of the plant island and since under normal conditions the flow from the underdrain system will be discharged via the surface water drainage system, the staff considers the overall effect of such drainage to be negligible.

5.2.3 Water quality standards

Guidelines for South Carolina surface waters classify the Broad River as "B" waters, subject to the following thermal standards:

1. Those portions of Broad River and Kings Creek that are above the junction* of these two streams shall be considered to be upper Piedmont streams and shall not exceed a temperature of 84°F at any time, after adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature, after passing through an adequate zone of mixing, be more than 5°F greater than that of water unaffected by the heated discharge.

2. Mixing zones are permitted; however, "the zone for mixing shall be limited to not more than 25% of the cross sectional area and/or volume of flow of the stream and shall not include more than one third of the surface area measured from shore to shore."

The applicant will be required to meet all applicable State and Federal standards.

5.3 PERFORMANCE OF THE HEAT DISSIPATION SYSTEM

5.3.1 Heated water discharge into the Broad River

The influence of the discharge of blowdown water on the temperature of the river downstream of the dam is of interest both in regard to meeting the State of South Carolina water quality standards and to the impacts the heated water may have on the aquatic biota. The state criteria are primarily concerned with three aspects: (1) whether the river temperature will exceed 84°F after mixing, (2) whether the excess temperature is greater than 5°F after mixing, and (3) whether the size of the mixing zone is 25% of the cross-sectional flow area (or 33% of the surface width). The size of the mixing zone is a function of the water release rate through the dam, the difference in temperature between the blowdown water and the river ambient temperature, and the river flow patterns downstream of the dam. In general, the period of most concern with regard to meeting the water quality standards is from September through December, when excess temperatures may be relatively high and when, at the same time, the water available for dilution of the blowdown water may be restricted due to low river flow rates.

The seven-day average lowest flow during the past ten years (the so-called "7 Q_{10} flow rate") in the Broad River near the site is given by the applicant as 470 cfs, and the lowest flow on record is given as 224 cfs (ER, Response to Question 5.1.22). The applicant states (ER, p. 5.1-1, Amendment 3) that at low flow conditions, with low reservoir pool and assuming no hydro generation, there could be a period of about 33 hr in which the only flow in the river downstream of the dam would be about 40 cfs of leakage through the wicket gates of the hydrostation, plus about 10 cfs of cooling tower blowdown. (The specified leakage flow rate has apparently not been measured at the dam by the applicant but was estimated on the basis of observed leakage at similar installations.) The situation of having only the leakage flow available for dilution of the blowdown excess temperature is undoubtedly the worst-case condition with regard to assessment of the thermal impact.

The temperature of the blowdown water is primarily a function of the wet-bulb temperature of the air drawn into the cooling towers. Monthly average blowdown temperatures are estimated by the applicant to range from about 86°F in July and 83°F in September to about 70°F during the winter months. (ER, Response to Question 3.4.1). The maximum blowdown temperature under summer conditions is estimated by the applicant to be 90°F and, under winter conditions, to be 70°F (ER, p. 5.1-2, Amendment 3). River temperatures can reach a maximum of about 81°F in the summer months, but during the periods of relatively low river flow, they can be about 70°F in September and about 40 to 45°F in the November-December period (ER, Fig. 2.5.1-6). The excess temperature of the blowdown water could thus have maximum values in the 20 to 30°F range during the period when only leakage flow is available for dilution. Although the applicant takes no credit in the thermal analysis for the cooling of the blowdown water as it flows down the rocks into the river, mention is made that this cooling effect would reduce the estimated areas within the surface isotherms. The staff considers that since the blowdown water has already been efficiently cooled in the cooling towers to approach the wet-bulb temperature, the additional cooling obtained from this arrangement will be insignificant.

The applicant proposes to discharge the blowdown water at the top of a rock outcropping at the west abutment of the Ninety Nine Islands Dam and to let it fall down the rocks to the spillway apron below. It will thus reach the river with little or no horizontal momentum. The estimated 40 cfs of leakage water during the period of hydrostation shutdown will be through the wicket gates located about 800 ft away near the east bank. The riverbed near the foot of the dam has a midstream 3/4-acre island, numerous small "islands," ripples, and sand and gravel bars that the staff assumes are shifting in character. During periods of normal river flow and release rates

*Kings Creek joins the Broad River about 1000 ft downstream of the Ninety-Nine Islands Dam.

through the dam, essentially the entire flow would be through the tailrace on the east side of the river; during the periods when only leakage flow occurs, undoubtedly this water will also tend to flow on the east side of the river, and cross-stream mixing with the blowdown water released on the west side will be restricted. The staff considers it reasonable to assume that the blowdown and leakage water will exist essentially as separate streams for a significant distance downstream. The point downstream at which the blowdown and leakage water become fully mixed is conjectural, but in the staff's opinion could be a minimum of 2000 to 3000 ft.

The applicant analyzed the thermal effects on the river of the 12 cfs of blowdown discharge, assuming 40 cfs of leakage water through the hydrostation, and for the wintertime worst-case condition when the excess temperature was assumed to be 30°F, estimated that the surface areas within the 3°C (5.4°F), 2°C (3.6°F), and 1°C (1.8°F) isotherms would be 0, 13.8, and 66.4 acres respectively (ER, p. 5.1-2, Amendment 3). The applicant also states that the plume of heated water is not expected to extend across the entire river in either summer or winter conditions. The staff has some reservations about the reported value of zero acreage for the area within the 5.4°F isotherm since the excess temperature has been taken as 30°F and the dilution factor is a maximum of 5. When estimating the surface areas, the applicant apparently assumed that the blowdown and leakage streams mix very rapidly, but he did not assume them to be well-mixed when making the statement that the plume would not extend across the river.

The staff analyzed the effects of the thermal discharge using a simplified method for accounting for the heat loss to the atmosphere similar to that employed by Pritchard.[2] The analysis was limited by lack of knowledge of the geometry of the blowdown and leakage water flowing down a relatively empty riverbed, but it was assumed that the two flows would mix at a linear rate, with complete mixing achieved 2000 ft downstream of the dam. A blowdown excess temperature of 30°F was assumed, and the stream was assumed to have an average depth of 1 ft and to be flowing at an average velocity of 0.5 fps. The surface heat loss to the atmosphere was calculated on the basis of a 10-mph wind velocity and varied from about 4.8 to 3.8 Btu/hr-ft^2-°F. The surface areas within the 3°C (5.4°F), 2°C (3.6°F), and 1°C (1.8°F) isotherms were estimated to be 4, 11, and 32 acres respectively. The 5°F isotherm would extend about 3000 ft downstream and would reach from water's edge to water's edge at that location; the 3°F isotherm would extend about 1-1/2 miles downstream, and the 1°F isotherm would extend to 5 miles downstream of the dam. Since the methods of calculation cannot be rigorous, the staff does not consider the differences between its estimates of surface areas within the isotherms and the applicant's estimates as significant, except in the case of the 5°F isotherm, which the applicant reported as zero area.

In summary, with regard to meeting the State of South Carolina water quality standards when the only flow in the river downstream of the dam is due to the gate leakage and the cooling tower blowdown, under the worst-case conditions that the staff considers it reasonable to assume, the surface temperature of the water would probably not exceed 84°F, but the 5°F isotherm would in all probability extend more than one-third of the way across the stream (combined blowdown plus leakage flows). If the excess temperature were between 25 and 30°F, as the applicant has assumed as a possible worst-case condition, the well-mixed temperature of the two flows could be more than 5°F greater than that of the water unaffected by the heated discharge. Although strict application of the standards to the abnormal situation of the combining of two distinct flows in an essentially empty riverbed requires some interpretation, in the staff's judgment, there is doubt as to compliance with the state standards.

The situation will be much the same as that described above for the 7 Q_{10} river flow rate of 470 cfs. Rapid mixing of the blowdown water with the main flow through the hydrostation will be inhibited by the tailrace structure and the character of the riverbed, and the blowdown water will move downstream along the west bank for a significant distance before dilution is complete. In the staff's view, it is also questionable in this case whether the state standards for thermal discharges will be met. At river flow rates greater than the 7 Q_{10}, mixing of the blowdown with the river water will be enhanced, but the situation will not be entirely eliminated until the river flow rate exceeds about 4000 cfs and water is spilling over the dam in the vicinity of the blowdown discharge point.

Because the staff's analysis indicates that there is doubt that the present discharge system can meet state thermal standards under all conditions, the applicant is required to develop alternate discharge arrangements or procedures so that state standards are met.

5.3.2 Cooling tower performance

5.3.2.1 Visible plumes

Under most meteorological conditions, the plumes of air-water vapor mixture discharged from the cooling towers will be visible for only a short distance above the tops of the towers. Under other conditions, particularly those that occur in the cold winter months, white visible plumes may rise to some height and travel relatively long distances downwind. For example, the applicant estimates that about 5% of the time, a visible plume may travel about 15 miles downwind toward the southwest (ER, Fig. 5.1.4-2). A visible plume of water vapor will cast a shadow on the ground that will reduce the sunlight intensity in the shaded area. While the moisture content of the cooling tower plumes is substantial, the amount is small in comparison with the burden of water in natural clouds, and outside of a radius of a few hundred feet from towers, no significant increase in the rainfall of an area due to cooling tower operation has been observed.

5.3.2.2 Ground-level fogging

One environmental impact of concern with regard to operation of cooling towers is the extent of the ground-level fogging that could occur as a result of visible cooling tower plumes touching the ground under certain meteorological conditions. When the atmospheric condition causes natural fog formation, the tower contribution will probably be only an indistinguishable part of the total fog present. The staff analyzed the towers for the number of hours per year of ground-level fog that might be produced in addition to the naturally occurring fog. The estimate is based on counting the average number of hours per year when the plume will touch the ground at a given point to cause 100% relative humidity when the atmospheric condition was normally at less than 100% relative humidity or free of ground-level fog. The staff's opinion is that this method is conservative and that it will cause estimates of more frequent fogging than will actually occur. The staff's analysis used ORFAD,[3] a predictive mathematical model based on the empirical plume rise equations of Briggs,[4] as modified by Hanna[5] and by Briggs[6] to account for the increased buoyancy effect of multiple plumes. However, credit was taken for the combined buoyancy effect for only three towers per group. The estimates did not take into account differences between the ground-level elevation at the tower site and the elevations of the points of interest in the surrounding countryside. The staff's analysis was based on U.S. Weather Bureau tapes of ten years of meteorological data (1955-1965) taken at Charlotte, North Carolina, which is located about 40 miles to the east-northeast. Computer calculations were made at 1-hr intervals in the meteorological data to provide a ten-year average value. Data used in the analysis are listed in Table 3.2.

The results of the staff's calculations are summarized in Fig. 5.1. The maximum amount of ground-level fogging was predicted as about seven additional hours per year of fog at points within about 1/4 mile northeast of the towers. About four hours of additional fog per year were estimated for the northeast sector extending out to 5 miles or more from the towers. The analysis was not carried beyond 5 miles because, in the staff's opinion, small values for the calculated hours of additional fog are neither meaningful nor important, nor are they justified in view of the limitations of the mathematical models and the input data.

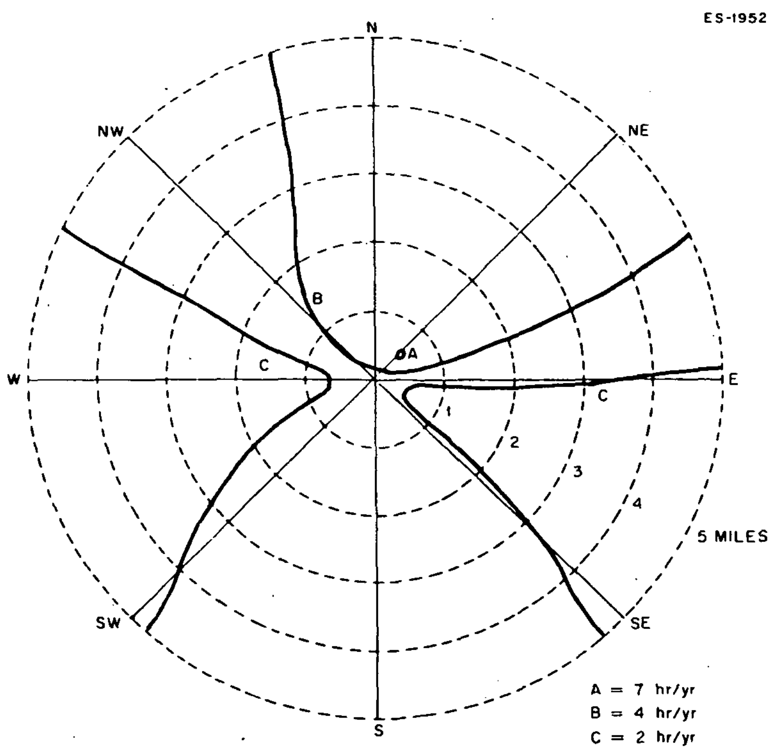

Fig. 5.1. Staff's analysis of hours of additional ground-level fog caused by operation of the cooling towers at the CNS.

5.3.2.3 Drift deposition

About 100 gpm of water droplets will be swept from the towers by the air stream and deposited in the vicinity of the station. These droplets will contain concentrations of dissolved solids up to a maximum of about 980 ppm, which is ten times that of the river water. The average chlorine concentration in the droplets from all nine of the cooling towers will be the same as the average chlorine concentration in the blowdown. A total of about 250,000 lb/year of dissolved solids will leave the towers in the drift. If this amount were deposited evenly over an area having a 5-mile radius, the deposition rate would be about 5 lb/acre-year. The deposition rate is not uniform, however, since the largest drops will fall to the ground almost immediately and the smaller drops can be carried by the plume for relatively long distances. The drop-size distribution data supplied by the applicant are given in Table 3.2. The applicant predicted that the dissolved solids deposition rate at the CNS would be a maximum of 480 lb/acre-year immediately adjacent to the station; at about 1/2 mile distance, the rate was estimated to be 24 to 36 lb/acre-year and at 1 mile, about 6 to 12 lb/acre-year (ER, Fig. 5.1.5-2).

The staff also analyzed the drift deposition rate for the CNS using the analytical model described in Sect. 5.3.2.2 and the data shown in Table 3.2. The rate of drift loss and the distribution of drop-size diameters used by the staff are the same as those used by the applicant. The solids content in the drift was assumed to be 530 ppm, which is based on average solids in the makeup water from the river; but the applicant used a more conservative value of 1150 ppm, which is based on maximum solids in the river. Both studies assume that the solids content of the drift is the same as that of the circulating water in the tower basin. The staff's results are summarized in Fig. 5.2. The staff estimated a maximum of about 23 lb/acre-year falling within the northeast sector about 3/4 mile from the towers. At a 1-mile distance the deposition rate was estimated at 13 lb/acre-year in the northeast and southwest sectors, and at 5 miles the rate was 0.4 lb/acre-year.

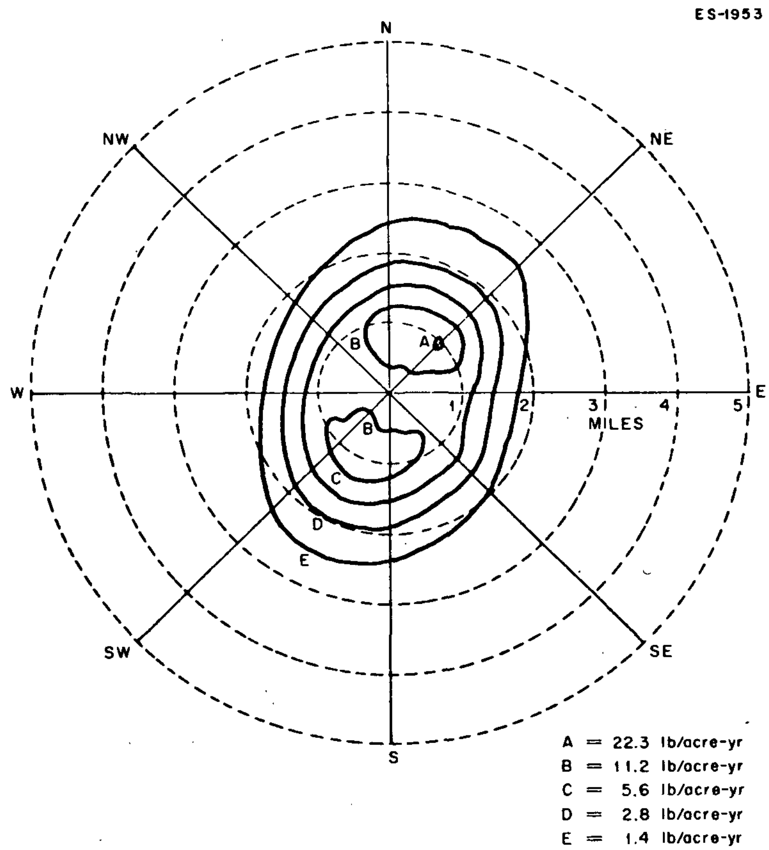

Fig. 5.2. Staff's estimate of drift deposition due to operation of the cooling towers at the CNS. (The maximum deposition rate was 22.3 lb/acre-year, which occurred in the northeast sector at about 3/4 mile from the station.)

5.3.2.4 Icing

Icing may occur in the immediate vicinity of cooling towers when water droplets fall or condense on cold surfaces and subsequently freeze. This effect is usually confined to the immediate vicinity of mechanical-draft towers and seldom occurs further than a few hundred feet away from tall natural-draft towers. There are no widely accepted methods of calculating the extent of icing. One rough approximation is to assume that icing will occur when the plume touches the ground and the temperature is below 32°F. On this basis, the hours per year in which icing would occur at a given point in addition to that which would take place naturally could be no greater than the predicted hours of additional fog for that location and would probably be considerably less. Since the hours of additional fog predicted for the vicinity of CNS cooling towers are very low, the amount of icing can be expected to be insignificant.

5.3.3 Water quality standards and effluent limitations

5.3.3.1 State water quality standards

Water quality standards were adopted by the State of South Carolina on September 8, 1971, and were approved by the U.S. Environmental Protection Agency on December 23, 1971. The Broad River at the CNS site is classified as "B" waters. This class of water is suitable for domestic supply after complete treatment and is also suitable for propagation of fish, industrial, agricultural, and other uses requiring water of lesser quality.[7] The staff considers that the construction and operation of CNS will comply with State of South Carolina standards if the procedures required by the staff are followed.

5.3.3.2 Federal effluent guidelines and standards

On October 8, 1974, the EPA published regulations concerning thermal discharges and effluent guidelines for steam-electric power generating plants.[8] The staff has reviewed the information that must be considered in determining whether CNS can be constructed and operated in conformity with the effluent limitations established by these regulations.

The Environmental Report describes the various effluents associated with the construction and operation of the facility. Assessment of the effects of these effluents are reported in this Environmental Statement. The staff's conclusion is that all effluents from operation of the facility that are regulated by the EPA effluent limitations are in conformity with those regulations and reflect the "best technology economically achievable" [40 CFR, 423-13(1)(1)]. A summary of the staff's findings follows:

Limitation 423.13(a)

The pH discharges shall be within the range of 6.0 to 9.0.

Assessment

Discharges should fall within the pH control range. Effluents from the demineralizer systems will be neutralized before discharge. Control will be used to assure that the pH of other discharges remains within required levels, if necessary by the development of specific operating procedures for incorporation in the Technical Specifications to the operating licenses.

Limitation 423.13(b)

There shall be no discharge of polychorinated biphenol compounds.

Assessment

There will be no discharge of polychlorinated biphenol compounds.

Limitation 423.13(c)

Low-volume waste source limitations on total suspended solids and oil and grease quantities.

Assessment

This limitation is not expected to be exceeded during plant operation. This may require the development of specific operating limitations to be incorporated as part of the Technical Specifications of the operating licenses to meet the applicable requirements of the NPDES permit when required.

Limitation 423.13(f)

Metal cleaning waste pollutant discharges.

Assessment

Waste water and waste solutions from cleaning operations will be treated during the construction period to remove suspended solids and chemicals. For limitation during operation, this may require the development of specific operating limitations to be incorporated as part of the Technical Specifications of the operating licenses.

Limitation 423.13(g)

Boiler blowdown pollutant discharges.

Assessment

The system as detailed in the applicant's Environmental Report complies with the applicable EPA effluent limitations.

Limitation 423.13 (h) and (i)

Cooling tower blowdown pollutant discharges.

Assessment

The EPA standards for maximum and average concentrations of free residual chlorine allowed in cooling tower blowdown should be met during operation of the proposed facility. Chlorine is further discussed in Sect. 5.5.2.2. All other cooling tower pollutant discharges will comply with applicable EPA effluent limitations.

Limitation 423.13(j)

Daily time limitation for discharge of chlorine.

Assessment

The applicant will chlorinate each unit sequentially for about 1 hr daily; however, some discharge of total residual chlorine will always exist in the blowdown because a reserve of total residual chlorine will remain in the circulating water flow of the cooling towers (Sect. 3.6). EPA effluent standards limit discharges of residual chlorine for a period not to exceed 2 hr daily. Since the blowdown discharge will not meet this limitation, the applicant will be required either to meet the EPA standard or to obtain a variance from the regional EPA administrator.

Limitation 423.13(l)(l)

Discharge of heat from the main condensers.

Assessment

The facility will use closed-cycle cooling systems employing mechanical-draft cooling towers and cold side blowdown discharge of heat at a temperature that does not exceed, at any time, the lowest temperature of recirculating water prior to the addition of makeup water. This will conform to the applicable EPA effluent limitations.

Limitation 423.40

Construction runoff.

Assessment

The applicant proposes construction practices to limit erosion and siltation resulting from construction practices. The staff is requiring that the applicant submit to the staff a surface runoff control plan to ensure that surface runoff will be adequately controlled to meet EPA standards.

The staff concludes that the facility, as designed by the applicant and as modified by staff requirements, will comply with State and Federal water quality requirements except for chlorine. In addition, the applicant will be required to have a certification issued under Section 401 of the Federal Water Pollution Control Act stating affirmative compliance with applicable requirements prior to issuance of a construction permit.

5.4 RADIOLOGICAL IMPACT

5.4.1 Impact on biota other than man

5.4.1.1 Exposure pathways

The pathways by which biota other than man may receive radiation doses in the vicinity of a nuclear power station are shown in Fig. 5.3. Two comprehensive reports[9,10] concerned with radioactivity in the environment and these pathways can be read for a more detailed explanation of the subjects that will be discussed below. Depending on the pathway being considered, terrestrial and aquatic organisms will receive either approximately the same radiation doses as man or somewhat greater doses. Although no guidelines have been established for desirable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for these species.[11]

5.4.1.2 Radioactivity in the environment

The quantities and species of radionuclides expected to be discharged annually by Cherokee Nuclear Station Units 1, 2, and 3 in liquid and gaseous effluents have been estimated by the staff and are given in Tables 3.4 and 3.5 respectively. The basis for these values is discussed in Sect. 3.5. For the determination of doses to biota other than man, specific calculations are done primarily for the liquid effluents. The liquid effluent quantities, when diluted in the discharge, would produce an average gross activity concentration, excluding tritium, of 0.0011 pCi/mℓ in the plant discharge area. Under the same conditions, the tritium concentration would be 0.78 pCi/mℓ.

Doses to terrestrial animals such as rabbits or deer due to the gaseous effluents are quite similar to those calcualted for man (Sect. 5.4.2).

5.4.1.3 Dose rate estimates

The annual radiation doses to both aquatic and terrestrial biota were estimated on the assumption of constant concentrations of radionuclides at a given point in both the water and air. Referring to Fig. 5.3, radiation dose has both internal and external components. External components originate from immersion in radioactive air and water and from exposure to radioactive sources on surfaces, in distant volumes of air and water, in equipment, etc. Internal exposures are a result of ingesting and breathing radioactivity.

Doses will be delivered to aquatic organisms that live in the water containing radionuclides discharged from the power station. This is principally a consequence of physiological mechanisms that concentrate a number of elements that can be present in the aqueous environment. The extent to which elements are concentrated in fish, invertebrates, and aquatic plants upon uptake or ingestion has been estimated. Values of relative bioaccumulation factors (ratio of concentration of radionuclide in organisms to that in the aqueous environment) of a number of waterborne elements for several organisms are provided in Table 5.1.

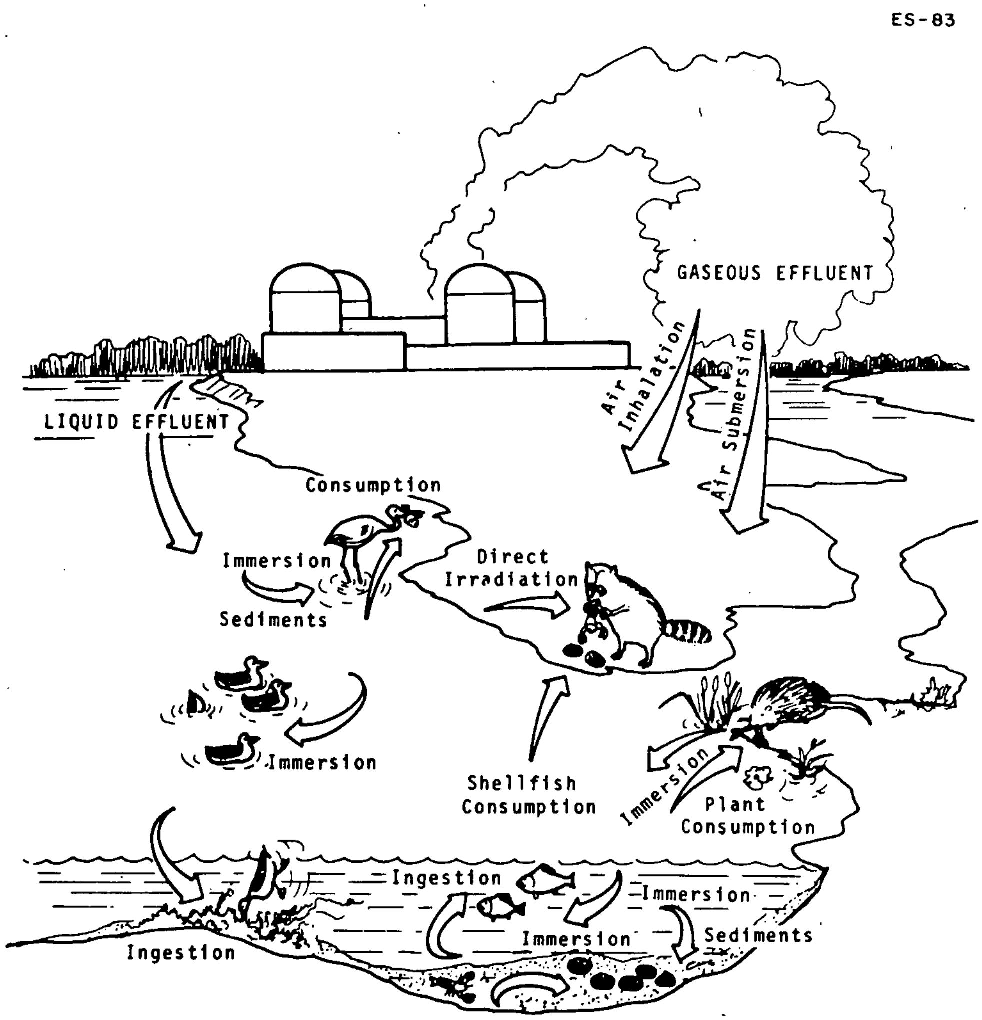

Fig. 5.3. Exposure pathways to biota other than man.

Doses to aquatic plants and fish living in the immediate area of the discharge which are due to water uptake and ingestion (internal exposure) were calculated to be 190 and 0.73 millirads/year respectively. The discharge region concentrations were those given above, and it was assumed that these organisms spent all of the year in water of maximum concentrations. All calculated doses are based on standard models.[12] The doses are quite conservative since it is highly unlikely that any of the mobile life forms will spend a significant portion of their life spans in the maximum activity concentration of the discharge region. Both radioactive decay and additional dilution would reduce the dose at other points.

External doses to terrestrial animals other than man are determined on the basis of gaseous effluent concentrations and direct radiation contributions at the locations where such animals may actually be present. Terrestrial animals in the environs of the station will receive approximately the same external radiation doses as man.

An estimate can be made for the ingestion dose to a terrestrial animal such as a duck, which is assumed to consume only aquatic vegetation growing in the water in the discharge region. The duck ingestion dose was calculated to be about 240 millirads/year, which represents an upper-limit estimate, since equilibrium was assumed to exist between the aquatic organisms and all radionuclides in water. A nonequilibrium condition for a radionuclide in an actual exposure situation would result in a smaller bioaccumulation and therefore in a smaller dose from internal exposure.

Table 5.1. Freshwater bioaccumulation factors (pCi/kg organism per pCi/liter water)

Element	Fish	Invertebrates	Plants
C	4,550	9,100	4,550
Na	100	200	500
P	100,000	20,000	500,000
Sc	2	1,000	10,000
Cr	200	2,000	4,000
Mn	400	90,000	10,000
Fe	100	3,200	1,000
Co	50	200	200
Ni	100	100	50
Zn	2,000	10,000	20,000
Rb	2,000	1,000	1,000
Sr	30	100	500
Y	25	1,000	5,000
Zr	3	7	1,000
Nb	30,000	100	800
Mo	10	10	1,000
Tc	15	5	40
Ru	10	300	2,000
Rh	10	300	200
Ag	2	770	200
Sn	3,000	1,000	100
Sb	1	10	1,500
Te	400	150	100
I	15	5	40
Cs	2,000	100	500
Ba	4	200	500
La	25	1,000	5,000
Ce	1	1,000	4,000
Pr	25	1,000	5,000
Nd	25	1,000	5,000
Pm	25	1,000	5,000
Sm	25	1,000	5,000
Eu	25	1,000	5,000
Gd	25	1,000	5,000
W	1,200	10	1,200
Np	10	400	300
Pu	4	100	350
Am	25	1,000	5,000
Cm	25	1,000	5,000

Source: S. E. Thompson, C. A. Burton, D. J. Guinn, and Y. C. Ng, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564, Rev. 1 (1972).

The literature relating to radiation effects on organisms is extensive, but few studies have been conducted on the effects of continuous low-level exposure to radiation from ingested radionuclides on natural aquatic or terrestrial populations. In the "BEIR" report,[13] it is stated in summary that evidence to date indicates that no other living organisms are very much more radiosensitive than man. Therefore, no detectable radiological impact is expected in the biota or terrestrial mammals as a result of the quantity of radionuclides to be released into Broad River and into the air by CNS.

5.4.2 Radiological impact on man

The NRC staff is presently reassessing assumptions and evaluating models for projected radioactive effluent releases and calcualted doses in order to reflect the Commission's guidance in its Opinion issued April 30, 1975, in the rule-making proceeding RM-50-2, NCRI-75/4R, page 277 as amended 40 FR 40816, September 4, 1975.

The revised specific models for a detailed assessment of individual and population doses have not been completed. For the interim, it can be said that the individual doses associated with the radioactive releases of the Cherokee Nuclear Station will be in accord with the requirements stated in Appendix I. Thus, no final plant design will be approved which will result in individual doses in excess of Appendix I requirements.

The staff has developed a procedure to quantitatively evaluate the maximum integrated doses that could be delivered to the U.S. population by radioactive emissions from CNS. A description of this procedure for gaseous effluents is contained in Appendix C. The intent of this estimate is to evaluate the radiological environmental impact of the facility by establishing an upper-bound population dose associated with plant operation which is unlikely to be exceeded when the detailed review is performed for the hearing before the Atomic Safety and Licensing Board.

5.4.2.1 Liquid effluents

Expected radionuclide releases in the liquid effluent have been estimated for CNS and are listed in Table 3.4. Doses to the population from these releases were calcualted using dose procedures consistent with the recommendations of ICRP-2.[12]

According to the applicant, about 17,000 people currently derive their drinking water from the river within 50 miles downstream of the plant. The man-rem contribution from other intakes on the river is expected to be negligible.

The cumulative dose resulting from the consumption of fish harvested from the river was estimated. It was conservatively assumed that 100% of the population within 50 miles of the plant consumed 5 g of fish per day caught in the region of the river where the coolant water discharges were diluted by an additional factor of 250 over those dilutions in the immediate discharge region.

Because of the remoteness of the site and the lack of activity on the river, population doses from other possible pathways are expected to be small compared to the above pathways.

The tritium released to the receiving water is assumed to enter the biosphere in the same manner as tritium released to the atmosphere. Thus the tritium discussion in Appendix C applies to all tritium sources from the plant.

The information presented in Table 5.2 includes the doses to the population due to the release of radionuclides in the liquid effluents.

Table 5.2. Annual integrated dose to U.S. population

Radionuclide group	Annual dose (man-rems)	
	Total body	Thyroid
Noble gases	11	11
Radioiodine	0.14	55
Particulate	13	11
Tritium	2.5	2.5
C-14	50	50
Total	77	130

5.4.2.2 Gaseous effluents

NRC staff estimates of the probable gaseous releases listed in Table 3.5 were used to evaluate potential doses to the U.S. population. As discussed in Appendix C, these gaseous effluents were considered in five categories, namely, noble gases, radioiodines, particulates, C-14, and tritium. Krypton-85 was treated separately from the other noble gases because of its relatively long half-life (about 11 years).

The population can be exposed via the pathways discussed in Appendix C. External total-body irradiation results from submersion in dispersed noble gases and from standing on surfaces containing deposited radioiodines and particulates. Internal total-body and organ exposures result from inhalation of contaminated air or ingestion of contaminated foodstuffs. Three food pathways were evaluated which involved consumption: meat, milk, and food crops.

Doses to the population were calculated by assuming uniform dispersal of the radionuclides. Direct exposure pathways evaluation to the population (e.g., noble gas submersion) assume a uniform population density. Indirect food pathways evaluations were based upon the assumption that meat, milk, and food crop productivity of the region is such that the land area east of the Mississippi River is capable of supporting the U.S. population. Table 5.2 includes the population doses resulting from this analysis.

5.4.2.3 Evaluation of radiological impact

Using conservative assumptions, the staff has estimated an upper-bound integrated exposure to the population of the United States due to operation of the Cherokee Nuclear Station. Appendix I to 10 CFR 50 requires that individual doses be kept to a small fraction of the doses implied by 10 CFR 20.

The above statements can be placed in perspective by noting that the individuals in the U.S. population receive an average of about 100 millirems/year from natural background radiation. Thus the annual population dose due to natural background to the U.S. population is about 21,000,000 man-rems.

Both the maximum individual doses and the upper-bound population doses resulting from operation of the Cherokee Nuclear Station are fractions of the doses individuals and the population receive from naturally occuring radiation.

5.4.2.4 Direct radiation

5.4.2.4.1 Radiation from the facility

The plant design includes specific shielding of the reactor, holdup tanks, filters, demineralizers, and other areas where radioactive materials may flow or be stored, primarily for the protection of plant personnel. Direct radiation from these sources is therefore not expected to be significant at the site boundary. Confirming measurements will be made as part of the applicant's environmental monitoring program after plant startup. Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 millirem/year at the site boundary.

5.4.2.4.2 Transportation of radioactive material

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the NRC report entitled *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants* (WASH-1238). The environmental effects of such transportation are summarized in Table 5.3.

Table 5.3. Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor

Normal conditions of transport

	Environmental impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lb per truck; 100 tons per cask per rail car
Traffic density	
Truck	Less than one per day
Rail	Less than three per month

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals per reactor year[a] (millirems)	Cumulative dose to exposed population per reactor year[b] (man-rems)
Transportation workers	200	0.0 to 300	4
General public			
Onlookers	1,100	0.003 to 1.3	3
Along route	600,000	0.0001 to 0.06	

[a]The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5000 millirems/year for individuals as a result of occupational exposure and should be limited to 500 millirems/year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirems/year.

[b]Man-rem is an expression for the summation of whole-body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if two people were to receive a dose of 0.5 rem (500 millirems) each, the total man-rem dose in each case would be 1 man-rem.

Source: Data supporting this table are given in the Commission's *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants,* WASH-1238, December 1972.

5.4.2.4.3 Occupational radiation exposure

Based on a review of the applicant's Preliminary Safety Analysis Report, the staff has determined that individual occupational doses can be maintained within the limits of 10 CFR 20. Radiation dose limits of 10 CFR 20 are based on a thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of plant personnel within these limits ensures that the risk associated with radiation exposure is no greater than those risks normally accepted by workers in other present-day industries.[14] Using information compiled by the Commission[15] on past experience from operating nuclear reactor plants (with a range of exposures of 44 to 5134 man-rems/year), it is estimated that the average collective dose to all onsite personnel at large operating nuclear plants will be approximately 450 man-rems per year per unit. The total dose for this plant will be influenced by several factors for which definitive numerical values are not available. These factors are expected to lead to doses to onsite personnel lower than those estimated above. Improvements to the radioactive waste effluent treatment system to maintain offsite population doses as low as practicable may cause an increase in onsite personnel doses if all other factors remain unchanged. However, the applicant's implementation of Regulatory Guide 8.8 and other guidance provided through the staff radiation protection review process is expected to result in an overall reduction of total doses from those currently experienced. Because of the uncertainty in the factors modifying the above estimates, a value of 1400 man-rems will be used for the occupational radiation exposure for the three-unit station.

5.4.2.5 Summary of annual radiation doses

The annual population doses (man-rem) resulting from the plant operation are presented in Table 5.4. As shown in this table, the operation of the Cherokee Nuclear Station will contribute a small fraction of the population dose that persons living in the United States normally receive from natural background.

Table 5.4. Summary of annual doses to the U.S. population

Category	Population dose (man-rems/year)
Natural environmental radioactivity	21,000,000
Nuclear plant operation	
Plant work force	1,400
General public	
Gaseous and liquid effluents (total body and thyroid)	210
Transportation of nuclear fuel and radioactive wastes	9

5.4.3 Environmental effects of the uranium fuel cycle

The environmental effects of uranium mining and milling, production of uranium hexafluoride, enrichment of isotopes, fabrication of fuel, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level and high-level radioactive wastes are within the scope of the AEC report (WASH-1248) entitled *Environmental Survey of the Uranium Fuel Cycle*. The contribution of such environmental effects is summarized in Table 5.5.

5.5 NONRADIOLOGICAL EFFECTS ON ECOLOGICAL SYSTEMS

5.5.1 Terrestrial

5.5.1.1 Cooling towers

One of the possible principal impacts of wet mechanical-draft cooling towers is the long-range change of environmental conditions caused by the release of large amounts of water vapor directly to the atmosphere. Such changes could involve increases in total regional rainfall, fog frequency, relative humidity, hours of cloud cover, days with precipitation, and frequency of thunder storms. The occurrence of such changes over broad regions as a result of the operation of cooling towers could have unforeseen impacts on ecological systems and on the use of these systems. To date, studies of possible regional environmental modifications have been few because

Table 5.5. Summary of environmental considerations for uranium fuel cycle

Normalized to model LWR annual fuel requirement

Natural resource use	Total	Maximum effect per annual fuel requirement of model 1,000-MWe LWR
Land (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90 MWe coal-fired power plant.
Permanently committed	4.6	
Overburden moved (millions of metric tons)	2.7	Equivalent to 90 MWe coal-fired power plant.
Water (millions of gallons)		
Discharged to air	156	≈2% model 1000 MWe LWR with cooling tower.
Discharged to water bodies	11,040	
Discharged to ground	123	
Total	11,319	<4% of model 1000 MWe LWR with once-through cooling.
Fossil fuel		
Electrical energy (thousands of MW-hour)	317	<5% of model 1000 MWe LWR output.
Equivalent coal (thousands of metric tons)	115	Equivalent to the consumption of a 45-MWe coal-fired power plant.
Natural gas (millions of scf)	92	<0.2% of model 1000-MWe energy output.
Effluents – chemical (metric tons)		
Gases (including entrainment)[a]		
SO_2	4,400	
NO_2[b]	1,177	Equivalent to emissions from 45-MWe coal-fired plant for a year.
Hydrocarbons	13.5	
CO	28.7	
Particulates	1,156	
Other gases		
F^-	0.72	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards – below level that has effects on human health.
Liquids		
SO_4^-	10.3	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constitutents that require dilution and the flow of dilution water are:
NO_3^-	26.7	
Fluoride	12.9	
Ca^{2+}	5.4	
Cl^-	8.6	
Na^+	16.9	NH_3 – 600 cfs.
NH_3	11.5	NO_3 – 20 cfs.
Fe	0.4	Fluoride – 70 cfs.
Tailings solutions (thousands of metric tons)	240	From mills only – no significant effluents to environment.
Solids	91,000	Principally from mills – no significant effluents to environment.
Effluents – radiological (curies)		
Gases (including entrainment)		
Rn-222	75	Principally from mills – maximum annual dose rate <4% of average natural background within 5 miles of mill. Results in 0.06 man-rem per annual fuel requirement.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.032	Principally from fuel reprocessing plants – whole body dose is 6 man-rem per annual fuel requirements for population within 50-mile radius. This is <0.007% of average natural background dose to this population. Release from Federal Waste Repository of 0.005 Ci/year has been included in fission products and transuranics total.
Tritium (thousand)	16.7	
Kr-85 (thousands)	350	
I-129	0.0024	
I-131	0.024	
Fission products and transuranics	1.01	
Liquids		
Uranium and daughters	2.1	Principally from milling – included in tailings liquor and returned to ground – no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production – concentration 5% of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants – concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106	0.15[c]	From reprocessing plants – maximum concentration 4% of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands)	2.5	
Solids (buried)		
Other than high level	601	All except 1 Ci comes from mills – included in tailings returned to ground – no significant effluent to the environment, 1 Ci from conversion and fuel fabrication is buried.
Effluents – thermal (billions of Btu's)	3,360	<7% of model 1000-MWe LWR.
Transportation (man-rem): exposure of workers and general public.	0.334	

[a] Estimated effluents based upon combustion of equivalent coal for power generation.

[b] 1.2% from natural gas use and process.

[c] Cs-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

Source: Paragraph 51.20(e), 10 CFR 51.

large cooling tower installations have been in use for a relatively short period of time. Also, large generating facilities are often some distance from first-order U.S. Weather Bureau stations that have long-term climatological records for the several meteorological factors required to assess the effects of cooling tower plumes.

Using precipitation increase as a single indicator of environmental modification, a year-long study of two 325-ft-high, natural-draft cooling towers at Keystone generation station (near Shelocta, Pennsylvania) showed that, except for substantial increases at two downwind stations during July 1969, precipitation measurements at nine U.S. Weather Bureau stations selected for monitoring purposes were within the range of variation established from an eight-year period just prior to plant operation.[16] All downwind stations did not register increased precipitation during the July period, however, which suggests that the increases noted at the two stations may have been purely chance events. Although a firm statement cannot be made on the environmental changes resulting from cooling tower operations, the proposed site for CNS is in a region with moderate-to-high potential for adverse effects from cooling tower plumes, based on frequencies of annual fog (>20 days) and low-level atmospheric inversions (>20-30% frequency).[1]

Deposition of drift solids due to cooling tower operation is described in Sect. 5.3.2.3. The majority of the deposition will occur to the north-northeast and south-southwest (Fig. 5.2). The maximum staff-calculated deposition rate was 22.3 lb/acre-year, which occurred in the northeast sector about 3/4 mile from the cooling towers. The natural deposition rate, assuming 47 in. of precipitation per year (ER, Table 2.6.1-1) with a total dissolved solids concentration of 5 ppm (estimated from data of Gambell and Fisher[17]), is 53 lb/acre-year.

Assuming that the above maximum of 23 lb/acre-year of solids is added to natural precipitation, the concentration of total solids in natural precipitation would be approximately 7 ppm. This concentration should have no significant impacts on vegetation because water containing as much as 640 to 1280 ppm total solids may be used for supplemental irrigation of plants having low salt tolerance.[18]

5.5.1.2 Transmission facilities

The operational impact of the transmission lines will be largely determined by right-of-way management practices. According to the applicant (ER, Sect. 5.6), inspections of the rights-of-way will be done from the air periodically. Bush-hogging and hand-clearing are scheduled on a three- to four-year cycle to control the resurgence of tall growth in the line corridors. No herbicides are used, and all low-growing shrubs are left intact.

Right-of-way vegetation can also be controlled by selective herbicide treatment as described by Niering and Goodwin,[19] Niering,[20] and Frank E. Egler in several papers. In this method, unwanted tree and shrub species that invade the cleared right-of-way would be killed by the basal spray technique. This technique would allow desired herbaceous and shrub species to form dense communities that would impede further invasion of unwanted species but would not grow high enough to be hazardous to the transmission lines. Maintenance activities and costs might be reduced, and relatively stable plant and animal communities might develop. This method may have substantial advantages over the bush-hogging and hand-cutting methods, which would require frequent cutting of sprouting brush and would regularly disrupt the developing plant and animal communities. Both bush-hogging and hand-cutting seldom serve to kill the roots of unwanted woody plants; rather, they often encourage a denser brushy growth, especially of root-suckering species. Costs of selective herbicide treatment for the first several years might approximate but should not be significantly greater than costs of bush-hogging and selective hand-cutting and might be significantly less during following years. The success of the selective herbicide treatment would depend on consultation with a competent plant scientist.

After clearing, the right-of-way environment will probably experience increased use by offroad vehicles, with their associated noise and damage to vegetation.

An additional operating impact associated with transmission lines is the possible production of ozone around high-voltage carriers, which could damage nearby vegetation. Contributions of ozone in excess of ambient levels by transmission lines and substations are not well documented in the literature. Recent studies[21,22] suggest no measurable (less than 2 ppb) increase in ozone concentrations around lines carrying 765 kV. Chronic exposures on the order of 30-150 ppb[23,24] are required to elicit damage in ozone-sensitive vegetation. Thus, considering that Cherokee lines will operate at 230 kV, vegetation damage due to ozone drift is considered unlikely.

Some wildlife deaths will result because of collisions with transmission lines and towers. The number of deaths along the 21 miles of CNS lines should be few compared to those caused by other man-made obstacles, such as television towers, microwave towers, radio towers, and buildings. Unfortunately, data on the significance of mortality caused by transmission lines are scant, probably because the kills are not as concentrated and extensive as the kills at some radio and television towers.

5.5.1.3 Railroad spur

The effects of operation of the railroad spur on biological systems are expected to be small. The applicant did not state what methods would be used to prevent growth of vegetation along the rails. Wildlife kills are expected to be minimal because of the slow speeds at which trains will be moving on the tracks.

5.5.2 Aquatic

5.5.2.1 Intake

Impingement

The makeup water intake structure will be built on the tip of a small peninsula that protrudes into Ninety-Nine Islands Reservoir about 1000 ft above the reservoir dam at a point where the main current of the river sweeps by (Fig. 2.4). River current is normally moderately fast (2.0-4.8 fps), but it may fall as low as 0.3 fps during the predicted 7 Q_{10} flow (ER, Question 2.7.12). The maximum intake velocity through the traveling screens will be about 0.5 fps (Sect. 3.4.2). Cooling tower makeup water will require a maximum withdrawal of 122 cfs.

The staff considers that the design of the intake structure will not be conducive to producing fish impingement for the following reasons:

1. The intake velocity is slow (∿0.5 fps).

2. The traveling screens are located flush with the front face of the structure, with the result that river current can sweep across the screens (Fig. 3.4). Any fish that becomes impinged will be swept off the screens by the current.

3. Lateral fish passages are present which will allow fish that pass through the trash racks to escape from the structure (Fig. 3.4).

4. No protected areas are present in front of the traveling screens (Fig. 3.4).

Because of the above-mentioned factors, the staff does not consider that significant fish impingement losses will occur as a result of the operation of CNS.

Entrainment

Makeup water for plant usage will require a maximum of 133 cfs and an average of 93 cfs to be withdrawn from the Broad River (Sect. 3.3). Mean monthly river flows at Gaffney, 5 miles above the site, range from 3860 cfs in March to 1660 cfs in September (ER, Fig. 2.5.1-5).

The lowest predicted average seven-day flow with a probability of occurring once in ten years (7 Q_{10}) is 470 cfs. The applicant is committed to releasing water from upstream reservoirs when river flows fall below the 7 Q_{10} flow plus the consumptive loss of water from the cooling towers; that is, the applicant will supplement flow when it is less than 470 cfs plus 112 cfs (or 582 cfs). At mean monthly river flows, the applicant will be removing from 2 to 7% of the total river flow. This percentage would increase under low river flows to a maximum of 23.8% at the 7 Q_{10} flow.

Assuming a random distribution of planktonic organisms due to the turbulence and mixing of the river, the withdrawal of makeup water would represent a removal of from 2 to 23% of the planktonic organisms of the river passing the intake. Organisms expected to be entrained include bacteria, algae, zooplankton, drifting benthic organisms, and the eggs, larvae, and young juveniles of fish. A 100% mortality is assumed by the applicant for organisms that pass into the heat dissipation system from the combined effects of mechanical injury and chemical, temperature, and pressure changes (ER, Sect. 5.1.2.3).

Virtually all the water passing the intake site quickly passes Ninety-Nine Islands Dam (Fig. 2.4). All planktonic organisms in this water are quickly lost from the aquatic environment above the dam after they pass the intake site. The entrainment of planktonic organisms by CNS will, therefore, have little additional impact on the biota of the reservoir or the river above the dam.

The aquatic environment that potentially would be adversely impacted by the loss of planktonic organisms by CNS entrainment would be that portion of the river below the dam. Since the trophic structure of the river probably has a detritus food base (Sect. 2.7.2.2), the loss of 2 to 24% of the plankton would not reduce the quantity of food available to benthos and fish. Of more concern is the unknown role that ichthyoplankton, which are derived from above the dam, play in recruitment to the fish populations below the dam. The applicant has provided data on ichthyoplankton in the river from September 1974 through mid-June 1975. Fish larvae were present in the river beginning in late April and continuing through May and June. The average density of larvae collected throughout this period was about 22 per 1000 m^3 and ranged from 0 to 570 per 1000 m^3. Collections at the site of the intake structure consisted of 74% *Dorsoma* spp. larvae (shad), 15% catostomid larvae (suckers), 5% *Lepomis* spp. larvae (sunfishes), 3% carp larvae, and 3% other cyprinid larvae (minnows). Both the density of larvae and the percentage of game fishes encountered were quite low. In comparison, the backwater areas of the reservoir were found, for the same sampling period, to have an average density of fish larvae about 36 times higher (800 per 1000 m^3), with game species comprising about 8% of the total.

Mean monthly river flows throughout the period when fish larvae were collected ranged from about 2800 to about 2000 cfs (ER, Fig. 2.5.1.5). Based on mean monthly flows, operation of CNS would, therefore, entrain a maximum of only 7% of an already very small population of fish larvae passing the site. Data are not presently available on fish larvae present in the river during late June, July, and August, when river flows would be lowest and the percentage of river flow withdrawn by CNS highest. Most fish species, however, spawn before this period of low river flow. The staff does not expect higher numbers of fish larvae, especially game species, to be present during the summer months.

Because of the low densities of fish larvae present in the river and the small percentage of river flow that will be withdrawn by CNS, the staff does not consider that the entrainment of fish larvae by the operation of CNS will have any adverse impacts on the fish populations of the river or the reservoir.

5.5.2.2 <u>Discharge</u>

<u>Thermal</u>

The operation of all three units of CNS will produce a cooling tower discharge of 12 cfs. The blowdown will be discharged through an open pipe at the top of a rock outcropping at the west abutment of Ninety-Nine Islands Dam and will fall down the rocks to the spillway apron below (Sect. 3.4.3). The point at which the blowdown enters the river is immediately below the dam at a point where little or no river current is present since the entire river normally flows through the hydrostation located on the eastern part of the dam (Fig. 2.4). The blowdown will, therefore, travel along the western bank of the river for some distance — at least 2000 to 3000 ft, depending on river flows — before becoming fully mixed with ambient river water (Sect. 5.3.1).

<u>Summer</u>. Under summer conditions the staff estimates that the maximum expected blowdown temperature will be about 90°F and will normally range from 83°F in September to 86°F in July. Ambient river water temperatures normally reach a maximum of 81°F during the summer. Referring to the species listed in Table 5.6, it can be seen that their upper lethal threshold temperatures, given an acclimation temperature of 81°F, will not be exceeded. In all probability, if the temperature of the blowdown plume exceeds tbe preferred temperature of a fish, the fish will seek out lower, more preferable temperatures. Some organisms will be entrained into the plume as it mixes with river water downstream; however, planktonic populations are not very important in the trophic structure of the river, and, in addition, the thermal shock experienced by entrained organisms will be small. As a result, the staff considers that no appreciable adverse thermal impacts to aquatic organisms will result from CNS operation under summer conditions.

<u>Winter</u>. Under winter conditions the temperature differential between the warm blowdown (70°F) and the cold river water (42°F) will be greater, and the zone of excess temperature will cover a larger area. This area will depend directly on the river flow; therefore, three flow regimes will be considered.

1. During periods of prolonged, low river flows, it is occasionally necessary to cease operation of the Ninety-Nine Islands Hydrostation for periods up to 33 hr (ER, Sect. 5.1.2.1). Under these conditions, only a leakage flow of about 40 cfs passes through the dam, mostly through the wicket gates on the opposite side of the dam from the blowdown discharge. As a result, mixing of blowdown with river water would be very slow. An area of about 5 acres would exist with excess temperature of 5°F or more, while the 2°F isotherm would encompass about 27 acres (Sect. 5.3.1). A small area would exist with excess temperature near 20°F. As a result, the water of a small area may be heated to 70°F or more. Fish that become acclimated to this high a temperature would be susceptible to lethal cold shock should the water temperature suddenly drop to the ambient temperature (Table 5.6). The staff does not consider

Table 5.6. Thermal tolerances of several fish species found in the Broad River

Species	Acclimation temperature (°F)	Stage/age	Locality	Upper lethal threshold (°F)	Lower lethal threshold (°F)
Micropterus salmoides[a]	68		Ohio	90.5	41.9
(largemouth bass)	77			94.1	
	86			97.5(u)	53.2
Notemigonus crysoleucas[a]	50	Adult	Composite of	85.1	34.7
(golden shiner)	59		Ohio, Florida,	86.9	39.2
	68		and Ontario	89.6	44.6
	77			92.3	55.2
	86			94.1	
Semotilus atromaculatus[b]	41	Adult	Ontario	76.4	
(creek chub)	50			81.1	
	59			84.7	
	68			86.5	33.3
	77			86.5	40.1
Catostomus commersonsi[b]	41	Adult	Ontario	79.3	
(white sucker)	50			81.9	
	59			84.7	
	68			84.7	36.5
	77			84.7	42.8
Dorosoma cepedianum[a]	77	Under-yearling	Ohio	93.2	51.4
(gizzard shad)	86			96.8	58.1
	95			97.7(u)	68.0
Gambusia affinis holbrooki[a]	59	Adult	Texas	95.9	34.7
(mosquito fish)	68			98.6	41.9
	77			98.6	
	86			98.6(u)	
Ictalurus nebulosus[a]	41		Florida to	82.2	
(brown bullhead)	50		Ohio (seasonal)	84.2	
	59			87.8	
	68			90.5	32.9
	77			92.8	39.2
	86			94.6	44.2
	93			94.6	
Ictalurus punctatus[a]	59	Adult	Florida and	86.7	0.0
(channel catfish)	68		Ohio	91.0	0.0
	77			92.3	0.0
Lepomis machrochirus purpurescens[a]	59	Adult	Florida	86.9	36.5
(bluegill sunfish)	68			89.6	41.0
	77			91.4	45.5
	86			94.2	51.8

(u) = ultimate lethal temperature.

[a]Source: J. S. Hart, "Geographic Variations in Some Physiological and Morphological Characters in Certain Freshwater Fish," *Publ. Ontario Fish. Res. Lab.* **LXXII** (1952).

[b]Source: J. S. Hart, "Lethal Temperature Relations of Certain Fish of the Toronto Region," *Trans. Roy. Soc. Canada* **51**(3):57–71 (1947).

the possibility of a cold-shock mortality significant, however, because the probability of simultaneous shutdown of all three units of CNS is very small, and the probability that such shutdown would occur in conjunction with shutdown of the hydrostation is even more unlikely.

2. When river flows are less than about 4000 cfs, all the flow passes through the hydrostation on the east side of the dam. Under these conditions, complete mixing of the blowdown with river water would not occur until at least 1000 ft below the dam because the flow from the hydrostation does not reach the west bank of the river until this point. As a result, at flows ranging from 470 to 4000 cfs, which are normally encountered at the CNS site (mean flow = 2472 cfs), the 5° isotherm of the blowdown would only be slightly smaller than at a flow of 40 cfs. However, adequate dilution should still occur so that excess temperatures sufficient to produce potential lethal cold shock should not be present; therefore, the staff does not expect any adverse thermal effects to occur.

3. When river flows exceed the capacity of the hydrostation (~4000 cfs), the excess water flows over the dam's spillway, extending from the hydrostation to the west bank. Under these conditions, dilution of the blowdown would be rapid, and no adverse thermal impacts would be expected.

Chemical

A description of CNS's chemical and biocidal systems is given in Sect. 3.6. Tables 3.6 and 3.7 list the chemical species, their concentrations in the cooling tower blowdown, and their incremental increases in concentration in the river. Several of the chemicals that will be released to the aquatic environment by CNS could potentially have adverse impacts.

Total dissolved solids. The cooling water blowdown after ten cycles of operation will have a maximum TDS concentration of 980 ppm. Complete dilution in the river at the low 7 Q_{10} flow of 470 cfs will produce an incremental increase of 22 ppm. Since the maximum ambient TDS concentration in the river is only 98 ppm, this increase will still produce a TDS concentration well within the normal range for fresh water and will have no adverse effects on the biota of the river. The median toxicity threshold of TDS for most freshwater invertebrates and fish ranges from 3000 to 15,000 ppm.[25]

Dissolved oxygen. Cooling tower blowdown will have dissolved oxygen concentrations at saturation due to aeration in the cooling towers. Even considering the elevated temperatures of the blowdown, the blowdown will produce only negligible changes in the dissolved oxygen concentrations in the river due to the small volume of blowdown involved (12 cfs), the high ambient river oxygen concentrations, and the low ΔT expected (5 F°) during the summer when oxygen levels are normally most critical.

Chlorine. The applicant's chlorination procedures are discussed in Sect. 3.6.1 and will consist of the application of 533-1066 lb of chlorine (as sodium hypochlorite) daily per unit (1600-3200 lb/day total) over a period of 1 hr. A free residual chlorine concentration of 1 mg/l will be obtained during warm weather, and 0.5 mg/l will be obtained during cold weather. Each unit will be chlorinated sequentially. Under this procedure, the blowdown would have a free residual chlorine concentration of 0.3 mg/l and a total chlorine reaction products concentration of 50 mg/l (see Table 3.6).

The relationship between time of exposure and concentration for the toxicity of residual chlorine to aquatic life (mostly freshwater fish) is summarized in Fig. 5.4. The greatest potential for prolonged exposure of aquatic organisms to toxic chlorine concentrations would occur during the colder months of the year when fish may be attracted to the blowdown's thermal plume (Sect. 5.1.2.2).

Because of the site of the blowdown discharge immediately below Ninety-Nine Islands Dam, dilution of blowdown with river water will be slow and concentrations of toxic residual chlorine will persist within a large area for prolonged periods, especially during times of low river flows.

Under low-flow winter conditions, the area within the 5° isotherm of the thermal plume from CNS blowdown would encompass an area of about at least 4 acres. The total chlorine reaction products concentration within this area would be large. The total residual chlorine present among the chlorine reaction products could be toxic to fish attracted to the thermal plume if they were subjected to prolonged exposures. Even after complete dilution of the river, total residual chlorine could still be present at a concentration (total chlorine reaction products, 1.2 mg/l) sufficient to kill fish exposed for more than 50 to 100 min (Fig. 5.4).

The potential clearly exists for severe losses of fish and other aquatic organisms of the river from releases of chlorine at EPA guideline limits (0.2 mg/l average and 0.5 mg/l maximum free available chlorine) from the operation of CNS. Because of the location of the blowdown discharge, at low river flows little or no dilution will occur until the blowdown flow mixes with the river flow at a point about 1000 ft below the dam and the fish and benthic invertebrates inhabiting an area of approximately 1 to 4 acres, depending on river flow, will be frequently subjected to toxic concentrations of total residual chlorine. As a result, fish and benthic invertebrates will probably be eliminated from this area. The fish populations that inhabit this area are probably

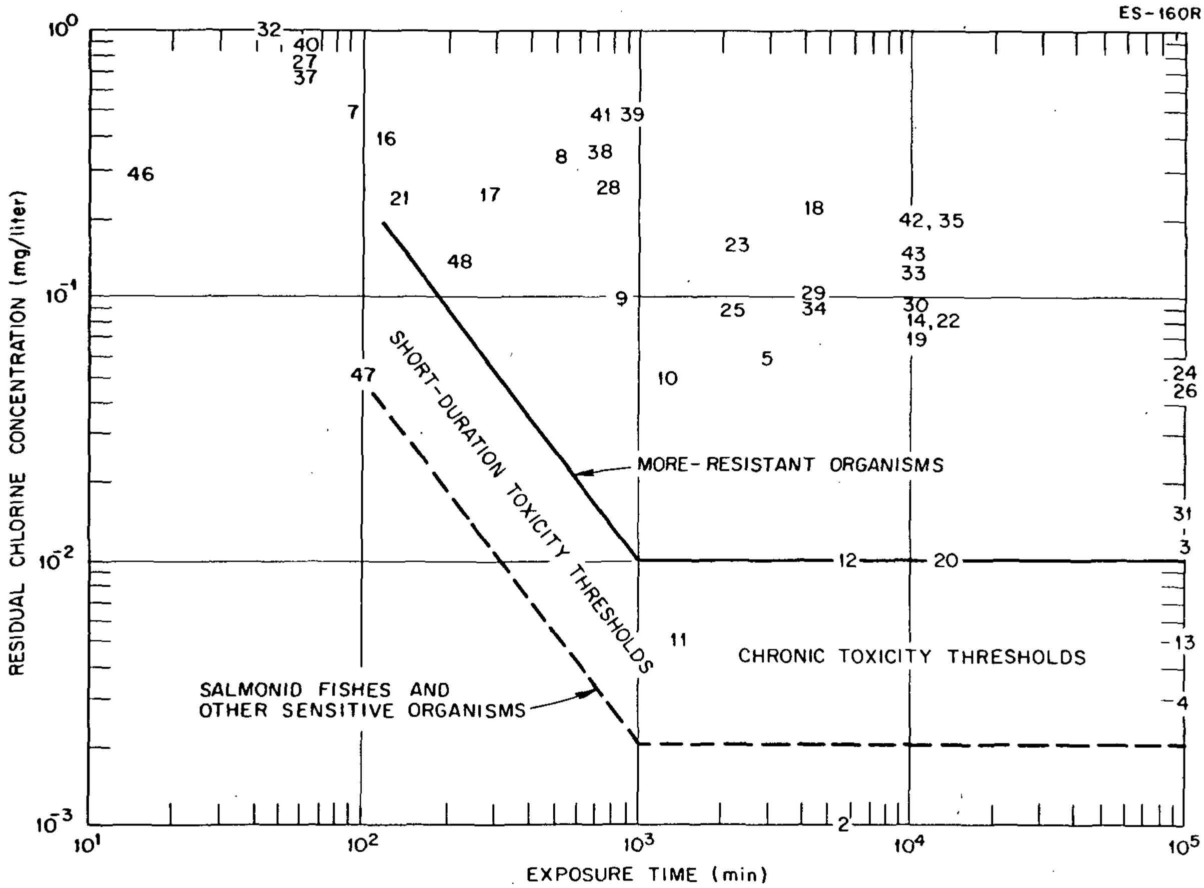

Fig. 5.4. Summary of residual chlorine toxicity data. (Key and references follow.)

similar to what was sampled by the applicant at station 15, located about 2000 ft below the dam (Fig. 6.1). The most common fish species encountered were gizzard shad (54%) and bluegills (17%), with other game species making up an additional 4% (ER, Table 2.7.2-17). Although the staff does not consider that the loss of fish and other aquatic biota from this small area will adversely affect their populations in the river because the area to be lost is only a negligible part of their available habitat in the river, either alternate discharge method and location (Sect. 9.2.3) is environmentally superior and the staff will approve the proposed discharge only if the applicant will commit to meet a chlorine design objective of total residual chlorine of not more than 0.1 mg/l and not discharge blowdown containing total residual chlorine when leakage through the dam is the only flow in the river downstream of the dam.

Alternate biocide

Only very limited data are available on the toxicity of the alternate biocide, *dodecylguanidine hydrochloride,* to aquatic organisms. The manufacturer of the biocide reported a 96-hr LC_{50} concentration of 7.5 mg/l for the bluegill, *Lepomis macrochirus*. Bioassays using the alternate biocide were conducted by the applicant using the green algae, *Selenastrum capricornutum*. At concentrations expected to be used at CNS, the alternate biocide killed all cultures grown at 50°F and at 68°F but did not kill the cultures grown at 86°F, although growth rates were reduced by 50% (ER, Sect. 5.4.3).

When used, the alternate biocide would be present at 10 mg/l in the blowdown and, after complete dilution in the river in the 7 Q_{10} flow of 470 cfs, it would be present at 0.25 mg/l (Table 3.7). A concentration of 0.25 mg/l would probably not be acutely toxic to most aquatic organisms; however, it may be chronically toxic if exposure were of a long duration.

Prior to approval of use of dodecyclguanidine hydrochloride as a biocide, the staff will require that adequate acute and chronic toxicity data be provided for representative, indigenous species of all trophic levels to assure that release will not produce adverse effects to aquatic biota.

Key to Fig. 5.4. Exposures of aquatic organisms to total residual chlorine
All concentrations were measured

Species	Point No.	Effect end point[a]	Reference
Cladoceran	2	Lethal (4 days)	Biesinger, 1971
Scud	3	Safe concentration	Arthur, 1971
	4	Safe concentration	Arthur and Eaton, 1972
Trout fry	5	Lethal (2 days)	Coventry et al., 1935
Brook trout	7	Median mortality (90 min)	Pyle, 1960
	8	Mean survival time 8.7 hr	Dandy, 1967
	9	Mean survival time 14.1 hr	Dandy, 1967
	10	Mean survival time 20.9 hr	Dandy, 1967
	11	Mean survival time 24 hr	Dandy, 1967
	12	67% lethality (4 days)	Dandy, 1967
	13	Depressed activity	Dandy, 1967
	14	7-day TL50	Arthur, 1971
Fingerling rainbow trout	17	Lethal (4 to 5 hr)	Taylor and James, 1928
Rainbow trout	16	Lethal (2 hr)	Taylor and James 1928
	18	96-hr TL50	Basch, 1971
	19	7-day TL50	Merkens, 1958
	20	Lethal (12 days)	Sprague and Drury, 1969
Chinook salmon	21	First death 2.2 hr	Holland et al., 1960
Coho salmon	22	7-day TL50	Arthur, 1971
	23	100% kill (1–2 days)	Holland et al., 1960
	24	Maximum nonlethal	Holland et al., 1960
Pink salmon	25	100% kill (1–2 days)	Holland et al., 1960
	26	Maximum nonlethal	Holland et al., 1960
Fathead minnow	27	TL50 (1 hr)	Arthur, 1972
	28	TL50 (12 hr)	Arthur, 1972
	29	96-hr TL50	Zillich, 1969
	30	7-day TL50	Arthur, 1971
	31	Safe concentration	Arthur and Eaton, 1972
White sucker	32	Lethal (30–60 min)	Fobes, 1971
	33	7-day TL50	Arthur, 1971
Black bullhead	34	96-hr TL50	Arthur, 1971
Largemouth bass	35	7-day TL50	Arthur, 1971
	37	TL50 (1 hr)	Arthur, 1972
	38	TL50 (12 hr)	Arthur, 1972
	39	Median mortality (15 hr)	Pyle, 1960
Yellow perch	40	TL50 (1 hr)	Arthur, 1972
	41	TL50 (12 hr)	Arthur, 1972
	42	7-day TL50	Arthur, 1971
Walleye	43	7-day TL50	Arthur, 1971
Miscellaneous fish	46	Initial kill 15 min	Truchan, 1971
Rainbow trout	47	100% lethal in plant effluent	Michigan Water Resources Commission, 1971
Daphnia magna	48	0 recovery	National Water Quality Lab, 1971

[a]TL50: median tolerance limit.

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Scale inhibitor

The applicant has studied the effects of the scale inhibitor, aminomethylene phosphonate, on the green algae, *Selenastrum capricornutum*. At concentrations that are expected to be used at CNS, the compound did not substantially affect algal growth. The effects of the scale inhibitor on higher trophic level organisms, however, is not known. Before the staff will approve the use of this compound, adequate data must be provided on the acute and chronic toxicity of the compound to representative, indigenous organisms of all trophic levels.

5.5.3 Sanitary and other wastes

During the operation of CNS, domestic sewage will total an estimated 8000 gpd. The sewage will receive tertiary treatment and chlorination (12-25 ppm). The effluent will be pumped into a holding pond and ultimately to the river (ER, Sect. 3.7.2). The chemical composition of the discharge to the river will contain an average of 4.1 ppm phosphate (as PO_4), 0.45 ppm of nitrates, and 0.45 ppm of ammonia. When added to the nutrients released in the blowdown, these concentrations will amount to a maximum incremental increase in the river (for a flow of 470 cfs) of 0.1 ppm of phosphates (PO_4), 0.04 ppm of nitrates, and 0.07 ppm of ammonia (Table 3.6).

Incremental increases of the above magnitude in phosphates, nitrates, and ammonia could stimulate increased primary production in the river. The amount that primary production will be increased will probably be minor. Because of high ambient turbidity (annual average TSS = 135 mg/l), primary production in the river is probably limited more by light than by any nutrient. Total residual chlorine will be present in the effluent at insignificant concentrations and will cause no adverse impacts to aquatic biota.

Summary of the impacts of CNS operation on the aquatic environment

The operation of CNS could have potential adverse effects on the aquatic environment of the river and the reservoir through impacts associated with the intake of cooling tower makeup water (impingement and entrainment) and through the discharge of effluents (chemical and thermal impacts).

The staff does not consider that significant fish impingement losses will result at CNS since the intake structure contains features that will minimize fish impingement.

Entrainment losses of ichthyoplankton at CNS should not cause adverse effects on fish populations because fish larvae are present in very low numbers in the river and because CNS operation will withdraw only a small proportion of river flows during periods when most fish larvae will be susceptible to entrainment. Entrainment losses of phytoplankton and zooplankton will be insignificant because of their relative unimportance in the river trophic structure. Total residual chlorine may be present in the blowdown in sufficient concentration to be toxic to aquatic organisms in the river. Because of the design and location of the blowdown discharge, concentrations of residual chlorine will persist for prolonged periods in the river, and the probability of mortalities to fish and other aquatic organisms is substantial. To mitigate this adverse situation, the applicant will be required to limit the concentration of total residual chlorine in the blowdown to 0.1 mg/l. No other chemical discharges are expected to create biological problems.

Under summer conditions, the blowdown temperature will not exceed the upper lethal threshold temperatures of river fishes, and no significant impact to fish or other aquatic biota are expected. Under winter conditions, the ΔT of the blowdown will be between 25 F° and 30 F°. Fish may be attracted to the relatively large area of elevated temperatures that will be present below the dam. Fish attracted to the area of maximum ΔT (20 F° to 30 F°) will be exposed to potential lethal cold shock, should all three units of CNS cease operating. The probability of this occurring, however, is very low.

The blowdown discharge should not create any significant problems of thermal blockage or benthic scour. The impacts of CNS operation on the aquatic environment are summarized in Table 5.7.

5.6 IMPACTS ON PEOPLE

5.6.1 Physical impacts

The staff concludes that the operation of the station will not result in any detectable odor offsite. Pollutants from fossil fuels used in the emergency diesel generators will have negligible impact since emissions will occur on an infrequent basis, will be of short duration, and will meet applicable standards.

Table 5.7. Summary of environmental impacts due to operation

Potential impact	Applicant's plans to mitigate	Expected relative significance	Corrective actions available and remarks
Impingement of organisms on intake screens	Intake velocity ≤0.5 fps. Impingement will be monitored. Intake design follows best technology available for minimizing impingement.	Insignificant	
Entrainment of organisms in cooling tower makeup water (Sect. 5.1.1.2)			
Phytoplankton and zooplankton	None	Insignificant	
Fish eggs, larvae, and juveniles	None	Insignificant	Low densities of ichthyoplankton are present. Applicant will remove only a small percentage of water flow during critical periods.
Chemical discharges (Sect. 5.1.2.1)			
Total dissolved solids	None	Insignificant	
Dissolved oxygen	None	Insignificant	
Chlorine	Intermittent use. Units will be chlorinated sequentially.	Significant; residual chlorine may be present at concentration toxic to aquatic organisms during periods of low river flow.	Applicant will be required to limit discharges of total residual chlorine to 0.1 mg/1, and no discharge of chlorine will be permitted when Ninety-Nine Islands Dam is not discharging water.
Sanitary wastes	Waste water treatment system		
Thermal effects (Sect. 5.1.2.2)			
High water temperatures	Closed-cycle cooling	Insignificant	
Cold shock	Closed-cycle cooling	Insignificant	
Thermal blockage	Closed-cycle cooling	Insignificant	
Scour at discharge	Low volume, low velocity discharge.	Insignificant	

Some noises will result from station operation. Major noise sources are the atmospheric steam dump, emergency diesel generators, air handling fans, switchyard, and cooling towers (ER, Sect. 5.7). The staff anticipates that the noisiest sources during normal operation will be the switchyard (primarily 60-cycle hum) and the mechanical-draft cooling towers. The applicant has indicated that noise levels due to cooling tower operation will not exceed 84 dB(A) in the range 63 to 8000 Hz at 250 ft from the towers (ER, Sect. 5.1.6). The shortest distance from cooling tower to site boundaries is about 3000 ft. Thus the staff does not consider that noise from cooling tower operation will cause any inconvenience at site boundaries.

The three reactor containment vessels, each about 160 ft above grade level, will be the tallest structures on the site. However, the plumes from the cooling towers will sometimes extend to heights in excess of the towers and consequently will be the most visible feature of the site. The applicant has indicated that plume lengths will exceed 1 mile about 10% of the time and will exceed 20 miles about 1% of the time during the period June-November (ER, Fig. 5.1.4-1). During the period December-May, visible plume lengths were calculated to exceed 1 mile about 10% of the time and to exceed 20 miles about 3% of the time (ER, Fig. 5.1.4-2), reflecting the expected increase in visible plume occurrence during the winter and spring months. Although these cooling tower plumes will contrast with the existing rural scene, they will not constitute a significant environmental cost.

5.6.2 Population growth and operating personnel income

The applicant estimates that about 250 permanent employees will be required for the operation of the station. The corresponding annual payroll will to be about $8,200,000.

5.6.3 Impact on community services

The applicant has not indicated the fraction of the required permanent employees that will be new residents of the nearby communities nor their distribution within these communities. However, the staff judges that the impact of the new residents on the communities in which they reside will be generally minor since their numbers are expected to be small in relation to the existing population. The staff considers that the taxes the new residents will pay will compensate their communities for the additional required services. The staff anticipates that the impacts on local highways will be greatly reduced after construction has been completed; therefore, traffic due to station operation will not place any undue burdens on traffic safety or highway maintenance personnel of the local communities.

5.6.4 Impact on local institutions

The principal institution that might be affected by the permanent work force could be the school systems of the local communities. However, since the total influx of operating personnel will be relatively small in relation to existing populations in these communities, the staff does not expect any significant effect on any school system as a result of plant operation. Neither does the staff consider that any other local institution will be significantly affected.

5.6.5 Impact on recreational capacity of the area

Because of the small numbers of persons that will move into the area in connection with the operation of the station and because the recreational opportunities currently existing in the area are expected to continue to exist during station operation, the staff does not consider that their presence will have any effect on recreational capacity of the area. Station operation will affect a small portion of the recreational capacity in the area since no recreational usage will be allowed within the fenced plant area; recreation on the Broad River will be restricted only during an emergency (ER, Response to Question 8.1.11). The staff does not consider that these losses in recreational capacity or potential restrictions on recreational use of the river will be of significance.

5.6.6 Tax payments by the station

The applicant has indicated that tax payments to the State of South Carolina in the form of franchise tax, power tax, income tax, and several minor taxes would probably amount to about $44.6 million per year (ER, Response to Question 8.1.6). Federal income tax liability is estimated to be about $71.4 million per year. Based on 1972 procedures, regulations, and rates, the total annual property taxes on CNS would be about $16,400,000 per year (ER, Response to Question 8.1.8); and the entire amount will go to Cherokee County. With the addition of the large capital investment in Cherokee County as a consequence of station construction [estimated assessed valuation of the station is about $134,200,000 (ER, Response to Question 8.1.7)], since the total assessed valuation of property in this county will be significantly increased [the 1972 assessed value was about $124,100,000 (ER, Table 8.1.2-1)], the county's tax rate may possibly be decreased with consequent reduced payments by the station. The revenue thus made available to the county government as a result of the presence of CNS will represent a considerable additional source of funds for this county. The staff concludes that this increase in revenue will be a significant benefit to the county.

5.6.7 Conclusions

The staff does not consider that noise or odor from station operation will significantly affect local residents. The visibility of the cooling tower plumes is not considered to be a significant environmental cost, although the staff recognizes that the appearance of these plumes in the rural countryside may offend some individuals.

Population added to the local communities as a result of the influx of operating personnel and their families will not contribute significantly to the population of these communities. The taxes paid by these workers to the local governmental units are expected to offset the additional services that the workers will require.

No local institutions will be significantly affected by the station's presence or by its operating personnel, nor will there be any significant adverse effect on existing recreational areas. The property taxes paid by the station to the local county government will be a significant benefit to this county.

REFERENCES FOR SECTION 5

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6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL PROGRAMS

6.1.1 Meteorological

The preoperational onsite meteorological program,[1] initiated in September 1973, consists of a 33-ft tower and a 135-ft tower (a converted electrical transmission tower) located where the proposed cooling towers will be. These towers will be replaced by a permanent meteorological facility. Wind speed and direction are measured at the top of the 33-ft tower. On the 135-ft tower, wind speed and direction are measured at the 135-ft level, vertical temperature gradient is measured between 30 ft and 130 ft, air and dewpoint temperatures are measured at 30 ft, and precipitation is measured near the ground. The data are recorded on strip charts.

The applicant has submitted one full year (September 11, 1973, through September 11, 1974) of onsite joint frequency distributions of wind speed and direction at the 33-ft level by atmospheric stability (as defined by vertical temperature gradient between 30 ft and 130 ft) in the format suggested in Regulatory Guide 1.23.[2] Similar distributions were submitted with wind data from the 135-ft level of the onsite tower. Also submitted were joint frequency distributions (with stability defined by the STAR program) for a five-year period (1968-1972) from Greenville-Spartanburg Airport. The staff has examined relative concentration (X/Q) values calculated using each joint frequency distribution (the wind speeds recorded at the 135-ft level were reduced to represent speeds at 33 ft by use of the power law for wind profiles). A Gaussian diffusion model with adjustments for building wake effects, described in Regulatory Guide 1.42,[3] was used to make estimates of relative concentration values. The relative concentration values calculated using each distribution were not significantly different in magnitude for pertinent distances and directions.

6.1.2 Ecological

6.1.2.1 Terrestrial

Cooling tower drift impact assessment

The applicant has presented an adequate statement of plans for determination of preoperational fog, visibility, and weather conditions for the Cherokee site for later postoperational correlation with conditions during operation of the cooling towers (ER, Sect. 6.1.3.1). No plans for preoperational monitoring of soil conditions in areas of future drift deposition were described, however. Therefore, the applicant should collect preoperational soil samples from several points where the drift is expected to be maximal for later studies of changes in salt content of the soil and other parameters resulting from cooling tower drift. Dissolved solids in groundwater should also be sampled so that any later changes in dissolved solids can be detected. As an alternative, soil and groundwater samples could be collected from affected areas after a time of operation and compared with samples from unaffected areas.

Terrestrial ecology

The applicant's data on terrestrial ecology were sufficient to determine, in general, the forest and vegetation types present on the Cherokee site and to determine most of the plant and vertebrate animal species commonly found on the site. The applicant's data were deficient with regard to species composition and various population parameters of plant and animal communities on the site and to the occurrence of endangered species. However, in the staff's judgment, the data supplied by the applicant, when supplemented by available literature on the ecology of the Piedmont Physiographic Province and staff observations, were adequate to permit a valid impact analysis.

After determining exactly what routes will be followed by the transmission lines and before any clearing is done, the applicant will be required to submit a report to the staff on the percentages of the proposed corridors in various land uses and in forest types given in Sect. 2.7.1 or in the following forest types, which can easily be identified from aerial photographs: coniferous, deciduous, mixed coniferous-deciduous, and thicket. The presence of any marshes, swamps, or historic sites must also be reported to the staff. Staff approval of specific routes will be required before the commencement of construction of transmission lines.

6.1.2.2 Aquatic

A preoperational ecological monitoring program has been undertaken by the applicant with the purpose of describing the important components of the aquatic ecosystem in the vicinity of the CNS site. Sampling was initiated in October 1973, and data have been presented to the staff for the period through October 1974.

Major emphasis has been expended on studying the Broad River, Ninety-Nine Islands Reservoir, and two onsite creeks (Fig. 6.1). In addition, several tributaries of the river have been sampled to provide complementary background information on the aquatic environment (ER, Fig. 6.1.1-1).

The water quality parameters and biological communities studied, plus the applicant's sampling schedule, are presented in the applicant's ER (ER, Tables 6.1.1-1 and 6.1.1-2). A brief summary of the sampling program is given in Table 6.1, while a more detailed description is given in the ER, Sect. 6.1.1.

Table 6.1. Sampling stations, gear, and methods used in the applicant's preoperation aquatic ecological monitoring program

Biological community	Sampling stations	Sampling gear	Sampling methods
Phytoplankton	1–23	Polyethylene bottles, alpha bottles, and a kemmerer bottle	Polyethylene bottles used for surface sampling; alpha bottle used for surface sampling from bridges; kemmerer bottle used for mid-depth and bottom sampling.
Periphyton	4, 8, 12, 15, 16, 17, 21, 23	Artificial substrates consisting of 1 in. X 3 in. glass slides embedded in weighted rubber stoppers	Samples are placed at each station each month. Slides are removed every two weeks.
Zooplankton	1–23	Wisconsin plankton net and Clark-Bumpus net	Wisconsin plankton net is used in the river and Clark-Bumpus net is used in the backwaters of the reservoir. Fifty-meter tows for each net.
Benthos	3–16, 21, 23	Surber sampler, Ekman grab, and Ponar grab	Surber sampler is used for shallow ground and rocky riffler; Ekman grab is used for soft substrates; Ponar grab is used for sand and in fast water.
Fish	2, 4, 5, 6, 9–16, 21, 23	Backpack and boat shocker, seines, fyke nets, and trammel nets	Electroschockers, 100-m stretch is sampled; seines, 25- or 50-m haul; trammel and fyke nets are set for 72 hr.

Generally, the applicant's preoperational monitoring program has been adequate. A few inadequacies existed initially which have been subsequently rectified. These included quantitative sampling for fish, ichthyoplankton, and benthic drift.

Beginning with sampling period 8, May 20-25, 1974, the applicant reduced the number of sampling stations from the original 23 to 12. Those that have been retained include 4, 8-15, 17, 21, and 23 (ER, Table 6.1.1-5). Figure 6.1 indicates those stations located in the immediate CNS site vicinity. The staff agrees with the applicant that this reduction in the number of sampling stations was expedient and should result in higher quality and more relevant data from the remaining stations.

6.1.3 Radiological

The applicant has proposed an offsite preoperational radiological monitoring program to provide for measurement of background radiation levels and radioactivity in the plant environs. The preoperational program, which provides a necessary basis for the operational radiological monitoring program, will also permit the applicant to train personnel and to evaluate procedures, equipment, and techniques, as indicated in Regulatory Guide 4.1.

A description of the applicant's proposed program is summarized in Table 6.2. Figure 6.2 shows the proposed sampling locations. The applicant has made a commitment to monitor the radioiodine pathways discussed in Sect. 5.3.4. More detailed information on the applicant's radiological monitoring program is presented in Sect. 6.1 of the ER. The applicant proposes to initiate parts of the program two years prior to operation of the facility, with the remaining portions beginning either six months or one year prior to operation.

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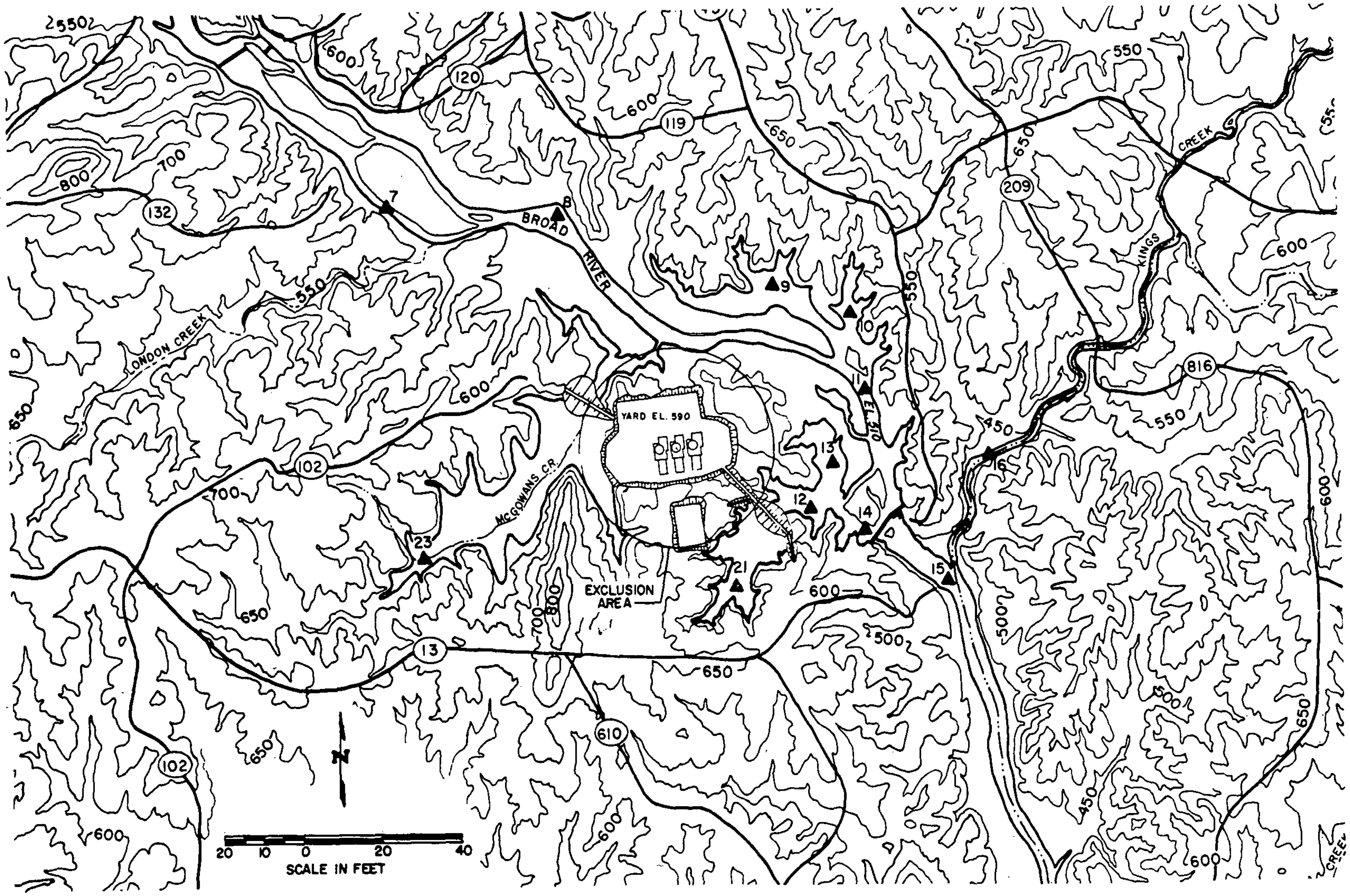

Fig. 6.1. Locations of aquatic sampling stations in the CNS site area.
Source: ER, Fig. 6.1.1-2.

Table 6.2. The preoperational radiological monitoring program

	Schedule	Gross alpha	Analyses Gross beta	Gamma analysis	Specific nuclides
1. Water	Monthly	x	x		^{89}Sr, ^{90}Sr, ^{3}H
	Quarterly	x	x	x	
2. Airborne particulates (including iodine, rain, and settled dust)	Monthly	x	x	x	^{131}I
3. Radiation dose and dose rate	Quarterly				
4. Bottom and shoreline sediment (including benthos)	Quarterly	x	x	x	^{60}Co
5. Aquatic vegetation and/or plankton	Quarterly (as available)	x	x	x	^{137}Cs, ^{40}K
6. Terrestrial vegetation, pasture grass, and crops (corn, beans, leafy green vegetables)	Quarterly (as available)	x	x	x	^{137}Cs, ^{40}K
7. Milk	Monthly			x	^{89}Sr, ^{90}Sr, ^{137}Cs, ^{40}K, ^{3}H, ^{131}I
8. Fish	Quarterly		x	x	^{89}Sr, ^{90}Sr, ^{137}Cs, ^{40}K

Source: ER, Table 6.1.1.

The staff concludes that the preoperational monitoring program proposed by the applicant is generally acceptable; however, to improve the effectiveness of the program, the staff recommends (1) that the applicant improve his analysis of milk samples to obtain a sensitivity of 0.5 pCi/l for I-131 and (2) that the applicant periodically sample domestic meats or wildlife forms in the pathway to man.

6.2 OPERATIONAL PROGRAMS

6.2.1 Radiological

The operational offsite radiological monitoring program is conducted to measure radiation levels and radioactivity in the plant environs. It assists and provides backup support to the detailed effluent monitoring (as recommended by Regulatory Guide 1.21), which is needed to evaluate individual and population exposures and to verify projected or anticipated radioactivity concentrations.

The applicant plans to continue the proposed preoperational program during the operating period. However, refinements may be made in the program to reflect changes in land use or preoperational monitoring experience.

An evaluation of the applicant's proposed operational monitoring program will be performed during the operating license review, and the details of the required monitoring program will be incorporated into the Environmental Technical Specifications for the operating license.

6.2.2 Terrestrial ecology

6.2.2.1 Cooling tower drift impact assessment

Because predictions of minimal vegetation damage were based on unverified drift deposition rates and plume behavior, the staff requires that the applicant establish a series of permanent plots at several locations within the area of cooling tower influence. The plots should be located in such a way that some lie in areas where the drift is expected or observed to be maximal. Foliage must be inspected for leaf burn and discoloration. Sampling should be carried out at monthly intervals extending through the first full year of operation of all three units and thereafter at quarterly intervals. If major damage to dominant vegetation is observed (e.g., extensive defoliation, dieback of trees and ornamentals on adjacent properties, decline of screening vegetation), appropriate steps should be taken to minimize drift losses and subsequent carry-over of circulating water solids. Also, if major damage to dominant vegetation occurs, groundwater must be sampled to detect any increases in dissolved solids over preoperational concentrations or over natural concentrations in unaffected areas offsite.

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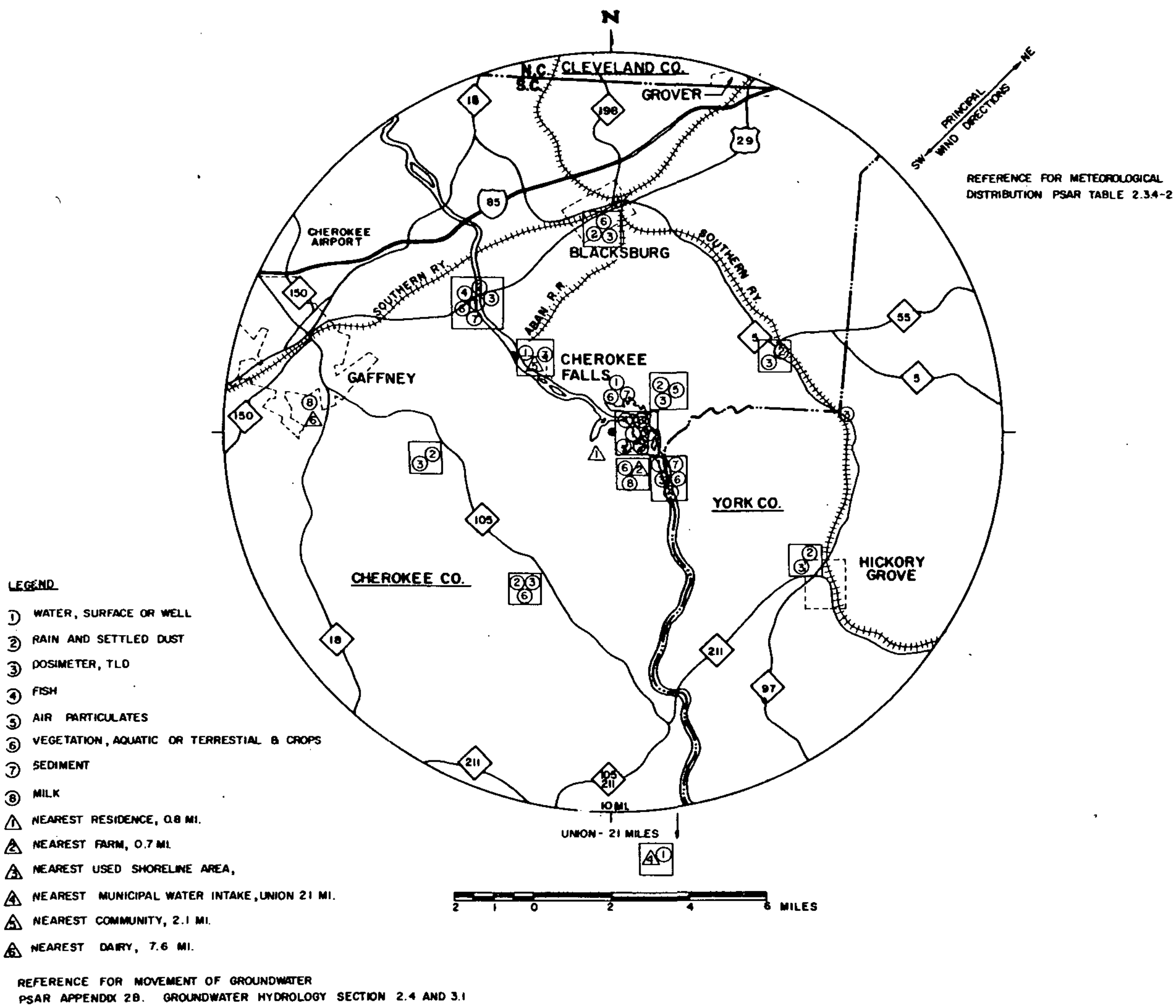

Fig. 6.2. Proposed radiological sampling stations.

6.2.2.2 Vegetation

The applicant stated that cleanup and restoration on transmission line rights-of-way entails smoothing and seeding of work areas, including the construction of access roads on the rights-of-way (ER, Sect. 4.2). Thus, all areas on the rights-of-way, according to the applicant's plans, should have a vegetative cover soon after construction is completed along each right-of-way. The staff requires that, after construction, the applicant survey the locations and approximate sizes of all areas on the rights-of-way where bare soil or subsoil is exposed and that the applicant make immediate attempts to revegetate such areas. This procedure would be most critical on slopes, where possible erosion would be maximal. As explained in Sect. 5.5.1, it is critical that vegetative cover be established before the topsoil is eroded away. After all bare areas have been initially revegetated, searches for bare areas should be made simultaneously with the transmission line inspections and bush-hogging and hand-clearing operations mentioned by the applicant (ER, Sect. 5.6).

For the station site, the site construction access roads, and the railroad spur, the applicant is required, as above, to survey and treat areas of bare soil.

6.2.2.3 Fauna

Because of the total ultimate dependency of all faunal populations on primary (plant) production, the staff places most emphasis on requirements that the applicant conserve topsoil and revegetate cleared areas with lush vegetation that forms a complete cover over soil. Given such conditions, animal populations should thrive, and on a long-term basis the total animal community should not experience serious reductions in numbers. Therefore, the staff does not require that the applicant establish a program for monitoring faunal populations.

6.2.3 Aquatic ecology

The applicant has not presented definitive plans for the operational aquatic ecological monitoring program. Prior to completion of the preoperational program, the data will be evaluated to determine which portions of the program should be continued for operational monitoring purposes.

Prior to issuance of an operating permit, the staff will issue Environmental Technical Specifications related to operational monitoring procedures.

REFERENCES FOR SECTION 6

1. Duke Power Company, Cherokee Nuclear Station Preliminary Safety Analysis Report, Docket Nos. 50-491, 50-492, and 50-493.

2. U.S. Atomic Energy Commission, Regulatory Guide 1.23, "Onsite Meteorological Programs," USAEC Directorate of Regulatory Standards, Washington, D.C., 1972.

3. U.S. Atomic Energy Commission, Regulatory Guide 1.42, "Interim Licensing Policy On As Low As Practicable for Gaseous Radioiodine Releases From Light-Water-Cooled Nuclear Power Reactors," USAEC Directorate of Regulatory Standards, Washington, D.C., 1973.

7. ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

A high degree of protection against the occurrence of postulated accidents in CNS is provided through correct design, manufacture, and operation and through the quality assurance program used to establish the necessary high integrity of the reactor system, as will be considered in the Commission's Safety Evaluation. Deviations that may occur are handled by protective systems designed to place and maintain the plant in a safe condition. Notwithstanding this requirement, the conservative postulate is made that serious accidents might occur, even though they may be extremely unlikely; and engineered safety features will be installed to mitigate the consequences of those postulated events judged credible.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed by using best estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the Commission's Safety Evaluation, extremely conservative assumptions are used to compare calculated doses that result from a hypothetical release of fission products from the fuel against the 10 CFR Part 100 siting guidelines. Realistically computed doses that would be received by the population and environment from the postulated accidents would be significantly less than those to be presented in the Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971, requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicant's response was contained in the Cherokee Nuclear Station Environmental Report, dated June 1974.

The applicant's report has been evaluated, using the standard accident assumptions and guidance issued by the Commission on December 1, 1971, as a proposed amendment to Appendix D of 10 CFR Part 50. Nine classes of postulated accidents and occurrences that range in severity from trivial to very serious were identified by the Commission. In general, accidents in the high-potential-consequence end of the spectrum have a low occurrence rate and those on the low-potential-consequence end have a higher occurrence rate. The examples selected by the applicant for these cases are shown in Table 7.1. The examples selected are reasonably homogeneous in terms of probability within each class.

Commission estimates of the dose that might be received by an assumed individual standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table 7.2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table 7.2. The man-rem estimate was based on the projected population within 50 miles of the site for the year 2020.

To rigorously establish a realistic annual risk, the calculated doses in Table 7.2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences that are anticipated during plant operations; and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures and some steam generator leakage, the events in Classes 3 through 5 are not anticipated during plant operation; however, events of this type could occur sometime during the 40-year plant lifetime. Although accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5, they are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table 7.2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered in the design bases of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is judged so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers); quality assurance for design, manufacture, and operation; continued surveillance and testing; and conservative design are all applied to provide and maintain a high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

Table 7.1. Classification of postulated accidents and occurrences

Class	NRC description	Applicant's examples
1	Trivial incidents	Evaluated under routine releases
2	Small releases outside containment	Minor spills and leaks; evaluated under routine releases
3	Radioactive waste system failure	Release of a waste gas storage tank; release of contents of a liquid storage tank
4	Fission products to primary system (BWR)	Not applicable
5	Fission products to primary and secondary systems (PWR)	Fuel cladding defects and steam generator tube leaks; off-design transients that induce fuel failure above those expected and steam generator tube leak; steam generator tube rupture
6	Refueling accident	Fuel bundle drop inside the containment; heavy objects dropped onto fuel in core
7	Spent fuel handling accident	Fuel assembly drop in the fuel storage pool; heavy object dropped into a fuel rack; fuel cask drop
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Loss of coolant accidents; rod ejection accident; steam line break
9	Hypothetical sequence of failures more severe than Class 8	Not considered

The NRC is continuing a study originated by the USAEC to assess these risks more quantitatively. The initial results of these efforts were made available in draft form on August 20, 1974.[1] This study, called the *Reactor Safety Study,* represents an effort to develop realistic data on the probabilities and sequences of accidents in water-cooled power reactors in order to improve the quantification of available knowledge related to nuclear reactor accident probabilities. The Commission organized a special group of about 50 specialists under the direction of Professor Norman Rasmussen of MIT to conduct the study. The scope of the study, which has been discussed with EPA and described in correspondence with EPA, has been placed in the NRC Public Document Room.[2]

As with all new information developed that might have an effect on the health and safety of the public, the results of these studies will be made public and will be assessed on a timely basis within the regulatory process on generic or specific bases as may be warranted.

Table 7.2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary which are less than those that would result from a year's exposure to the maximum permissible concentrations of 10 CFR Part 20. Table 7.2 also shows the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident. Any of these integrated exposures would be much smaller than those from naturally occurring radioactivity. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. The conclusion from the results of the realistic analysis is that the environmental risks due to postulated radiological accidents are exceedingly small and need not be considered further.

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

As discussed in Sect. 5.4.2.5, the staff has completed an analysis of the potential impact on the environment of transporting fuel and solid radioactive wastes for nuclear power plants under existing regulations. The results of this analysis were published in a report entitled *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants.*[3] The report contains an analysis of the probabilities of occurrences of accidents and the expected consequences of such accidents, as well as the potential exposures to transport workers and the general public under normal conditions of transport.

Table 7.2. Summary of radiological consequences of postulated accidents[a]

Class	Event	Estimated fraction of 10 CFR Part 20 limit at site boundary[b]	Estimated dose to population in 50-mile radius (man-rem)
1.0	Trivial incidents	*c*	*c*
2.0	Small releases outside containment	*c*	*c*
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.048	5.2
3.2	Release of waste gas storage tank contents	0.19	20
3.3	Release of liquid waste storage contents	0.005	0.57
4.0	Fission products to primary system (BWR)	NA	NA
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	*c*	*c*
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	0.001	0.12
5.3	Steam generator tube rupture	0.064	6.8
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.01	1.1
6.2	Heavy object drop onto fuel in core	0.17	19
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.006	0.68
7.2	Heavy object drop onto fuel rack	0.026	2.7
7.3	Fuel cask drop	0.15	16
8.0	Accident initiation events considered in design basis evaluation in the Safety Analysis Report		
8.1	Loss-of-coolant accidents		
	Small break	0.11	22
	Large break	0.14	54
8.1(a)	Break in instrument line from primary system that penetrates the containment	NA	NA
8.2(a)	Rod ejection accident (PWR)	0.014	5.4
8.2(b)	Rod drop accident (BWR)	NA	NA
8.3(a)	Steamline breaks (PWRs outside containment)		
	Small break	<0.001	<0.1
	Large break	<0.001	<0.1
8.3(b)	Steamline break (BWR)	NA	NA

[a]The doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials resulting in both a direct and an inhaled dose. Our evaluation of the accident doses assumes that the applicant's environmental monitoring program and appropriate additional monitoring (which could be initiated subsequent to a liquid release incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in a timely manner such that remedial action could be taken if necessary to limit exposure from other potential pathways to man.

[b]Represents the calculated fraction of a whole-body dose of 500 millirems, or the equivalent dose to an organ.

[c]These radionuclide releases are considered in developing the gaseous and liquid source terms presented in Section 3 and are included in doses in Section 5.

The initial fuel supply for each unit of CNS will be supplied from Windsor, Connecticut. New fuel elements will be shipped approximately 830 miles from the fabrication plant to the site by truck.

Each unit will replace about 81 of the 241 fuel assemblies each year. Spent fuel elements will be shipped from the site by truck or rail to Barnwell, South Carolina, a distance of about 170 miles.

Solid radioactive wastes will be shipped by truck to the nearest disposal site in Barnwell, South Carolina (Chem-Nuclear Services), a distance of about 170 miles. This will involve approximately 53 shipments per year for three units.

The transportation of cold fuel to the plant, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the AEC report mentioned above.[3] The environmental risks of accidents in transportation are summarized in Table 7.3. (Normal conditions of transport were summarized in Table 5.3.)

Table 7.3. Environmental risks of accidents in transport of fuel and waste to and from a typical light-water-cooled nuclear power reactor[a]

	Environmental risk
Radiological effects	Small[b]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[a]Data supporting this table are given in the Commission's *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*, WASH-1238, December 1972.

[b]Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

REFERENCES FOR SECTION 7

1. U.S. Atomic Energy Commission, *Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Draft,* WASH-1400, August 1974.

2. Letter from W. D. Doub, USAEC, to D. D. Dominick, Environmental Protection Agency, June 5, 1973.

3. U.S. Atomic Energy Commission, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants,* WASH-1238, December 1972.

8. THE NEED FOR POWER GENERATING CAPACITY

The staff's assessment of the applicant's need for additional power generating capacity in the period 1983-1989 is presented in this section. The evaluation includes discussions of the applicant's power system, power requirements, power supply and reserve requirements.

8.1 APPLICANTS SERVICE AREA AND REGIONAL RELATIONSHIPS

8.1.1 Applicant's service area

The applicant, Duke Power Company (DPC), supplies retail and wholesale electricity to a service area of about 20,000 sq miles located in western North Carolina and South Carolina (Fig. 8.1) and served populations of about 3,205,000 and 566,000 in these two states, respectively, in 1973.[1] Its service area includes 50 counties in North Carolina and South Carolina; in 44 of these it is the principal supplier of electricity.[2] Duke Power Company supplies retail electric service to about 211 cities and wholesale electric service to about 39 other municipalities for resale over their distribution systems. It also supplies wholesale electrical energy to Rural Electrical Association cooperatives and to other utilities. In 1973, 15% of DPC's total kilowatt-hour sales were at wholesale rates.[3] The applicant obtains about 70% of its operating revenue from its North Carolina customers and about 30% from those in South Carolina.

8.1.2 Regional relationships

The applicant's service area is within the Federal Power Commission's (FPC) Southeastern Power Survey Region[4] and is located nearly entirely within the FPC's power supply area (PSA) 21 (Fig. 8.2). The applicant is a party to the Southeastern Electric Reliability Council (SERC), which is one of the Nation's nine regional reliability councils. The Southeastern Electric Reliability Council encompasses the same area as the Southeastern Power Survey Region. This region has about 17.5% of the area of the continental United States and about 15.4% of the 1967 population.[5] Southeastern Electric Reliability Council is divided into four subregions: Florida (PSA 24), Southern Companies (PSAs 22 and 23), Tennessee Valley (PSA 20), and the Virginia-Carolinas PSAs 18 and 21). Areas of load concentration within SERC are shown in Figure 8.2. This figure indicates that within PSA 21, most of the major area of load concentration is located within the applicant's service area (as indicated in Fig. 8.1). The applicant is a member of the Virginia-Carolinas (VACAR) subregion. It is not currently a member of any power pool.

8.2 POWER REQUIREMENTS

Planning for electric utility needs is based on both a forecast of anticipated annual energy consumption and peak load demand over a given period of years. The applicant's historical and projected energy consumption and peak load demands, the effects of energy conservation and the staff's forecast of peak load demand are discussed in the following sections.

8.2.1 Energy consumption

Historical and forecast energy consumption and annual peak load for the applicant's service area is given in Table 8.1. Energy consumption grew from 20,322 x 10^6 kWhr in 1964 to 46,502 x 10^6 kWhr in 1973, a 9.6% compound annual rate of growth. Energy consumption was 45,630 x 10^6 kWhr in 1974, a decrease from 1973 of 1.9%. During the period 1964 to 1973 the applicant's service area experienced a rate of growth in energy consumption considerably greater than that of 7.3% for the nation as a whole.[6,7,8] In 1974 national energy consumption remained at the 1973 level. The lack of growth in energy consumption during 1974 is attributable to both a pervasive economic recession and an energy crisis due primarily to high prices and temporary shortages of oil.

The percentage consumption of electricity in major customer categories is shown in Table 8.2 for the applicant's system and compared with the South Atlantic states, and the United States as a whole. The figures in Table 8.2 indicate that the applicant's percentage residential sales of electricity is lower than the United States' average but that its commercial and industrial sales percentage is higher. These statistics reflect the degree of industrialization in the applicant's service area and especially reflects the importance of electricity intensive industry, noteably textiles.

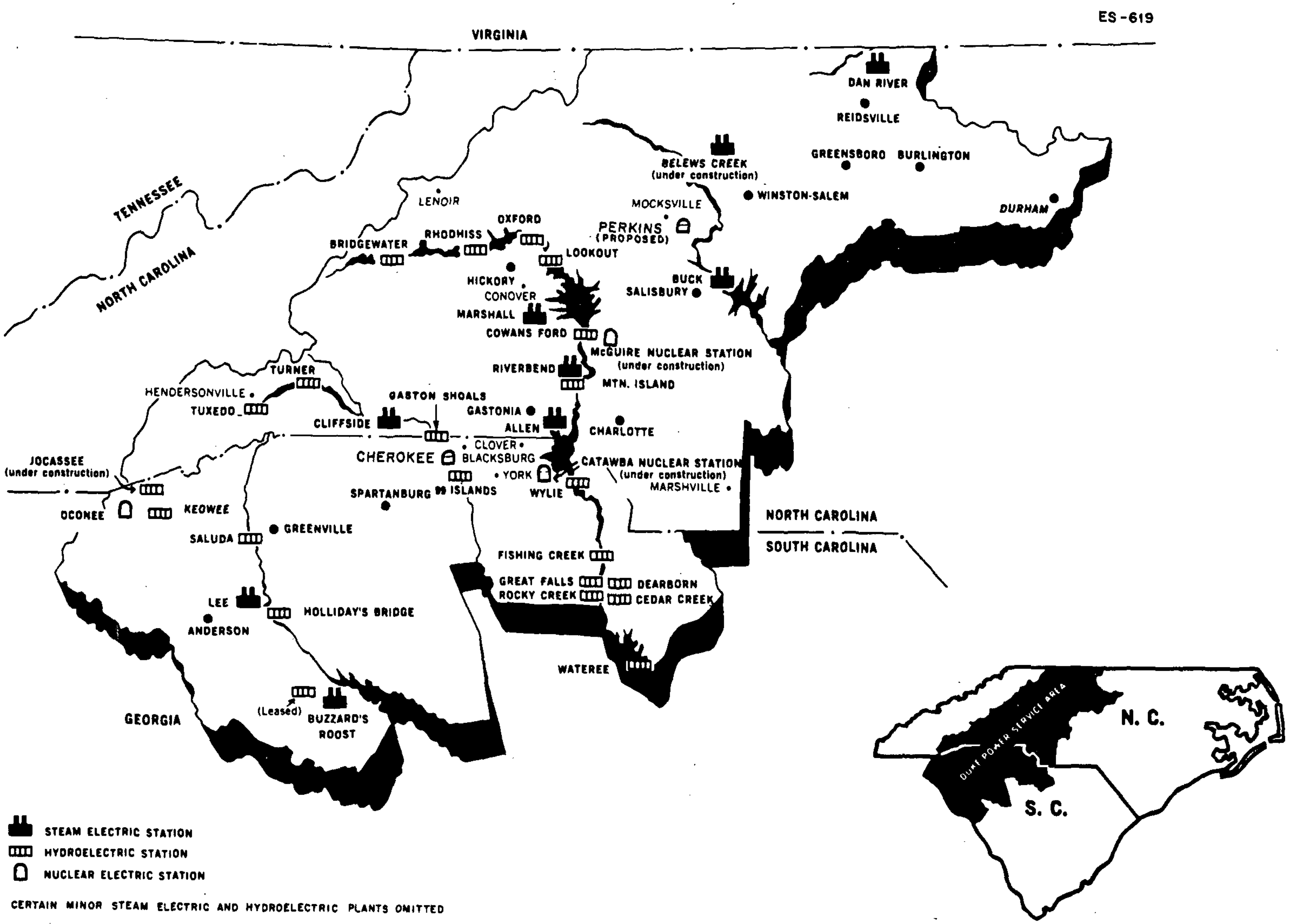

Fig. 8.1. Duke Power Company service area.

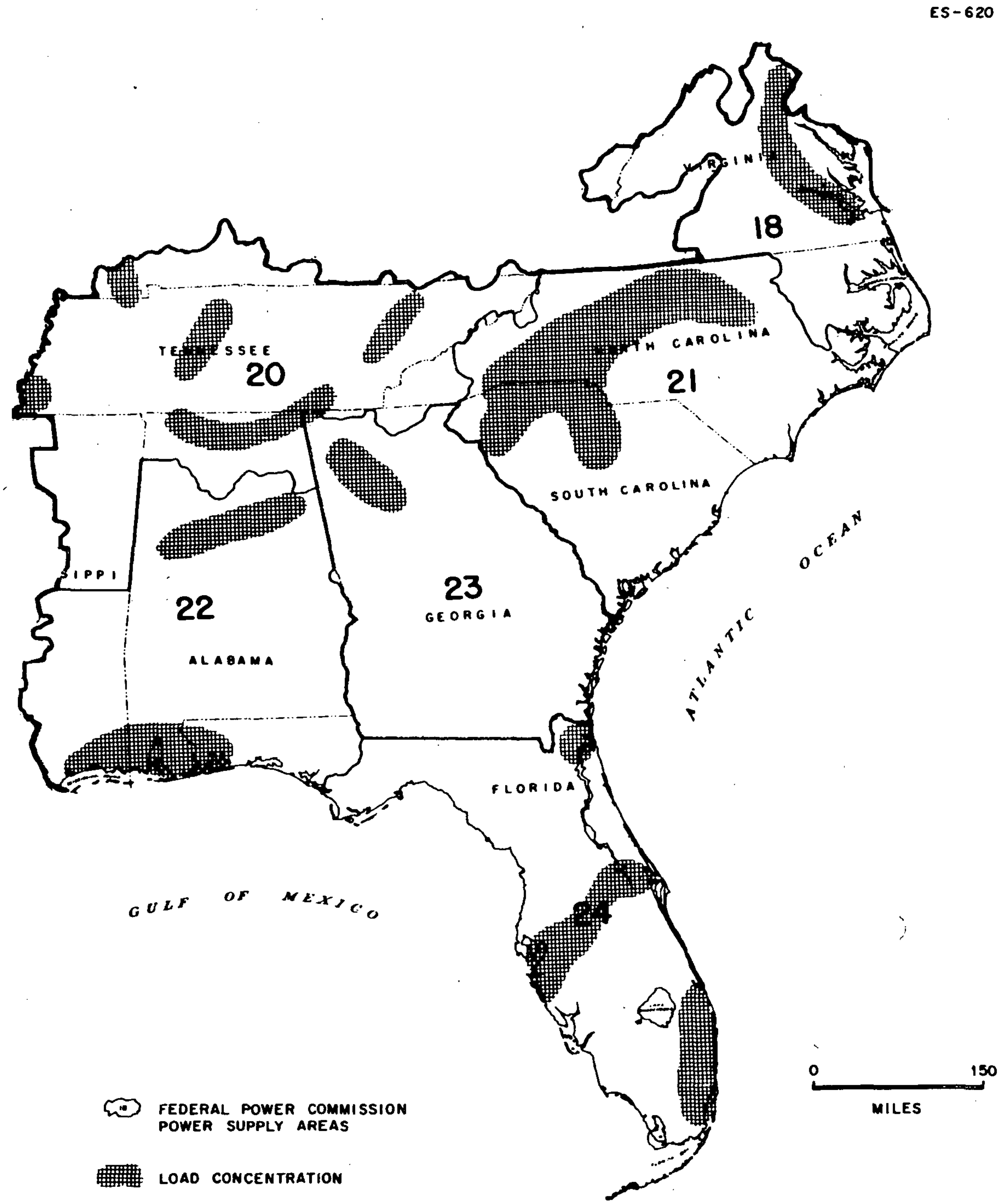

Fig. 8.2. The area encompassed by the Southeastern Electric Reliability Council, its FPC Power Supply Areas, and areas of load concentration.

TABLE 8.1

ENERGY CONSUMPTION AND SUMMER PEAK LOAD
DUKE POWER COMPANY, HISTORIC AND FORECAST, 1964-1988

Year	10^6 KWhr[a]	MWe[b]
Actual		
1964	20,322	3,522
1965	22,648	3,826
1966	25,692	4,440
1967	28,139	4,580
1968	31,032	5,364
1969	33,900	5,614
1970	36,641	6,284
1971	39,576	6,622
1972	42,990	7,450
1973	46,283	8,236
1974	45,240	8,058
Forecast		
1975	47,734	8,633
1976	52,387	9,721
1977	56,851	10,512
1978	61,346	11,341
1979	65,942	12,209
1980	70,637	13,119
1981	75,699	14,073
1982	81,041	15,074
1983	86,719	16,124
1984	92,746	17,226
1985	98,715	18,383
1986	105,239	19,598
1987	112,096	20,875
1988	119,629	22,217

[a]SOURCE: ER, Table 1.1.1-1.

[b]SOURCE: Actual, ER Table 1.1.1-1; Applicant's forecast of 12-23-74 attachment to letter from D. B. Blackmon to R. A. Gilbert dated January 31, 1975.

Table 8.2 Percentage consumption of electricity in several categories for the United States in 1960; for the United States, and the South Atlantic States in 1972, and for the applicant's service area in 1973

	USA 1960[a]	USA 1972[a]	South Atlantic States[b,c]	DPC 1973[d]
Residential	28.7	32.4	37.0	27.8
Commercial and Industrial	67.3	63.5	59.0	71.3
Street and highway lighting	0.9	0.8	0.7	0.3
Other public authorities	2.3	2.7	3.2	0.6
Other	0.8	0.6	0.2	0.02

[a]Edison Electric Institute, *Statistical Yearbook of the Electric Utility Industry of 1972*, calculated from data presented on p. 31.

[b]ibid-calculated from data presented on p. 33.

[c]Delaware; Maryland; Washington, D.C.; Virginia; West Virginia; North Carolina; South Carolina; Georgia; and Florida.

[d]Duke Power Company, *Uniform Statistical Report - Year Ended December 31, 1973*, p. E.14, data for 1973. Does not include 15.1% of the total DPC output which was in the category of "Sales for Resale."

In forecasting energy consumption, the applicant gives explicite consideration to a number of demographic, economic and technological factors.[9] Residential energy consumption forecasts incorporated federal population forecasts, other demographic trends, judgmental assumptions on the future availability of alternative sources of energy and appliance saturation. Industrial energy consumption forecasts are based on an assumption that industrial growth in the service area will be some what lower than in the recent past. Textile energy is specifically related to GNP in the forecast.

Table 8.1 shows consumption is forecast to grow from 45,240 x 10^6 kwhr in 1974 to 92,746 x 10^6 kwhr in 1984 and 119,629 x 10^6 kwhr in 1988. The applicant forecasts a rate of growth declining slower over the period from 8.5% between 1976 and 1977 to 6.7% between 1987 and 1988.

8.2.2 Peak load demand

Historical and forecast annual maximum peak load demand for the applicant's system is given in Table 8.1. Peak load grew from 3,522 MWe in 1964 to 8,236 MWe in 1973, a 9.9% compound annual rate of growth. Peak demand was 8,058 MWe in 1974 or 2.2% below the 1973 level. As in energy consumption, the rate of growth in peak load was considerably higher than that of the nation as a whole, 7.8% over the period 1964 through 1973.[6,7,8] Non-coincident peak demand, nationally, in 1974 was 349,350 MWe, 1.6% over that in 1973.[7] As for energy consumption, this lack of growth is attributable to the recession and the energy situation.

The applicant forecast of peak load considers base and weather responsive components (ER 1.1-4). Both summer and winter peaks are forecast. Forecasts of sales (energy consumption) and peak load are made independently and their consistency is checked by the reasonableness of the derived load factor.[9] In its system load forecast of January 10, 1975, the applicant revised its previous forecast downward to account for the anticipated impact of a load management program now being formulated.[10]

The applicant assumes that the present economic recession will retard an upturn in peak demand until 1976. Thereafter, peak demand is forecast to grow to 17,226 MWe in 1984 and 22,217 MWe in 1988. The applicant forecasts a rate of growth declining over the period from 8.1% between 1976 and 1977 to 6.4% between 1987 and 1988. During the forecast period 1975-1990 winter peak load is growing slightly faster than summer peak load surpassing it in 1985 and being 2.0% higher by 1988.[11]

8.2.3 The impact of energy conservation and substitution on energy and peak load demand

The sudden distruption of oil supplies, shortages in natural gas supplies and drastic price increases for all forms of energy have focused the Nation's attention on the importance of energy conservation as well as on measures to increase the availability of alternative energy sources. A number of significant efforts have been made during the past several years in forecasting the nation's energy needs and to estimate the potential for conserving energy and the potential for developing alternative sources of energy.[12,13] While the staff analysis of peak demand in section 8.5.1 adopts certain results of the Federal Energy Administration's Project Independence analysis which accounts for potential energy conservation, it is useful to summarize a number of conservation measures and considerations which have a specific bearing on energy requirements and peak load demand in the applicant's service area.

8.2.3.1 Recent experience

Implementation of energy conservation measures by households, businesses, and government has already contributed to the lack of growth in the national consumption of electricity since the third quarter of 1973. Consumption of electricity, in the applicant's service area, has been less than previously forecast by an average of 29% during the period October 1973 to October 1974. Monthly peak load demand was lower than forecast by an average of 26% during the same period. While the technical feasibility of numerous energy conservation measures in residences, public buildings, factories, shops and transportation has been well documented, the degree to which these measures will be implemented on a permanent basis is quite speculative at this time and needs further analysis.

8.2.3.2 Promotional advertisement and conservation information services

In the past, Duke Power Company has attempted, through advertising, to accelerate the demand for electricity in its service area. Generally, the major thrust of advertising was to promote demand during off-peak periods, thereby covering expensive peaking capacity with expanded lower cost baseload capacity. Notably, electric space heating, and water heating have been promoted to offset the higher seasonal peaking demands and to level loads.

The applicant terminated promotional advertising in March 1973[14] and, by direct mail and mass-media advertising, disseminated information designed to promote efficient residential usage of electricity. Accordingly, elimination of promotional advertising is no longer an important measure for the applicant to use to dampen demand. On the other hand, promotional advertising by manufacturers of electrical appliances and equipment has not been eliminated. These manufacturers spent an estimated $450 million in promotional advertising in 1972.[15]

The staff's opinion is that there is increasing evidence that programs that promote conservation of electricity will have a significant impact on projected demand.

8.2.3.3 Change in utility rate structure

The Federal Power Commission regulates the rates for interstate wholesale electric energy,[16] while the North Carolina Utilities Commission and the South Carolina Public Service Commission regulate the rates that utilities charge the ultimate consumer in the applicant's service area.[17]

Historically, utility rate structures were designed to encourage consumption of electricity by using declining block rates, which reflected the declining average cost of furnishing additional kilowatt hours of electrical energy to each customer. Under today's conditions of increasingly scarce fuel resources, declining block rates, by lowering the price of each additional kilowatt hour, leads to unnecessary use of electricity. The most commonly mentioned alternatives to declining block rates to dampen demand for electricity are the increase of block rates, peak load pricing, and flat rates.

The applicant is continually studying the effects of alternative rate structures. The North Carolina Public Utilities Commission has stated that, among other considerations, an appropriate rate design should conserve energy resources.[25]

Table 8.3 presents statistics on the average cost of electricity to consumers and the average energy (kilowatt-hours) used per customer from 1964 through 1971. Statistics such as these indicate that increasing consumption of electricity may occur in spite of increasing prices. The question that statistics such as these do not answer, is at what point will the costs of residential and commercial electricity cause the consumer to significantly decrease his demand. It is likely, however, that with sufficiently high prices the growth rate of total demand could be significantly reduced. Since the demand for electricity is also sensitive to such other factors as the gross national product, the local economy, the substitution of electricity for more scarce fuels, population growth, and local temperature variations, there are questions of how long it would take a rate change to have a detectable effect.

8.2.3.4 Load shedding, load staggering, and interruptible load contracts to reduce peak demand

Load shedding is an emergency measure employed to prevent system collapse when peak demand placed upon the system is greater than the system is capable of providing. This measure is usually not taken until all other measures are exhausted. The Federal Power Commission's report on the major load shedding that occurred during the northeast power failure of November 9 and 10, 1965, indicates that reliability of service of the electrical distribution systems should be given more emphasis, even at the expense of additional costs.[18] This report identified several areas that are highly impacted by loss of power, such as elevators, traffic lights, subway lighting and prison and communication facilities. The serious impact on areas such as these means that load shedding should only be considered a temporary method to overcome a shortage of generating capacity during an emergency.

Load staggering, especially if associated with some price incentive, may prove to have some limited potential as a conservation measure. Basically, this alternative involves shifting the work hours of industrial or commercial firms to avoid diurnal or weekly peaks and shifting now critical residential loads to off-peak hours. The applicant's load management program is considering several load staggering measures.[10]

Table 8.3. Statistics on cost and consumption of electricity (1964–1971)[a]

	Average cost to consumers – cents per kilowatt – hour			Average kilowatt – hours per customer (thousands)		
	Residential	Commercial	Industrial	Residential	Commercial	Industrial
1971	2.32	2.20	1.10	7.639	42.598	1735.482
1970	2.22	2.08	1.02	6.700	40.480	1695.087
1969	2.21	2.06	0.98	6.246	37.607	1666.019
1968	2.25	2.07	0 97	5.706	35.009	1578.366
1967	2.31	2.11	0.98	5.220	32.234	1481.496
1966	2.34	2.13	0.98	4.931	30.238	1445.802
1965	2.39	2.18	1.00	3.618	28.093	1289.949
1964	2.45	2.26	1.02	4.377	25.450	1217.878

[a]Federal Power Commission, *Statistics of Privately Owned Electric Utilities in the United States, 1971*, FPCS 226, U.S. Government Office, Washington, D.C., October 1972.

For interruptible load contracts to be effective in system planning, the load reduction must be large enough to be effective in system stability planning. Thus, this type of contract is primarily related to industrial customers. Currently, the applicant does not have a rate schedule for interruptible loads. The acceptability of interruptible load contracts to industrial customers depends upon balancing the potential economic loss resulting from unannounced interruptions against the saving that results from the reduced price of electricity. If the frequency or duration of interruptions increases as a result of insufficient installed capacity, the customer will convert to a normal industrial load contract. Even if the applicant had a large interruptible load, it is speculative to project that customers would continue this contractual relationship if faced with frequent and long periods of no electrical service.

None of the above measures can be considered as viable alternatives for required additional capacity, and they can do little to solve the energy shortage.

8.2.3.5 Factors affecting the efficient utilization of electrical energy

During the past two years, much of industry, the Federal Government, and many State and local governments have made the promotion of energy conservation a priority program. The Department of Commerce has developed a department-wide effort to (1) encourage business firms to conserve energy during operation, (2) encourage the manufacturing and marketing of more energy-efficient products, and (3) encourage businessmen to disseminate information on energy conservation. The National Bureau of Standards has been given a leading role in promoting the development and implementation of energy-saving standards. The programs include voluntary labeling of household appliances; research, development, and education relative to energy conservation in building; efficient use of energy in industrial processes; and improved energy in environmental control processes. While many efficiencies in electricity usage have already been gained and further efficiencies will be realized, any present estimates of the magnitude of future electricity savings must be treated as tentative and subject to continual reassessment.

The need for generating capacity is based on annual peak load demand and not on the volume of consumption over the year. Any conservation measures that reduce consumption but not peak demand will have little or no impact on the need for capacity. The applicant's most recent forecasts for total sales and annual peak-load demand indicate that total sales are expected to grow at less than peak demand. The growth in peak demand will continue to be strongly influenced by installation of air conditioning and electric heating in an increasing percentage of residential, commercial and industrial buildings.

Considerable efficiency can be achieved in space conditioning by improved insulation and the use of building materials with better insulation properties as well as by using equipment that transfers or stores excess heat or cold. For example, the seven-story Federal Office Building to be built in Manchester, New Hampshire, illustrates the potential for energy conservation in future commercial buildings that will use existing technology.[19] For this particular building, energy savings are anticipated to be a minimum of 20 to 25% over a conventionally designed building in the same location. Heat savings alone are expected to be 44% because of better insulated walls, less window area, use of efficient heating and heat storage equipment, and the use of solar collectors on the roof.

In 1971, FHA established new insulation standards to reduce average residential heating losses by one third. Studies have shown that it is possible to gain even greater reductions in heat loss through improved insulation at costs that are economical over a period of years.[20] Improved insulation helps conserve energy not only in winter but also reduces the air-conditioning burden in the summer.

Lighting, which has accounted for about 24% of all electricity sold nationally, is another area where savings are being realized. Many experts believe recommended lighting levels in typical commercial buildings have been excessive.[21] Calculations reveal that adequate illumination in commercial buildings can be achieved at 50% of current levels through various design and operational changes.[22] Another study indicates that if all households in 1970 had changed from incandescent to fluorescent lighting, the residential use of electricity for lighting would have been reduced approximately 75%, and total electrical sales would be reduced approximately 2.5%.[23] However, since the majority of residential lighting occurs in off-peak hours, the reduction on peak demand would be less than 1%.

The potential for greater energy efficiency in household appliances is well recognized. The National Bureau of Standards is working with an industrial task force from the Association of Home Appliance Manufacturers in a voluntary labeling program that would provide consumers with energy consumption and efficiency values for each appliance and educate them about the use of this information. Room air-conditioners are the first to be labeled. The next two categories of household appliances that will be labeled are refrigerators, refrigerator/freezers, and hot-water heaters.

The importance of energy-efficiency labeling of appliances is that it will allow the consumer to select the most energy-efficient appliance. A recent study entitled, "The Room Air Conditioner as an Energy Consumer," has estimated that an improvement in the average 1973 efficiency of 6 BTU/Whr to 10 Btu/Whr (a 67% increase) could hypothetically save electric utilities almost 58,000 MW in 1980.[24] This study was based on sales in 1972 and escalated these sales figures at the rate existing at that time to the 1980 date. It was further assumed that new and replacement air conditioners would have the higher efficiencies. Air conditioners that are more energy efficient require a combination of increased heat exchanger size and higher efficiency compressors that will result in higher initial cost. The consumer must be convinced that it is profitable for him in the long run to purchase the more expensive machine. Today, however, there is a high degree of uncertainty in predicting to what extent consumers will actually purchase these more expensive appliances. In addition, selection of central air conditioning by developers and many home owners has historically been based on minimizing front-end costs consistent with meeting local building codes.

Considerable opportunity for electricity conservation exists in industry in addition to lighting and air-conditioning efficiency already mentioned. Electric motors should be turned off when not in use and motors should be carefully sized according to work they are to perform. Small savings can be realized by de-energizing transformers whenever possible. Fuel requirements for vacuum furnaces can be reduced by 75% if local direct-combustion low-quality heat is employed rather than high-quality electrical heating.[25]

The above examples of potential energy saving will certainly impact energy and peak load to some degree in the future. The precise degree, however, is speculative at this time. The applicant is aware of the desireability of promoting energy conservation and is considering the potential impact on peak demand in its system (ER 1.1.2, and Reference 10).

In addition, the staff is aware that the National Institute of Occupational Safety and Health has recommended heat stress standards to the Occupational Safety and Health Administration which, if adopted, would require a significant number of employers to air-condition their plants.[26] This possible requirement would likely contribute to peak load demand.

8.2.3.6 Consumer substitution of electricity for scarce fuels

While conservation measures are rather quickly adopted in a crisis situation, the consumer's substitution of electrical energy for fuels, such as oil or gas, takes several years to result in a substantial upward impact on the need for power. The staff expects that substitution of electricity for scarce energy sources will likely accelerate in the applicant's service area because of the uncertainty of oil and gas supplies and because of the outlook for higher prices for them relative to the price of electricity produced from coal-fueled or nuclear-fueled plants. For instance, in the applicant's service area 25% of living units were electrically heated in 1970 and a projected 60% will be electrically heated by 1980. Other increases are forecasted in the growth of electric water heaters and ranges. The advent of electric automobiles or other new uses of electricity cannot be discounted but are not now quantified in projecting need for power since the use of such items is speculative. The staff concludes that substitution effect will, to some degree, offset savings from energy conservation techniques.

8.3 RESERVE REQUIREMENTS

8.3.1 Applicant's reserve requirements

Reliability of electricity supply is one condition which all electric power systems attempt to assure in capacity planning. As a member of the Southeastern Electric Reliability Council (SERC) the applicant supports the four objectives of the SERC Agreement:

(a) encourage the development of reliability agreements among the systems within the region;

(b) exchange information with respect to planning and operating matters relating to the reliability of bulk power supplies;

(c) review periodically activities within the region on reliability;

(d) provide information with respect to matters considered by the Council, where appropriate, to the Federal Power Commission and to other Federal and State agencies concerned with reliability." (ER 1.1-7)

Reliability is associated with an excess of generating capacity over the likely annual peak load. This excess is termed the reserve margin.

Reliability, although conceptually measurable in terms of probability of a set of coincident events which would lead to a loss of system load, is in practice quite difficult to estimate with any precision. While probabilistic computational routines such as loss of load computer codes are increasingly used for estimating reserve margins required to achieve specified levels of reliability, the applicant rejects this technique for its system at this time. Three reasons are given:

(a) No operating experience exists relative to the size and types of DPC's nuclear units.

(b) Such calculations must consider interconnections of transmission systems which would require an overly burdensome data input.

(c) The level of reliability to be chosen is arbitrary and the resulting reserve margins are dependent on the choice of reliability. (ER 1.1-11).

The applicant is cognizant of the work being conducted in the area of probabilistic techniques to compute appropriate reserve margins and, in fact, has had loss of load studies made for its system.[27] To reduce the loss of load probability for the applicant's system to one day in ten years would require over 30% reserve.

The applicant's procedure for computing required reserve margin, including allowance for nuclear unit refueling, is to add to the forecast summer peak load an allowance for extreme temperature (4.35%), loss of the largest unit on the system (1,280 MWe), miscellaneous capacity reductions (4.42%) and nuclear unit refueling (1,180 MWe) (ER 1.1-10). Thus, with a forecast peak load of 22,217 MWe in 1988, required reserves would be 4,411 MWe and the reserve margin would be 19.9%. Because the allowances for loss of largest units on system and for nuclear unit refueling are constant, the required percentage reserve will decline over time as forecast peak increases.

In its 1970 National Power Survey, the Federal Power Commission estimated the reserve requirements for the Southeast Region to be 20-21% for the period 1970-1990.[28] The Federal Power Commission has indicated that most systems attempt to operate with a reserve margin of 15-25%. For long range planning purposes, it is normal to increase future reserve allowances by 5 to 10% of the forecast peak load as a contingency against unforseen construction delays or estimating errors.[29] Therefore, the staff would not consider a reserve margin of up to 30% unreasonable for long-range planning in the applicant's system. The staff, however, does view reserve margins for the applicant's system below 15% as dangerously low for purposes of long range planning.

8.3.2 Regional reserves

As mentioned previously, the applicant is a member of the Southeastern Reliability Council. SERC reviews existing and planned power supplies and transmission systems within its region to ensure high reliability of the region's power supply. The projected reserve margin for SERC for the peak demand of the year is in the range 15-21% for the period 1975-1984 and is in the range of 17-18% for the period 1982-1988.[30] The reserve margins indicated above are for the summer peaks; reserve margins for the winter peaks are generally lower than the summer peaks for this region.

Reserve margins for the VACAR Subregion of SERC for the peak demand of the year range from 9% to 29% during the period 1975-1984. Thus, within the SERC, it appears that the VACAR Subregion will have a significantly higher reserve margin than the SERC average for the foreseeable future. Since the applicant's expected reserve margin averages about 17% for the period 1975-1983, it is apparent that the other VACAR members are projected to have higher reserve margins than the applicant's.

8.4 POWER SUPPLY

The applicant's planned system capacity 1975 through 1988 is shown in Table 8.4. Total installed generating capacity available for the 1975 summer peak is 11,214 MWe and firm purchases are 169 MWe. A major unit addition to the system is planned every year from 1975 to 1988 except for 1977 and 1980. By 1988, total capacity, including firm purchases available for summer peak, will be 25,051 MWe.

8.5 STAFF FORECAST AND ANALYSIS OF RESERVES

The results of an independent analysis of staff demand forecasts and reserve margins are presented in this section. The analysis synthesizes the results of two recent federal studies, one concerned with future energy supply and demand and the other concerned with forecasting regional economic activity.

8.5.1 Peak load forecast

The "Project Independence Report" released by the Federal Energy Administration in November 1974, represents the most comprehensive energy analysis yet undertaken. The report was developed during the period of March to November, 1974, thus the long run implications of economic and energy related developments during the spring and summer of 1974 are reflected in the analysis.

The "Project Independence Report" provides two projections of future electricity demand -- a business-as-usual case, and an increased electrical use case that entails greater government participation in management of energy demand. The increased electrical use case is based upon redistribution of energy consumption toward those sources of energy which can be produced domestically. Specifically, this case substitutes electricity, using coal and uranium resources, for other energy end use purposes. Under the business-as-usual case, with oil at $11/barrel, electric demand is projected to grow 6.3 percent per year between 1973 and 1985. Under the Demand Management Case, electric demand is projected to grow 7.4 percent annually during the same period. The results of these two projections are presented in Table 8.5.

TABLE 8.5

ELECTRICAL CAPACITY PROJECTIONS
(in gigawatts)

Items	Existing Capacity, end-1973	1985 Projections [1,2] BAU $11/BBL.	Demand Management
Total Electricity Capacity	424	992	1,002
Growth Rate 1973-1985, %/yr.	--	6.3	7.4
Hydro Capacity GWe	65	100	100
Nuclear Capacity GWe	20	204	240 [2,3]
Coal Capacity GWe	167	327	379
Oil Capacity GWe	78	81	64[4]
Gas Capacity GWe	61	48	48
Combustion Turbine GWe[5]	33	162	171

[1]Beginning of year projections (nuclear at end of year would be 234 and 275 for BAU and AD respectively).
[2]Without conservation.
[3]Accelerated nuclear construction schedules.
[4]The demand management projection includes conversion of about 16,500 megawatts of existing oil-fired generation capacity to coal.
[5]These figures reflect projected increased market penetration of intermediate load combined cycle plants and continued use of gas turbine peaking plants.

Source: Project Independence Report, FEA, Table II-24.

TABLE 8.4 PLANNED POWER CAPACITY AT THE TIME OF SUMMER PEAK. DUKE POWER COMPANY 1975 THROUGH 1988

(MWe)

Item	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Generating Capability before additions or retirements - MW	10,909	11,214	12,274	12,274	13,454	14,634	14,634	15,787	16,940	18,085	19,637	21,156	22,343	23,623
Firm Purchases - MW	169	169	169	169	169	148	148	148	148	148	148	148	148	148
Total Production Capacity before Additions - MW	11,078	11,383	12,443	12,443	13,623	14,782	14,782	15,935	17,088	18,233	19,785	21,304	22,491	23,771
Capacity Additions and (Retirements) - MW														
Jocassee 3 and 4	305													
Belews Creek 2		1,060												
McGuire 1				1,180										
McGuire 2					1,180									
Catawba 1							1,153							
Catawba 2								1,153						
Perkins									1,280		1,280		1,280	
Cherokee										1,280		1,280		1,280
Bad Creek										500	500			
Buck and Riverbend Comb. Cycle									(135)					
Lee 5C, 6C; Dan River 4C,5C; Buck 3, 4										(228)				
Dan River 6C; Riverbend 8-11C; Urquhart 3C, 4C; Cliffside 1,2											(261)			
Buck 7-9C												(93)		
Total Capacity for Summer Peak - MW	11,383	12,443	12,443	13,623	14,803	14,782	15,935	17,088	18,233	19,785	21,304	22,491	23,771	25,051

SOURCE: Enclosure to letter from D. B. Blackmon to R. A. Gilbert dated January 31, 1975. Re: Catawba, Perkins, and Cherokee Nuclear Stations.

The FEA report points out a number of uncertainties in the projections of future electricity requirements.[31] These uncertainties include relative availability and prices of alternative fuels, growth in peak demand relative to total kwh consumed, the trend in generating efficiency and the success of rate restructuring to lower growth in peak demand. Additional uncertainties discussed in the report concern potential financial and technical constraints on the rate at which generating capacity can be placed in operation.

FEA uses a long run price elasticity of demand, depending on the assumptions about the price of oil, of about -0.44 for household and commercial and -1.20 to -1.36 for industrial and forecasts an average electricity price, in constant dollars, of 22.2 mills/kwh in 1985 compared to 18 mills/kwh in 1972.[32] If demand proves to be more responsive to price, future growth in national consumption of electricity would be lower than the estimated 6.3 percent per year.

Another significant uncertainity is the relative rate of growth between peak load and energy requirement. From 1968 to 1972 peak load grew nationally at 8.4 percent annually compared to 7.4 percent for total output. While the staff has no conclusive estimates of the relative growth of peak load demand and energy demand over the next decade, the staff believes that, nationally, load leveling efforts will be only partially successful in reducing the peak load growth rate to equal that of total electrical energy consumption.

A 6.3 percent growth rate in total consumption could imply upwards of a 7.0 percent growth rate in peak load nationally by 1980. Load leveling measures including revised rate structures, and modification of technologies and consumption behavior will take a number of years to be fully realized.

Gross National Product (GNP) has grown at an annual rate of 4.3 percent in real terms during the period 1962 to 1973. The growth rate of GNP in constant dollars in recent years has been -0.5 percent in 1970, 3.4 percent in 1971, 6.2 percent in 1972 and 5.9 percent in 1973. The growth rate for 1974 was negative. Forecasts of the growth rate in GNP and its components under alternative energy strategies are summarized in Table 8.6. Note that in each case, economic growth is projected to recover slowly form its present low rate but will not reach the level experienced during the 1960's. Growth is projected to be higher in a $7/bbl of oil situation, which has less dampening effect than the $11/bbl situation.

By identifying differences in projected growth of major economic variables such as population and income, it is possible to draw conclusions about the expected rate of growth in demand for electricity within a service area relative to the national rate of growth. The most widely used set of long run regional economic projections, OBERS Projections, Regional Economic Activity in the U.S., is prepared by the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) and the U.S. Department of Agriculture, Economic Research Service for the U.S. Water Resources Council.[33] The complex projection procedure used is based on the empirical and theoretically supported observation that economic growth over time is related to the size and productivity of the labor force. Projections of population and the labor force are published by the U.S. Bureau of the Census. Estimates of future output per man hour are based on detailed analyses of trends in productivity in each sector of the economy and judgmental forecasts of significant future developments which might affect productivity. While no projections coincide exactly with the Applicant's service area, a reasonably representative forecast can be spliced together, for the service area, by totaling BEA Economic Areas 025, 026, 028, and SMSA (Standard Metropolitan Statistical Area) 065.

The relevant comparisons between the Applicant's service area and the nation as a whole are laid out in Tables 8.7 through 8.11. Table 8.11 summarizes the comparison. Note that population is projected to grow 78 percent faster in the Applicant's service area than for the nation during the period 1970-1980. From 1980 to 1985 population will grow 56 percent faster while in 1985-1990 it will grow 40 percent faster. Total personal income will grow 17 percent faster from 1970 to 1980, 14 percent faster from 1980 to 1985; and 31 percent faster from 1985 to 1990. The deterioration in the relative growth rate of per capita income indicates that the period in which wages in the region began to catch up to the national average is probably over and that wages will probably stabilize slightly below the national average. Overall, it is apparent that the applicant's service area will have a considerably higher rate of growth in population and income than the nation as a whole.

TABLE 8.6

ANNUALIZED COMPOUND RATES OF GROWTH FOR GROSS NATIONAL PRODUCT, CONSUMPTION, INVESTMENT, EMPLOYMENT, AND PRODUCTIVITY

	$11/bbl Base Case	$11/bbl Accelerated Supply	$7/bbl Base Case
Gross National Product[a]			
1973-77	2.4	2.4	4.3[b]
1973-80	2.8	2.8	3.8[c]
1973-85	3.2	3.2	3.7[d]
Personal Consumption[a]			
1973-77	2.4	2.4	3.9[b]
1973-80	2.9	2.9	3.6[c]
1973-85	3.2	3.2	3.4
Gross Private Domestic Investment[a]			
1973-77	2.5	2.5	7.5[b]
1973-80	2.5	2.6	5.5[c]
1973-85	3.1	3.1	4.9[d]
Employment			
1973-77	1.8	1.8	1.9[b]
1973-80	1.7	1.7	1.8[c]
1973-85	1.5	1.5	1.5[d]
Productivity			
1973-77	0.5	0.6	2.4[b]
1973-80	1.1	1.2	2.1[c]
1973-85	1.7	1.7	2.2[d]

[a] 1971 dollars serves as base.

[b] Based upon 1974-78 period.

[c] Based upon 1974-80 period.

[d] Based upon 1974-85 period.

SOURCE: Project Independence Report, FEA, Table VI-2, P. 320.

TABLE 8.7

UNITED STATES POPULATION, EMPLOYMENT, PERSONAL INCOME
& EARNINGS, ACTUAL & PROJECTED, SELECTED YEARS 1962-1990

Item	1962	1970	1980	1985	1990
Population, midyear (million)	185.7	203.9	223.5	234.5	246.0
Per Capita Income (1967 $)	2,585	3,476	4,700	5,400	6,100
Total Employment (million)	66.4	79.3	96.1	101.1	106.4
Earnings Per Worker (1967 $)	n.a.	7,090	8,700	9,800	11,000
Total Personal Income ($ billion)	480	709	1,068	1,273	1,517

*Employment for 1960.

SOURCE: 1972-E OBERS Projections, Vol. 1, Table 1, p. 38.

TABLE 8.8

AVERAGE ANNUAL PERCENTAGE RATES OF CHANGE, UNITED STATES POPULATION, EMPLOYMENT,
PERSONAL INCOME & EARNINGS, ACTUAL & PROJECTED, SELECTED PERIODS 1962-1990

Item	1962-1970*	1970-1980	1980-1985	1985-1990
Population	1.2	0.9	9.0	1.0
Per Capita Income	3.7	3.1	2.8	2.5
Total Employment	1.8	1.9	1.0	1.0
Earnings Per Worker	n.a	2.1	2.4	2.3
Total Personal Income	5.0	4.2	3.6	3.6

*Employment for the period 1960-1970.

Source: Estimated from Table 8.7.

TABLE 8.9

POPULATION, EMPLOYMENT, & PERSONAL INCOME, TOTAL OF BEA ECONOMIC AREAS 025, 026 & 028 & SMSA 065, HISTORICAL & PROJECTED, SELECTED YEARS 1962-1990

Item	1962*	1970	1980	1985	1990
Population, midyear (thousands)	3,307	3,647	4,288	4,586	4,906
Per Capita Income (1967 $)	2,037	3,024	4,158	4,744	5,413
Per Capita Income Relative (U.S. = 1.00)	.79	.87	.88	.88	.89
Total Employment (thousands)	1,261	1,576	2,015	2,145	2,284
Employment/Population Ratio	.38	.43	.47	.47	.47
Total Personal Income (million 1967 $)	6,738	11,029	17,831	21,758	26,553

*Employment for 1960.

TABLE 8.10

AVERAGE ANNUAL PERCENTAGE RATE OF CHANGE, POPULATION, EMPLOYMENT, & PERSONAL INCOME, HISTORIC & PROJECTED, BEA ECONOMIC AREAS 025, 026, & 028, & SMSA 065, SELECTED PERIODS 1962-1990

Item	1962-1970*	1970-1980	1980-1985	1985-1990
Population	1.2	1.6		.4
Per Capita Income	5.1	3.2	2.7	2.7
Total Employment	2.2	2.5	1.3	1.3
Total Personal Income	6.4	4.9	4.1	4.1

* Employment 1960-1970.

TABLE 8.11

BEA ECONOMIC AREAS 025, 026, & 028 & SMSA 065 AS A RATIO OF UNITED STATES AVERAGE ANNUAL RATE OF CHANGE OF POPULATION, EMPLOYMENT & INCOME, HISTORIC & PROJECTED, SELECTED PERIODS 1962-1990

Item	1962-1970*	1970-1980	1980-1985	1985-1990
Population	1.00	1.78	1.56	1.40
Per Capita Income	1.38	1.03	0.96	1.08
Total Employment	1.22	1.32	1.30	1.30
Total Personal Income	1.28	1.17	1.14	1.31

* Employment 1960-1970.

An estimate of the likely growth rate of peak load in the applicant's service area was derived relative to forecast national rates of growth in electric demand population and economic activity. If the future growth rate in peak load falls between the forecasted business as usual and the demand management cases, say a 7.0% growth rate, then growth of peak load nationally will average only about 10% or 11% below the rate experienced from 1964 through 1973. During the 1964 through 1973 period the growth rate of peak load in the applicant's service area was 27% greater than the national rate. If the applicant's rate of growth in peak load were to be lowered by 11%, it would be reduced from 9.9% to 8.8%. The relative demographic and economic information summarized in Table 8.11 supports a continuation of the substantially higher rate of growth of peak load in the applicant's service area than that nationally. Population will grow considerably faster in the applicant's service area. Assuming the fertility rate to be essentially the same as the national average and considerable in-migration, there will be an accompanying net increase in new households. While per capita income will not increase relatively as fast as in the 1960's, it will at least keep pace with the national rate of growth. Applicance saturation data from the applicant's service area would indicate that there is still considerable opportunity to increase usage of electricity by existing household customers through substitution of electric heating for gas and oil and increased use of air conditioning. Even if it were assumed that considerable efficiencies could be realized in peak usage through load leveling measures and considerably higher electricity prices, a 7.0% growth rate is a 20.0% reduction from 8.8% growth rate. The conclusion drawn by the staff is that over the period through the late 1980's the applicant will experience an average compound rate of growth in peak load of well over 7.0% and perhaps as high as 8.8%. The staff considers the average 7.5% compound rate of growth in the applicant's peak load forecast, from 1975 through 1988, to be reasonable.

8.5.2 Analysis of the adequacy of reserve margins

The following analysis of the applicant's potential reserve situation in the late 1980's, summarized in Table 8.12, clearly illustrates that actual peak load would have to be considerably below staff and applicant forecasts before the three Cherokee units would not be needed in 1988. Under the staff's conservative lower forecast based on a 7.0% compound annual growth rate, the three Cherokee units would be needed as scheduled. Any delay beyond 1988 would result in inadequate reserves. The reserve margins associated with the applicant's forecast is considered, by the staff, to be inaequate. A growth rate in peak load as high as 8.8% would completely jeopardize the reliability of the applicant's system. At the other extreme using a 6.0% growth rate, which the staff considers quite unlikely, it would be possible to slip the Cherokee schedule by two years and still maintain adequate reserve.

Extrapolation of the applicant's estimates of reduction in summer peak load indicate that in 1988 peak load could be reduced by 5.0%. For the 7.0% growth rate forecast peak load would be 19,764 MWe in 1988 and the reserve margin would be 26.8%, well within acceptable limits.

8.6 SUMMARY AND CONCLUSIONS

The staff has considered the historic electric power demand and electrical energy requirements of the Duke Power Company, Power Supply Area 21, the Southeastern Region and the United States as a whole. Various electrical and economic forecasts have been evaluated. These include: energy and power forecasts of the applicant, electrical demand forecasts of the Federal Energy Administration and OBER's regional economic projections. Specific consideration was given to the potential for conservation of electricity on one hand and substitution of electricity for scarce and high priced gas and oil on the other. The applicant's future reserve requirements and generating capacity placement plans were also examined.

The staff finds that peak load in the Duke service area will grow at compound annual rates well above 7.0% and perhaps slightly above 8.0% over the period to 1988. The staff also finds the applicant's load forecasts reasonable and on the lower side of the range of growth rates deemed likely. With the applicant's present construction schedule, the three Cherokee units will be needed by 1988 at rates of growth of peak load of 7.0% and higher. Even at an unreasonably low assumed rate of 6.0%, the units would be required by 1989 or 1990 at the latest.

TABLE 8.12

RESERVE MARGIN ANALYSIS FOR APPLICANT AND STAFF PEAK LOAD FORECASTS 1983 THROUGH 1990

Item	1983	1984	1985	1986	1987	1988	1989	1990
Forecast of Summer Peak Load								
Applicant's - MWe[a]	16,124	17,226	18,383	19,598	20,875	22,217	23,630	25,111
Staff's								
at 8.8% growth - MWe	16,951	18,442	20,065	21,831	23,752	25,843	28,117	30,591
at 7.0% growth - MWe	14,833	15,871	16,982	18,171	19,443	20,804	22,260	23,818
Extreme lower limit assumption								
at 6.0% growth - MWe	13,760	14,585	15,460	16,388	17,371	18,413	19,518	20,689
Total Capacity for Summer Peak - MW[b]	18,233	19,785	21,304	22,491	23,771	25,051	25,051	25,051
Reserve Margin								
Applicants forecast-%	13.1	14.9	15.9	14.8	13.9	12.8	6.0	c
Staff's								
at 8.8% growth-%	7.6	7.3	5.2	3.0	0.1	c	c	c
at 7.0% growth-%	22.9	24.7	25.5	23.8	22.3	20.4	12.5	5.2
Extreme lower limit assumption								
at 6.0% growth-%	32.5	35.7	37.8	37.2	36.8	36.1	28.3	21.1

[a] Applicant's forecast of 12/23/74.

[b] Applicant's capacity schedule as of 1/10/75. It is assumed that no additional capacity is added in 1989 and 1990.

[c] Negative reserve margins.

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7. *56th Semi-Annual Electrical Power Survey*, A report of the Electric Power Survey Committee of the Edison Electric Institute, October 1974.
8. *Electrical World*, February 1, 1975 p. 30.
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24. J. C. Moyers, "The Room Air Conditioner as an Energy Consumer," ORNL-NSF-EP-59, Oak Ridge National Laboratory, October 1973.
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28. Federal Power Commission, "The 1970 National Power Survey, Part I", December 1971, Table 18.12, p. I-18-23.

29. Federal Power Commission, "The 1970 National Power Survey, Part I", December 1971, p. I-1-58.

30. Southeastern Electric Reliability Council, "Coordinated Bulk Power Supply Program - 1974-1992", April 1, 1975, pp. 5-6

31. Ref. 12, 127.

32. Ref. 12, Appendix A II, p 60.

33. "1972 OBERS Projections, Regional Economic Activity in the U. S., Series E Population, by Economic Area, Water Resources Region and Subarea, State, and SMSA and Non-SMSA Portions of the Areas, Historical and Projected, 1929-2020", (in 7 volumes) U. S. Water Resources Council, Washington, D. C., April 1974.

9. COST-BENEFIT ANALYSIS OF ALTERNATIVES

9.1 ALTERNATIVE BASE-LOAD ENERGY SOURCES AND SITES

9.1.1 Alternatives not requiring creation of new generating capacity

9.1.1.1 Purchased power

The applicant has indicated (ER, Sect. 9.1.1) that purchase of base-load power is not a viable alternative in amounts in excess of those already scheduled (148 MWe, 1984-1988). Purchased energy is generally only a viable alternative when excess capacity exists in another region or system during the time period when needed by the applicant. Constructing new capacity in a different region or system, especially to supply the needs of the applicant, would merely shift the energy-producing burdens to another region without any significant overall advantages. Moreover, wheeling large blocks of power from one system to another inescapably results in transmission losses. Also, if large blocks of power were wheeled on a routine basis, the existing transmission interconnections would not be sufficient to wheel this power and to also maintain existing reliability of service criteria. Thus, new transmission lines would undoubtedly be required from the power source to the applicant's system.

In its report to the Federal Power Commission for the 1970 National Power Survey, the Southeast Regional Advisory Committee discussed seasonal diversities within the southeast as capacity sources. The Committee concluded that opportunities for seasonal exchange not already implemented were relatively small and uncertain so that little, if any, transmission for seasonal exchange purposes could be justified.[1]

The staff concludes that purchasing base-load power for the expected lifetime of CNS is not a practicable alternative.

9.1.1.2 Postponed retirement or reclassification of existing units

The applicant has indicated an intent to retire some existing generating capacity (approximately 717 MWe) between 1975 and 1987 (Table 8.4). By 1987, all of the existing nonsupercritical base-load coal-fired stations (the supercritical coal-fired units are Belews Creek 1 and 2 and Marshall 3 and 4) will probably largely be used for intermediate-type operation. Because of the difference between the planned retirement capacity and the capacity of the proposed station, postponed retirement cannot be considered a viable alternative to the proposed action.

9.1.1.3 Base-load operation of intermediate or peaking facilities

Extended operation of units designed for intermediate or peaking operation would result in extensive maintenance problems and reduced availability of the peaking capacity and reduced system reliability when needed, since these units are not designed for nearly continuous, base-load operation. This case is particularly true for the peaking units and, to a lesser extent, for intermediate-type units. Moreover, fuel costs for these units are higher than those designed for base-load duty; also, fuel for some of these units (oil- and gas-fired) is expected to be in relatively short supply and may not be available for their continuous operation. Since a substantial portion of the applicant's peaking capacity is hydroelectric or pumped-storage hydroelectric capacity, the extent to which these facilities can be operated is dependent upon the water supply. The applicant has indicated that both types of hydroelectric facilities are limited to use only for peaking purposes (ER, Sect. 9.1.3). The applicant has also indicated that its system needs a major block of generation to operate in the load-following portion of the curve and that to upgrade these (fossil-fueled) units to base-load operation would deprive the system of an important part of the generation mix needed for efficient operation. Another aspect to be considered is that without the addition of new generating capacity, the peak demand of the applicant's system will eventually outgrow the system's total generating capacity and will result in the absence of any reserve capacity. Thus, the staff concludes that base-load operation of existing intermediate or peaking facilities is not a feasible alternative for the long term.

9.1.1.4 Reactivating or upgrading older plants

Because the applicant plans to retire only small existing units between 1975 and 1987 (Table 8.4) and because those scheduled to be retired in 1974 and 1975 are also relatively small (totaling only 151.7 MWe) and are used only for peaking purposes (ER, Sect. 1.1.2, Table 1.1.2-2), reactivating older plants apparently is not a viable alternative to building new base-load capacity in the amount to be supplied by CNS.

Upgrading existing facilities by a significant extent is generally not economically feasible because most boiler and turbine-generator facilities are closely matched. Thus, upgrading would require replacement of boilers, turbines, and condensers, with a resulting probable cost approaching that of new capacity. An associated additional disadvantage is that all output from these units would be lost during the rebuilding period. Furthermore, installation of higher capacity at a particular location would require additional capability to dissipate waste heat and probably additional transmission lines. The applicant has indicated that upgrading existing plants is not feasible (ER, Sect. 9.1.2). The staff does not consider upgrading to be a viable alternative to replace the power expected to be supplied by CNS.

9.1.1.5 Conclusions

The staff concludes that, although postponing reclassification of some base-load units to intermediate-type operation (load-following) might allow the construction of CNS to be delayed for a period of time, it would not eliminate the need for base-load capacity in the future. Thus the staff concludes that there are no feasible alternatives to meet the projected energy requirements without the creation of new generating capacity.

9.1.2 Alternatives requiring the creation of new generating capacity

9.1.2.1 Energy type and source considerations

Coal

Coal supplied the energy for 84.1% of the power generated by the applicant in 1973.[2]

Low-sulfur coal, or an SO_2-removal system, is expected to be required in new stations that will begin operation during the time CNS is scheduled to begin generating power. Southeastern coal is generally high-sulfur coal although the applicant has indicated that the coal currently used is less than 1% sulfur (ER, Sect. 9.3.2). Another source of low-sulfur coal would be from western mines such as those in Montana; consequently, transportation costs would be high. The applicant has not indicated whether or not low-sulfur eastern coal would be available for the proposed units. Therefore, the staff has considered that any coal-fired plant in the applicant's system might use high-sulfur southeastern coal along with SO_2-removal systems.

The staff has estimated capital costs of a 3840-MWe coal-fired station located at the Cherokee site, utilizing mechanical-draft cooling towers with and without SO_2-removal systems. These costs are presented in Table 9.1, which compares them with the applicant's estimates for a coal-fired station and with the staff's and applicant's estimates for a uranium-fueled station. Operating and maintenance cost estimates are also given, and annual production costs are compared at plant factors of 0.8, 0.7, and 0.6.

Oil

Oil was used to generate about 2.5% of the applicant's power in 1973;[2] its use was mainly for intermediate-type and peaking units. Its relatively small usage compared to coal (see above, Coal) is indicative of the relative costs of these two sources of energy in the applicant's service area in 1973. Thus the applicant does not consider oil to be a feasible alternate fuel source (ER, Response to Question 9.1.7). The staff concurs in this evaluation.

In addition to the economic aspects that preclude the further consideration of oil as a fuel for a large base-load power station, other factors also discourage its use. An important factor is the future availability of oil in the United States as a fuel for base-load power stations. As events since late 1973 have shown, oil supplies from foreign countries (which make up a significant part of our total annual consumption) are subject to availability and costs as dictated to a large extent by political considerations. The cost factor is important not only as related to predicting the economics of station operation but also with regard to the United States' balance-of-payments problems. The latter problems could lead to restrictions on the large-scale use of oil for power stations in order to conserve it for other purposes for which there is no readily available substitute (such as fuel for internal combustion engines and raw materials for synthetic

TABLE 9.1. Estimated Capital and Operating Costs for 3840-MWe nuclear (PWR) and coal-fueled power stations utilizing mechanical-draft cooling towers

All figures are 1988 dollars

	Nuclear			Coal: With SO_2-removal equipment			Coal: Without SO_2 removal equipment		
Capital, dollars/kWe[a]	678[b]			550			452		
Applicant's estimate[c]	598						374		
Unit production costs, dollars/MWhr									
Fuel	8.9[d]			25.6			29.3		
Operating/Maintenance	2.4[e]			3.9[g]			2.1[g]		
Total	11.3			29.5			31.4		
Annual Production costs, millions of dollars									
(Plant factor)	(0.8)	(0.7)	(0.6)	(0.8)	(0.7)	(0.6)	(0.8)	(0.7)	(0.6)
Fuel	239	209	180	689	603	517	788	690	591
Operating/maintenance[h]	64	56	48	105	92	79	57	50	43
	303	265	228	794	695	596	845	740	634
Present worth production cost, dollars/kWe[i]	744	651	560	1950	1707	1464	2075	1817	1557
Total present worth generating cost, capital plus production, dollars/kWe	1422	1329	1238	2500	2257	2014	2527	2269	2009
Kilowatt-hours generated/yr (10^9)	26.9	23.6	20.2	26.9	23.6	20.2	26.9	23.6	20.2
Annualized generating cost, mills/kWhr[i]	21.5	23.0	25.0	37.8	39.0	40.6	38.2	39.2	40.5

[a]See Summary and Conclusions of this section for a description of the methods of estimating capital costs.

[b]Average value for three 1280-MWe units. Commercial operation of Units 1, 2, and 3 is scheduled for January 1984, 1986, and 1988 respectively. Length of workweek was considered to be 40 hr. Interest during construction was assumed to be 8%/year (compound). Escalation rates during construction used for the calculations were 8.5%/year for site labor, 7.5%/year for site materials, and 7.5%/year for purchased equipment.

[c]ER, Table 9.3.1-1, plant cost. Excludes substation and transmission line costs.

[d]The Nuclear Industry, 1974, USAEC Report WASH 1174-74, Chapter 1. The estimated 1974 dollar cost of \$3.02/MWhr was esclated to 1988 at 8%/year. The applicant has reported in Electrical World, July 15, 1975 an even lower cost of \$2.23/MWhr.

[e]An operating and maintenance cost of \$0.81/MWhr for 1974 derived from Chapter 1 of WASH 1174-74 was escalated to 1988 at 8%/year.

[f]Coal costs are based on March, 1975 data on the costs and quality of fossil fuels delivered to electric utility generating plants in the continental United States (Federal Power Commission News, Vol. 8, No. 25, June 20, 1975). The low sulfur coal contains 0.5% or less sulfur. The costs shown are for coal delivered in North Carolina and were 122.5¢/MBtu for low sulfur and 107.1¢/MBtu for high sulfur (2-3% sulfur). A heat rate of 8800 Btu/kWhr was assumed (Uniform Statistical Report-Year ending December 31, 1973, Duke Power Company, p. E-19, average value for base-load, supercritical Marshall Units 3 and 4). All costs were escalated at 8%/yr.

[g]Operating and maintenance costs for Duke Power Company for 1971 of \$0.566/MWhr (Steam-Electric Plant Construction Cost and Annual Production Expenses, Twenty-Fourth Annual Supplement-1971, Federal Power Commission, February 1973, Table 10, XXIX) were escalated to 1988 at 8%/year. 1974 operating and maintenance costs for a working SO_2 removal system were 0.6/MWhr ("Stack Gas Scrubber Makes the Grade," Chem. Eng. News 53, p. 22 (Jan. 27, 1975)) and were escalated to 1988 at 8% per year.

[h]Calculated for a plant factor of 0.76 and ratioed to plant factors used.

[i]Assuming a 10% discount rate for a 30-year period.

organic chemicals). Therefore, even disregarding the economics of station operation, the unreliability of foreign supplies of oil makes it desirable for a utility not to increase its dependence on oil as a fuel source. The staff concludes that it is not reasonable at this time for the applicant to plan a base-load electrical generating station that would consume large quantities of oil.

<u>Natural gas</u>

Only about 2.5% of the applicant's 1973 power was generated by the use of natural gas,[2] and this power was used mainly for intermediate-type and peaking units. For the future, domestic supplies of natural gas are not expected to be available in the quantities required for long-term (30-40 years) operation of a natural-gas-fueled power station to replace the applicant's proposed uranium-fueled station.[3]

Although consumption of gas by electric utilities for generation of electrical power increased by about 203% during the period 1962-1971,[4] the 1970-1971 consumption increased only 1.6%, and during 1971-1972 consumption decreased slightly (Fig. 9.1).[5] In the South Atlantic states, consumption decreased by 1.7% during 1970-1971.[4] A major reason for the nationwide reduced gas

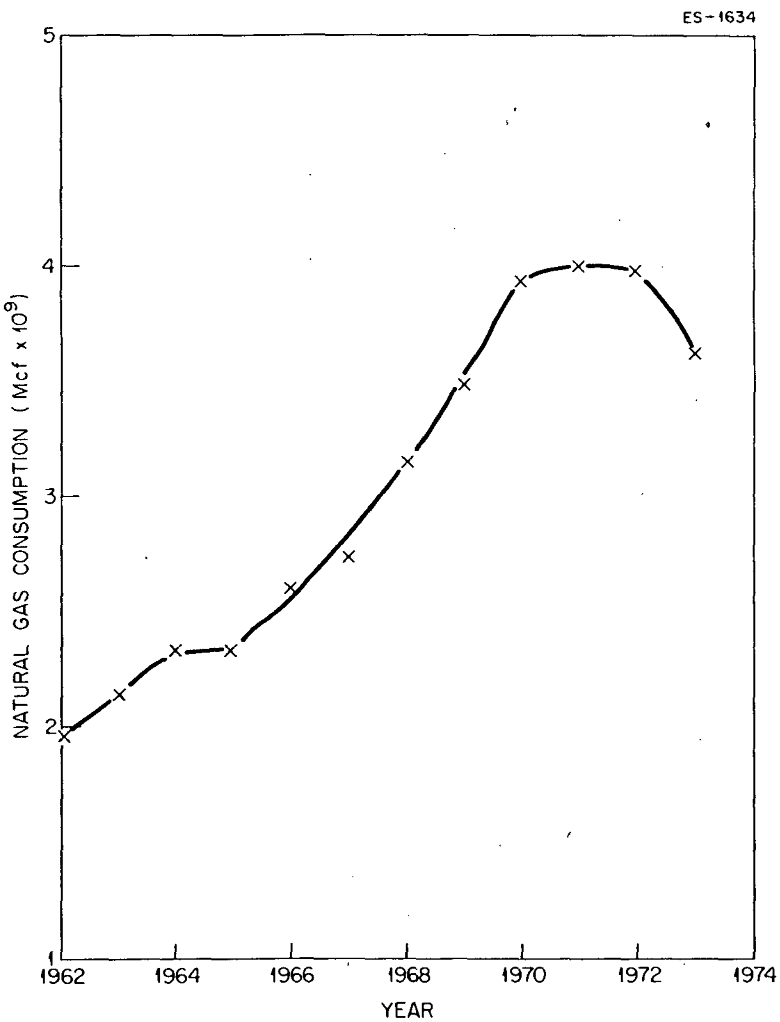

Fig. 9.1. Consumption of natural gas in the United States by electric utilities for electrical energy generation. <u>Source</u>: Edison Electric Institute, *Statistical Year Book of the Electric Utility Industry for 1973*, Table 41S.

consumption by electric utilities is the difficulty in obtaining new supplies.[6] The trend is to channel the Nation's limited supplies of natural gas away from use as a boiler fuel into household and other premium uses.

Therefore, the staff does not consider that natural gas is a viable alternative fuel for the applicant's proposed base-load station.

Hydroelectric

Because of the characteristics of streamflows in the applicant's service area, hydroelectric power generation is limited in usefulness to peaking service (ER, Response to Question 9.1.3). In 1973, hydroelectric facilities (including pumped storage) generated about 5.4% of the applicant's total power generation.[2] The applicant has indicated that there are only a few hydroelectric sites remaining that are suitable for development for peaking service and none for base-load service (ER, Sect. 9.2.1, p. 9.2-4). The applicant has stated that the Federal Power Commission lists 30 locations in its service area where hydroelectric power could be developed; the estimated total annual energy potential of all 30 sites is only about one-twelfth the annual energy generation planned for CNS (ER, Response to Question 9.1.3, citing ref. 7). The staff concludes that it is not practicable to utilize hydroelectric power in the applicant's service area to supply base-load power in the amount expected to be generated by CNS.

Geothermal

Geothermal electric power generation, at favorable geologic sites, has been found to be feasible and competitive with other commercial sources of energy. However, world capacity was only about 1000 MW in 1973.[8] It has made significant contributions to the power supply of northern California. The first geothermal plant (12.5 MW) in the field, The Geysers field, was commissioned in 1960. Subsequent additions (in units as large as 55 MW) have led to the current capacity at this field of about 302 MW at an average total generating cost of less than 6 mills per kilowatt-hour; ultimate capacity of this field is estimated at between 500 and 1000 MW.[9]

Development of geothermal energy as a source of steam for the production of electric power in the United States has occurred only in this one field in northern California. Other possible locations are under investigation, but these are primarily in the western part of the United States

Although a thermal spring does appear to exist near the applicant's service area in North Carolina,[10] the applicant has indicated that the kinds of geological formations that produce steam suitable for use in geothermal plants appear to be nonexistent in the Carolinas (ER, Response to Question 9.1.4).

Geothermal energy development is not without significant environmental problems. Chief among these are thermal effects, land despoilment, contamination of ground and surface waters, noxious gases, noise, land subsidence, and requirement of a supply of cooling water for closed-system generating modes.[11] The possibility of seismic effects also exists. A geothermal station also requires more land than nuclear or fossil-fueled plants and has a greater water consumption and waste thermal discharge per unit of electricity than these other plants because of lower turbine conversion efficiencies at the lower geothermal steam pressures and temperatures.

The staff concludes that the applicant cannot reasonably consider geothermal power as an alternate energy source for the applicant's proposed base-load uranium-fueled power station within the time frame required for the power to be available.

Solar power

Although solar generation of electricity may be a future supplier of electrical energy in the United States, a pilot plant has not yet been put into operation. To succeed as a base-load plant, low-cost methods of power storage (to supply power when the sun is obscured by clouds or at night) would have to be developed and coupled with the solar energy conversion units. Even if a considerable number of technological problems are solved, commercial operation of a solar power station would not be expected until about 1990.[12] If solar energy is utilized for a peaking power station (in localities where the peak occurs during hot, sunny days when air conditioning is a major load), even this energy source is not likely to be competitive before 1990.[13] Thus the staff does not consider solar power as a viable alternative to the applicant's proposed base-load uranium-fueled power station.

Wind power

Power from the wind has been obtained on a 1-MW scale in Vermont, and currently there are plans to construct a 0.1-MW windmill in Ohio.[14] Because wind power is intermittent, it is unsuitable as a source of base-load power unless coupled with low-cost storage facilities that have not yet been developed. Additionally, the use of large systems of windmills on land might change air current patterns that would, in turn, affect local temperatures and humidities.[15] Proposed pairs of 800-ft-tall towers with wind-powered turbines slung from cables in between[14] also have obvious aesthetic problems.[16] However, tower heights of 100-150 ft are currently considered optimum in terms of tradeoffs between construction costs and the increased strength and constancy of the wind with increasing altitude.[14] As a consequence of the above-mentioned considerations, the staff does not consider that power from the wind is a viable alternative to the applicant's proposed base-load station at this time.

Fusion power

The present status of nuclear fusion as a source of energy is such that a demonstration plant is not expected to be built before about 1990, and a commercial power station is not expected to be available before the year 2000.[17] Therefore, the staff does not consider fusion power to be a viable alternative to the applicant's proposed nuclear power station at this time.

Municipal solid wastes

A utility in New Jersey[18] considered the 35,000 tons/day of solid wastes (domestic, commercial, and industrial) produced in New Jersey as an alternative fuel source for electric power generation. Using an average heat content of 5000 Btu/lb and the assumption that 50% of the wastes produced are combustible, this utility calculated that the power that could be generated would be 700 MWe. Even if sufficient solid waste from other sources were available, it is very doubtful that the administrative, legal, and technical problems could be resolved to create a facility to replace the applicant's proposed base-load station in the time frame required. The staff does not consider that the burning of municipal solid waste is a viable alternative.

Coal gasification

Pilot plants for coal gasification have been constructed. This process appears to be a promising alternative for fueling large central power stations, but it is not developed to the extent that it can be considered as an alternative to the applicant's proposal. A commercial process might be available by the late 1980s.

Coal liquefaction

Development of coal liquefaction processes has not progressed to the same extent as for coal gasification processes. Although one or more processes should be commercially available by the late 1980s, their development will not be in time to be considered as an alternative to the applicant's proposed station.

Magnetohydrodynamics

Construction of a large-scale magnetohydrodynamic electrical generating station depends upon the solution to a number of technological problems. Therefore, such a station is not expected to be available until even later than coal gasification or liquefaction technology and, consequently, will not be available in the time frame required by the applicant.

Other

There are a number of other alternative energy sources, such as conversion of foreign natural gas to methanol and its transportation to the United States as a liquid; extraction of fuel oil from oil shale or from tar sands; or the use of fuel cells. However, these sources cannot be considered as viable alternatives to meet the applicant's requirements for power in the time frame that this power is needed, because they are either not technically feasible at this time or are not available in the quantities needed.

Summary and conclusions

Of the various types of energy sources that were considered, the staff found that only coal was a viable alternative to nuclear as fuel for a large base-load power station. The staff's cost comparison of these two types of power stations is given in Table 9.1. The following is a brief discussion of the staff's method of comparison.

A computer program has been used by the staff to estimate capital costs for the nuclear and coal stations. This computer program, CONCEPT (see Appendix D), was designed primarily for use in examining average trends in costs, identifying important elements in the cost structure, determining sensitivity to technical and economic factors, and providing reasonable long-range projections of costs. The main factor in this computerized approach is the technique of separating the plant cost into individual components, applying appropriate scaling functions (to account for the difference in size from a reference design) and location-dependent cost adjustments (to account for costs of materials and labor at particular regions of the country), and escalating these costs to different construction and startup dates. These capital cost estimates are given in Table 9.1 for both the coal-fired and uranium-fueled plants. The coal-fired plant was evaluated with and without SO_2-control equipment. From an economic standpoint, the values presented in Table 9.1 indicate that a nuclear power station is the clear choice of the two viable types considered whether or not SO_2-removal equipment is needed for the fossil plant.

From an environmental viewpoint, the major effects of the alternative generating system results from the condenser cooling water requirements and the radioactive and nonradioactive particulate and gaseous effluents. The coal-fired station would have essentially the same type of condenser cooling water system as the nuclear station; but because of its higher efficiency and the transfer of some heat to the atmosphere through stack gases, the intake water requirement, the quantity of water evaporated by the cooling tower, and the quantity of water returned to the Broad River as blowdown would be less (by about 30%) than for a nuclear station. The particulate and gaseous emissions from a coal-fueled station would be significantly higher than those from a nuclear station, but they would meet the applicable standards and thus should be acceptable. Although the radioactive effluents from a nuclear station are potentially higher than those from a coal-fired station, the controls imposed on the nuclear station would result in such effluents being equivalent to only a fraction of the natural background radioactivity.

The creation and shipment of radioactive wastes from the nuclear station are adverse environmental effects, as are the transportation and onsite storage of coal for the coal-fueled station. In addition, the use of coal as a fuel would require the storage or disposal of large volumes of ash. From an aesthetic standpoint, the presence of smokestacks and their plumes at a coal-fired station is an additional feature not present with a pressurized-water nuclear reactor station. However, this feature will generally be overshadowed by the presence of the plumes from the mechanical-draft cooling towers.

The staff concludes that the significantly lower generating costs of a nuclear station, compared with the coal-fueled station, are not offset by any particular environmental advantage of the latter station; therefore, the selection of a nuclear station is warranted.

9.1.2.2 Candidate regions' study for plant siting

The applicant's service area encompasses about 20,000 sq miles in the Piedmont sections of North and South Carolina. Thus, it has a large area from which to select a suitable site, and the applicant has indicated that it has found no justifiable reason or advantage for considering sites outside its service area; neither the economic nor the environmental impact of the proposed project would thereby be improved (ER, Sect. 9.2.1).

From power network reliability and transmission considerations, it is generally considered desirable to locate power stations reasonably close to those areas utilizing their output. Thus, an initial major criterion with respect to power plant site selection is consideration of the existing and predicted loads (and load-generation mix) in relation to existing capacity, the capacity under construction, and the environmental and capital costs of transmission lines. A second major criterion is the availability of condenser cooling water that is required in relatively large amounts for base-load power stations. As a consequence of the latter consideration, the applicant has divided his entire service area into four load-generation regions that generally correspond to the four major river basins (Savannah, Broad, Catawba, and Yadkin) in the applicant's service area (Fig. 9.2) (ER, Sect. 9.2.1). Table 9.2 lists the four regions and the base-load capacity in each by 1983.

The four areas, which generally run from the northwest to the southeast, bear no relationship to the load development in the applicant's service area, since load development has generally followed the main line of the regional railroad system that runs generally from the northeast to

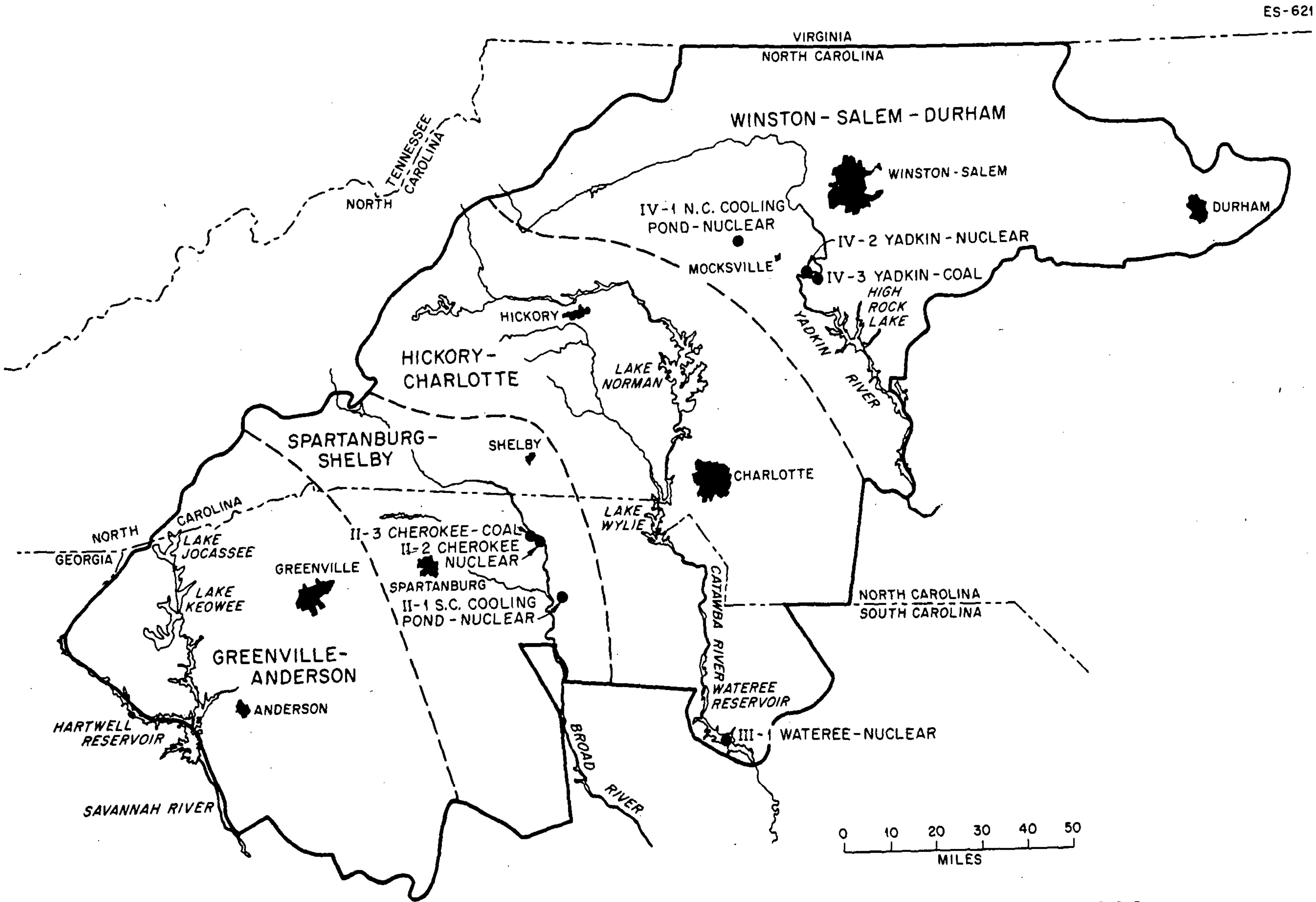

Fig. 9.2. Load-generation regions in Duke Power Company's service area. Source: ER, Fig. 9.2.2-1.

the southwest. The transmission network within the applicant's system has been developed as an integrated network to permit installation of new generating capacity to economically serve the entire service area. However, in the long run, both economic and reliability considerations dictate a reasonable balance of load and generation within each of the areas, even though an imbalance may exist for short periods of time (ER, Response to Questions 9.1.6 and 9.2.1).

Table 9.2. Duke Power Company's four major load-generation regions, their major rivers, and their approximate 1983 base-load power capability

Region	Major river	Approximate base-load power capability in 1983 (MWe)
Greenville-Anderson	Savannah	2950
Spartanburg-Shelby	Broad	770
Hickory-Charlotte	Catawba	2440
Winston-Salem-Durham	Yadkin	3000

The siting procedure for locating CNS was carried out simultaneously with the siting of the Perkins Nuclear Station, since construction of both stations is planned on approximately the same time schedule. Each station will consist of three 1280-MWe nuclear units, with the Perkins units scheduled for commercial operation in 1983, 1985, and 1987 and the Cherokee units scheduled for commercial operation in 1984, 1986, and 1988. The applicant has indicated that potential sites for these two stations exist in all four regions of its service area. However, the Broad River and Yadkin River regions were selected as the primary candidate areas mainly because of the resulting improved system reliability and operation with a minimum of new transmission line mileage and the availability of sites for closed-cycle cooling operation with minimum land requirements. One additional site, which is outside these two regions on the lower Catawba River by the Wateree Reservoir, was also considered.

9.1.2.3 Candidate site-plant alternatives

The two viable alternatives for fueling the proposed station were uranium and coal. Having reached this consideration, the applicant sought suitable locations for these plants in each of the two selected candidate areas (plus the location near the Wateree Reservoir, as mentioned above). In making a selection of potential suitable sites, the applicant indicated that the following site criteria were used:

1. Land area — sufficient acreage.

2. Physical site characteristics — all characteristics suitable.

3. Nature of surrounding area — low population density; minimally affected land use.

4. Benefits to surrounding area — local tax revenues, employment opportunities.

Using these criteria, four site-plant alternatives were located in each of the two candidate areas, and two site-plant alternatives were located near the Wateree Reservoir, for a total of ten site-plant alternatives. One potential nuclear station location, which could utilize either a cooling pond or closed-cycle cooling towers, was found in each candidate area; one potential site utilizing closed-cycle cooling towers was found in each area to be suitable for either a coal or a nuclear station; and the Wateree Reservoir location was considered to be suitable for a nuclear station using either closed-cycle cooling or once-through cooling. As indicated above, of the ten site-plant alternatives, three involved either a cooling pond or once-through cooling at an existing reservoir. The applicant indicated that the Environmental Protection Agency had informed them that cooling towers would also be necessary for these systems (ER, Sect. 9.3.5). Thus the applicant indicated that these three site-plant alternatives utilizing lake cooling for waste heat dissipation were not feasible alternatives; therefore, the only feasible cooling system is closed-cycle cooling towers. A summary of the significant characteristics of the five potential sites (two of which are suitable for either coal or nuclear fuel) is given in Table 9.3.

As discussed in Sect. 9.1.2.1, regarding costs of producing power in nuclear plants or coal-fired plants, the economic advantage clearly belongs to the uranium-fueled stations. In comparing the potential sites, there appears to be no significant environmental advantage for the coal-fired stations in relation to nuclear stations. Moreover, as indicated in Table 9.3, the coal-fired stations will generally require more land than the nuclear plants (for ash disposal purposes). Thus, from the site-plant alternatives presented by the applicant, the choice appears to be the selection of the better two nuclear-plant locations from five potential choices — Turkey

Table 9.3. Comparison of the applicant's feasible site-plant alternatives

All sites to utilize closed-cycle cooling towers

	Broad River region			Yadkin River region			Wateree Reservoir (Catawba River) (nuclear)
	Turkey Creek (nuclear)	Cherokee		Hunting Creek (nuclear)	Yadkin (Perkins)		
		Nuclear	Coal		Nuclear	Coal	
Location	30 miles ESE of Spartanburg, S.C.	21 miles ENE of Spartanburg, S.C.		9 miles NW of Mocksville, N.C.	6–8 miles SE of Mocksville, N.C.		20 miles S of Lancaster, S.C.
Topography	Gentle hills and slopes	Gentle hills and slopes		Gentle hills and slopes	Gentle hills and slopes		Gentle hills and slopes
Cooling water	7350-acre lake (to be constructed)	Broad River		7200-acre lake (to be constructed)	Yadkin River		Wateree Reservoir
Total land required, acres	8300	2263	2584	8124	1600	1100	710
Land excess costs over Cherokee, millions of dollars	12		4.5	10	2	3	0
Exclusion area, acres	450	450		450	450		450
Current land use	Rural	Rural	Rural	Rural	Rural	Rural	Rural
Transportation access (miles from interstate hwy)	Poor (20)	Good (7)		Good (10)	Good (10)		Poor (20)
Access road construction							
Highway, miles	0.5	0.2	0.5	0.2	0.2	0.2	1
Railroad, miles	8.9	7	6.5	16	6.4	6.4	12
Transmission line required, miles	110	21	21	117	15	26	240
Transmission line excess costs over Cherokee, millions of dollars	20		2	11	0.5	0.5	74
Switching stations, number	1	1	1	2	2	2	1
Construction labor force	Readily available	Readily available		Available	Available		Probably available
Major operation impacts	Minor	Potential ground fog		Minor	Potential ground fog		Minor
Aesthetic features	Cooling towers and plumes	Cooling towers and plumes	Cooling towers, plumes, and chimneys	Cooling towers and plumes	Cooling towers and plumes	Cooling towers, plumes, and chimneys	Cooling towers and plumes
Impacts on biota	Construction of new lake	Minor		Construction of new lake	Minor		Minor

Creek, Cherokee, Hunting Creek, Yadkin (Perkins), and Wateree. As compared to Cherokee and Yadkin (Perkins), the Turkey Creek and Hunting Creek sites require considerably more land for the cooling water storage ponds, and they also require significantly longer transmission lines. Thus, since there are no apparent environmental advantages to the Turkey Creek and Hunting Creek sites as compared to Cherokee and Yadkin (Perkins) and since there are additional environmental disadvantages associated with the requirement of additional land for storage reservoirs and transmission lines, the selection of Cherokee and Yadkin (Perkins) appears reasonable. The other alternative site, Wateree, although not requiring as much land for the station, does require about 220 additional miles of transmission lines. There does not appear to be any environmental advantage to be gained by the additional expenditures required for this transmission line from Wateree. Therefore, it would appear that the selection of the Cherokee and Yadkin (Perkins) sites, as compared to the Wateree site, is a reasonable choice.

Summary

The applicant has made a search for suitable sites within its service area. Although ten site-plant combinations were identified, six involved the same three lakes. In one case the cooling system to be used for the plant on each of these lakes was once through and, therefore, did not comply with the Federal Water Pollution Control Act as implemented by EPA regulations (40 CFR Part 423). Therefore, lake combinations utilizing once-through condenser cooling systems were not considered in the staff's final comparisons. These same three lakes were also considered with closed-cycle cooling, and this was the comparison used in the staff's analysis. Two of the site-plant alternatives utilized coal as fuel. No significant environmental advantage appeared to accrue for a coal-fired station, as compared to a nuclear station; and since the coal-fired station is at a significant economic disadvantage, the applicant's choice of a nuclear station appears reasonable. Of the five potential nuclear plant sites, the applicant selected the Cherokee site and the Yadkin (Perkins) sites for locations for the proposed six nuclear units to begin operation in 1984-1988. There appears to be no significant environmental disadvantages associated with nuclear plant operation at the selected sites. The other three potential sites appear to offer no significant environmental advantage as compared to those selected. Moreover, a significant amount of additional acreage for the plant site and for transmission lines would be required if power plants were constructed at these three other locations, as compared to the two selected sites. Therefore, the staff concludes that the applicant's method of site selection was reasonable and that none of the other sites offer any obvious superiority to the Cherokee and Yadkin (Perkins) locations.

9.2 ALTERNATIVE PLANT DESIGNS

9.2.1 Cooling systems

9.2.1.1 Once-through cooling

At full load, CNS will reject about 2.6 x 10^{10} Btu/hr (7616 MW) of heat into the environment. If this release were accomplished by a once-through cooling system using a typical temperature rise through the condensers of 20 F°, a cooling water flow rate of at least 2.6 x 10^6 gpm (5790 cfs) would be required. Since this rate exceeds the average flow rate in the Broad River, once-through cooling is obviously not a viable alternative for the CNS.

9.2.1.2 Dry cooling towers

Dry cooling towers transfer heat by radiation and convection from water flowing inside finned tubes to a moving stream of air outside the tubes. The lowest temperature the water could possibly achieve is the dry-bulb temperature of the air. Thus the condensing pressure of the turbines will be higher than if wet cooling towers were used (where the water temperature can approach the wet-bulb temperature of the air), and the system will have a significantly lower thermal efficiency. In addition, since the heat-transfer coefficient to the dry air is relatively low, surface area requirements and costs are high. Large, dry-type cooling towers have not been developed commercially in the United States to the extent that cost and performance data are readily available. Therefore, this method of cooling is not considered practical at this time.

9.2.1.3 Wet-dry type cooling towers

This type of cooling tower has provisions for operating without the evaporation of water when outside temperatures are sufficiently low or when visible plumes, fogging, or icing would create a particular problem. These towers cost significantly more than the wet type, and they afford poorer plant thermal efficiencies. The wet-dry type tower is not a viable alternative for CNS.

9.2.1.4 Cooling ponds

The water surface area required for a cooling pond is 1 to 3 acres for every megawatt of electricity generated; therefore, to cool the condensing water needed for the three units at CNS would require a surface area of 4000 to 12,000 acres. The water evaporation rate from the pond surface would not be greatly different from that in the cooling towers. If the bottom must be sealed against seepage losses or if caves and other underground passages must be plugged, these expenses can add significantly to the costs. The environmental impact and the costs of creating a large pond make this alternative impractical for CNS.

9.2.1.5 Spray pond

A spray pond for CNS might require an area of 150 to 200 acres. Drift and ground-level fogging effects would be considerably greater than for cooling towers, although both would tend to be confined more to the general vicinity of the pond. A spray pond would probably be required in addition to the settling basin because water supplied from the Broad River to make up for evaporation normally contains too much suspended material to be used directly. The nuclear service water pond and waste water pond could not be incorporated as part of the spray pond for cooling condensing water. A spray pond is considered to be one of the less attractive alternatives for the CNS cooling system.

9.2.1.6 Wet, mechanical-draft cooling towers with rectangular layout

The performance of wet, mechanical-draft cooling towers with the cells laid out in rows in a rectangular fashion would be similar to the circular mechanical-draft (CMD) towers proposed by the applicant. However, when the wind direction tends to be perpendicular to the rows in the rectangular layout, the plume buoyancy forces would not be as great because there would be less merging of plumes to gain increased buoyancy forces. The land area requirements for the rectangular layout were estimated by the applicant to be about 145 acres as compared to about 37 acres for the circular mechanical-draft types (ER, Fig. 10.1.2-1). The applicant also estimates the capital cost of the rectangular layout to be more than for the circular mechanical-draft type by about $12 million (ER, Table 10.1.0-1 and Response to Question 10.1.4).

9.2.1.7 Natural-draft-type cooling tower

Wet, natural-draft-type cooling towers are perhaps the most viable of the alternative cooling methods for CNS. Although the height of such towers (500 ft or more) would make them highly visible, this height contributes significantly to the plume rise performance, and essentially no ground-level fogging, icing, or drift problems could be expected. Natural-draft-type towers create relatively little noise. Although the applicant estimates the capital cost to be considerably higher than for the CMD type, the savings in operating costs are offsetting, and the net costs are different by less than 1% (ER, Table 10.1.0-1 and Response to Question 10.1.4). Three large natural-draft towers could serve in place of the nine CMD units proposed for the station, but, according to the applicant, the land area requirement would be about 52 acres as compared to the 37 acres required for the circular mechanical-draft towers (ER, Fig. 10.1.3-1).

9.2.2 Intake system

In selecting the appropriate intake structure for CNS, the applicant considered four alternative designs: (1) a bankside river intake structure, (2) an off-river intake structure, (3) a perforated pipe intake with off-river pump structure, and (4) an infiltration bed intake with off-river pump structure.

EPA guidelines for the best technology available for the design of intake structures[19] suggest that (1) an intake structure should be constructed flush with the river bank, (2) the traveling screens should be located flush with the front face of the structure to allow the river current to sweep across the traveling screens, and (3) provisions should be made to locate fish passageways between the screens and the trash racks.

The staff considers that the applicant's proposed design, the bankside river intake structure, which incorporates these guidelines, is the best among the four alternatives considered.

9.2.3 Blowdown water discharge

The applicant has offered two alternatives to its proposed method and location (ER, Sect. 10.3.2.1) for discharging cooling tower blowdown:

1. Bankside single port discharge (ER, Sect. 10.3.2.2). The discharge would be from a single port on the west bank of the river about 1200 ft downstream of the dam. The discharge would be at or about the river water surface, with a discharge velocity of about 5 fps. (For the staff analysis of theialternative see DES Section 3.4 and 5.3.)

2. River bottom single port diffuser (ER, Sect. 10.3.2.3). The discharge would be from a single port on the river bottom about 1200 ft downstream of the dam. Discharge would be perpendicular to the river water flow, and the staff assumes that the discharge velocity would be about 5 fps.

The staff has assessed all three options and considers that the proposed method demonstrates the following advantages and disadvantages when compared to the two alternatives.

Advantages

1. The proposed method is more economical.

2. The proposed method entails less land usage and construction impact.

3. Both alternatives would require disruption of the river bottom to some extent because of cofferdam requirements.

Disadvantages

1. The proposed method has the poorest potential for rapid and adequate dilution of the blowdown with river water. The river current exhibits a pattern which the staff considers would be conducive to faster and more thorough mixing at the point where the alternative discharges are located.

2. The staff considers the alternatives to have a lesser potential for aesthetic impact.

3. The staff considers that the proposed discharge has a higher potential for contravention of state standards on thermal discharges than do the alternatives because the alternatives allow more effective mixing, as discussed above.

Overall, the staff is of the opinion that, from aquatic and thermal impact standpoints, either of the two alternatives is probably preferable to the proposed discharge because of the potential effects of residual chlorine and the heated blowdown. Therefore, staff approval of the proposed discharge is dependent upon an applicant commitment concerning limitations on chlorine as outlined in Section 5.5.2.2 and the development of alternate discharge arrangements or procedures so that state thermal standards are met.

9.2.4 Transmission lines

The applicant has outlined a proposed routing and an alternate routing for each of the three fold-ins connecting with other lines of the applicant's existing and proposed system (Fig. 3.9). Comparisons for each of the three fold-ins are given below, based mainly on staff estimates for alternate routes. Based on the staff's analysis, the proposed routes appear to be preferable to the alternatives in terms of environmental impacts.

Cherokee Station to Shelby Tap-Peach Valley 230-kV line

The selected route is 0.5 mile longer than the alternative but does not require a crossing of the Broad River, as does the alternative. Land use in terms of the amount of land in forest and field is similar for both routes. Another possible alternate route would follow the existing right-of-way for a 44-kV line that runs northwestward and crosses the Shelby Tap-Peach Valley line. This alternative, however, would be 5.9 miles long compared to the 5.2-mile selected route, and it would require clearing 162 acres on a 251-ft right-of-way.

Cherokee Station to Catawba-Pacolet 230-kV line

The selected route is 0.7 mile shorter than the alternative and does not require a crossing of the Broad River. The alternate route comes to within about 5000 ft of Hickory Grove, but otherwise, land uses along the two routes are similar. The selected and alternate routes cut across approximately 0.67 mile and 0.3 mile, respectively, of forested game management areas. The alternate route would parallel 4.2 miles of existing right-of-way of a 44-kV line (staff judgment from aerial photograph) and would require clearing a right-of-way only 251 ft wide along this stretch; the total acreage to be cleared, however, would be slightly less (196 vs 207) for the selected route because of its shorter length.

Cherokee Station to Catawba-Shelby Tap 230-kV line

The selected route is 2.8 miles shorter than the alternative. Land uses along both routes are similar, and both routes require a crossing of the Broad River. The alternate incoming route crosses about 0.6 mile of a game management area, while the selected route crosses no game management area. The staff considers the selected routes to be preferable to the alternate routes.

9.2.5 Railroad spur

A 3- to 4-mile segment of the proposed 7-mile spur from the CNS will either parallel or be constructed on an existing 33-kV right-of-way corridor through forested land. The remaining segment will require purchase of new corridor through land that is approximately 75% forested. The applicant submitted an analysis of three alternate routes and concluded that the proposed route is the preferable one, based on a number of environmental, social, and economic considerations.[20] The staff agrees and requires that the spur be constructed on the existing right-of-way as much as practicable. The spur should be located as close to one side of the right-of-way as possible so that if a transmission line must be constructed along the spur, a minimum amount of forest adjoining the right-of-way will need to be cleared.

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10. CONCLUSIONS

10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

10.1.1 Abiotic effects

Of the 1272 acres within the site boundary, about 750 acres of forested and semiforested land will be cleared during construction. A net volume of about 1,461,000 yd^3 of excavated material will be used to fill low-lying areas on the site. A total of about 406 acres at the site will be occupied by ponds (184 acres), settling basins (96 acres), cooling towers (37 acres), switching stations (36 acres), and permanent station structures (53 acres). Transmission line rights-of-way will require about 654 acres. The principal associated impact will be the conversion of about 550 acres of forested land to low-growing grassland and herbaceous cover. The remaining land will probably revert to its former uses (croplands and pasture) following construction. Construction of the railroad spur line will permanently remove about 73 acres of woodland and 10 acres of harvested cropland from their current uses. Access roads will remove about 23 acres from their present land use (mostly forested areas). The approximately 1373 acres of forested land that will be cleared for station and transmission line construction represents about 3.7% of the total forested land within a 5-mile radius and about 1% and 0.01% of Cherokee County's and South Carolina's forested areas, respectively. Removal of the aforementioned acreages from their current land uses is not expected to have a significant effect on area land-use patterns.

Site construction will remove about 12% of the backwaters of Ninety-Nine Islands Reservoir from recreational uses such as fishing, waterfowl hunting, and boating. Station operation will result in the loss of an average of about 112 cfs of Broad River water through evaporation and drift, which represents about 4.5% of its mean monthly flow. Loss of this amount of water is not expected to significantly affect other uses of the river. Station discharges to the river will meet all applicable State and Federal water quality standards; therefore, these discharges are not expected to adversely affect other river water users. Local groundwater is not expected to be significantly adversely affected by station operation.

Cooling tower operation will produce visible plumes that may extend for as much as 15 miles for 5% of the time during winter months. Ground-level fogging, as a consequence of cooling tower operation, was predicted by the staff to occur an additional 25 hr/year at some points within 1/4 mile of the towers. This additional fogging is considered to be small and not of major concern. Additional icing from tower operation is also expected to be inconsequential. Salt deposition from cooling tower drift is expected to have a negligible impact on areas outside the site boundary (maximum deposition, approximately 23 lb/acre-year within 3/4 mile of the towers).

10.1.2 Biotic effects

10.1.2.1 Terrestrial

The major adverse environmental impacts on terrestrial ecosystems during construction will result from land clearing and erosion. Impacts to terrestrial wildlife at the site will range from loss of some individuals due to direct destruction during construction (the less mobile species) to habitat destruction and subsequent small reductions in the populations of some species. The clearing of approximately 1% of Cherokee County's forested land for station and transmission line construction will reduce the county's population of wildlife that usually inhabits this type of habitat by about the same fraction. However, successional stages of vegetation are important to some species (e.g., white-tailed deer, bobwhite quail, cottontail rabbit); and the subsequent revegetation of some of the cleared areas will tend to increase the population of those species. Area waterfowl populations are not expected to be significantly affected by station construction or operation.

10.1.2.2 Aquatic

Construction of the river intake and discharge structures and runoff from the site during rainstorms (during construction) will cause increased turbidity in the river and the reservoir. About 50% of the reservoir's backwater areas will be affected to some extent. Therefore, during construction, some turbidity-intolerant fishes (e.g., bluegills and largemouth bass) will temporarily avoid these areas. However, after construction, the biota of these areas is expected to revert back to its former composition. In general, impacts of station construction on the reservoir are expected to be minor.

Withdrawal of water from the river for cooling tower makeup and radioactive waste dilution will range from 2 to 23% of the river's total flow, depending upon withdrawal rates and seasonal river flows. Because the water passing the intake site would normally soon pass over Ninety-Nine Islands Dam if not removed by the intake structure, entrainment losses from station operation are not expected to affect the reservoir. However, downstream fish populations could potentially be affected by ichthyoplankton losses.

Chemical and dissolved oxygen concentrations in the station's discharges are not expected to adversely affect the aquatic biota in the river. Thermal discharges, as a consequence of cooling tower blowdown, are likewise expected to have negligible impact on these biota.

10.2 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

10.2.1 Scope

The purpose of this section is to set forth the relationship between the proposed use of man's environment implicit in the proposed construction and operation of the generating station (as permitted under the terms of the proposed construction permit) and the actions that could be taken to maintain and enhance the long-term productivity.

10.2.2 Enhancement of productivity

The construction of CNS will have potentially beneficial effects on the economics of both North and South Carolina. The capacity of CNS represents 14.8% of the total projected system dependable capacity of Duke Power Company at the time the plant is to be in operation. At present, the applicant's service area includes about 20,000 sq miles in west-central North Carolina and northwestern South Carolina.

10.2.3 Uses adverse to productivity

10.2.3.1 Land usage

Approximately 2263 acres will be required for the CNS site, with approximately another 655 acres being required for transmission. Of this acreage, about 53 acres will be under permanent usage, that is, permanent facilities. There will be 16 families and one recreational home displaced as a result of the applicant's acquiring land for the construction of CNS. Since only about 6% of the area within 5 miles of the site is cleared land suitable for pasture or farming, little impact on agricultural products is expected to result from the construction of CNS. The State and local taxes on the property (estimated to be $16.4 million annually) greatly outweigh any loss from agricultural production.

10.2.3.2 Water usage

The construction of CNS will decrease the surface area of the reservoir available for public usage. The impoundment of a backwater area to create the basins represents about 12% of the reservoir area.

About 1.9×10^{10} gpy of water will be consumptively used by CNS, representing approximately 3% of the annual flow of the river at the site. This use is not considered a significant impact on present or future uses of the river. Releases from the circulating water system and the wastewater treatment system, when mixed with the river flow, will be within State and Federal water quality standards. The staff concludes that there will be no significant adverse effect on water usage due to construction or operation of CNS.

10.2.4 Decommissioning

No specific plan for the decommissioning of CNS has been developed. This is consistent with the Commission's current regulations that contemplate detailed consideration of decommissioning near the end of a reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan that is submitted to the NRC for review. The licensee will be required to comply with Commission regulations then in effect, and decommissioning of the facility may not commence without authorization from the NRC.

To date, experience with decommissioning of civilian nuclear power reactors is limited to six facilities that have been shut down or dismantled: Hallam Nuclear Power Facility, Carolina Virginia Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua Reactor, and the Elk River Reactor.

The following alternatives can be and have been used in the decommissioning of reactors. (1) Remove the fuel (possibly followed by decontamination procedures); seal and cap the pipes; and establish an exclusion area around the facility. The Piqua decommissioning operation was typical of this approach. (2) In addition to the steps outlined in (1), remove the superstructure and encase in concrete all radioactive portions that remain above ground. The Hallam decommissioning operation was of this type. (3) Remove the fuel, all superstructure, the reactor vessel, and all contaminated equipment and facilities and fill all cavities with clean rubble topped with earth to grade level. This last procedure is being applied in decommissioning the Elk River Reactor. Alternative decommissioning procedures (1) and (2) would require long-term surveillance of the reactor site. After a final check to assure that all reactor-produced radioactive material has been removed, alternative (3) would not require any subsequent surveillance. Possible effects of erosion or flooding will be included in these considerations.

Estimated costs of decommissioning at the lowest level are about $1 million plus an annual maintenance charge on the order of $100,000.[1] Estimates vary from case to case, with a large variation arising from differing assumptions as to level of restoration. For example, complete restoration, including regrading, has been estimated to cost $70 million.[2] At present land values, consideration of an economic balance alone likely would not justify a high level of restoration. However, planning required of the applicant at this stage will ensure that variety of choice for restoration is maintained until the end of useful plant life.

The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and scrap value versus the complete demolition and removal of the complex. In any event, the operation will be controlled by the rules and regulations in effect at the time in order to protect the health and safety of the public.

10.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

10.3.1 Scope

Irreversible commitments generally concern changes set in motion by the proposed action that, at some later time, could not be altered to restore the present order of environmental resources. Irretrievable commitments are generally the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization.

Commitments inherent in environmental impacts are identified in this section, while the main discussions of the impacts are in Sects. 4 and 5. Also, commitments that involve local long-term effects on productivity are discussed in Sect. 10.2.

10.3.2 Commitments considered

The types of resources of concern in this case can be identified as (1) material resources, such as materials of construction, renewable resource material consumed in operation, and depletable resources consumed and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources that, generally, may be irreversibly committed by the operation are (1) biological species destroyed in the vicinity, (2) construction materials that cannot be recovered and recycled with present technology, (3) materials that are rendered radioactive but cannot be decontaminated and materials consumed or reduced to unrecoverable waste including the U-235 and U-238 consumed, (4) the atmosphere and water bodies used for disposal of heat and certain waste effluents to the extent that other beneficial uses are curtailed, and (5) land areas rendered unfit for other uses.

10.3.3 Biological resources

10.3.3.1 Terrestrial

A total of about 406 acres will be covered with structures and ponds. Of this total, permanent station structures and cooling towers will cover about 90 acres. This acreage represents a habitat loss, but only that part of the site that cannot be recovered after dismantlement of the plant can be considered a permanent loss.

10.3.3.2 Aquatic

About 17% of the acreage of Ninety-Nine Islands Reservoir will be lost as running water habitat due to construction of the sedimentation basin. There will be an irretrievable loss of some fish and planktonic organisms from the Broad River due to withdrawal of the makeup water necessary for operation of the plant.

10.3.4 Material resources

10.3.4.1 Materials of construction

Materials of construction are almost entirely of the depletable category of resources. Concrete and steel constitute the bulk of these materials; numerous other mineral resources are incorporated in the physical plant. No commitments have been made on whether these materials will be recycled when their present use terminates.

Some materials are of such value that economics clearly promotes recycling. Plant operation will contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed to reclaim and recycle the constituents. Some parts of the plant will become radioactive by neutron activation. Radiation shielding around each reactor and around other components inside the primary neutron shield constitutes the major materials in this category, for which it is not feasible to separate the activation products from the base materials. Components that come in contact with reactor coolant or with radioactive wastes will sustain variable degrees of surface contamination, some of which would be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry. Quantities of materials used in nuclear plants of about 3300-MWe power output (three 1100-MWe units) are shown in Table 10.1. Production, consumption, and reserves are also given.

Construction materials are generally expected to remain in use for the full life of the plant, in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend on need.

10.3.4.2 Replaceable components and consumable materials

Uranium is the principal natural resource irretrievably consumed in plant operation. Other materials consumed, for practical purposes, are fuel-cladding materials, reactor-control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion-exchanger regeneration, ion-exchange resins, and minor quantities of materials used in maintenance and operation. Except for the uranium isotopes U-235 and U-238, the consumed resource materials have widespread usage; therefore, their use in the proposed operation must be reasonable with respect to needs in other industries. The major use of the natural isotopes of uranium is for production of useful energy.[3]

The three reactors in the plant will be fueled with uranium enriched in the isotope U-235. After use in the plant, the fuel elements will still contain U-235 slightly above the natural fraction. This slightly enriched uranium, upon separation from plutonium and other radioactive materials (separation takes place in a chemical reprocessing plant), is available for recycling through the gaseous diffusion plant. Scrap material containing valuable quantities of uranium is also recycled through appropriate steps in the fuel production process. Fissionable plutonium recovered in the chemical reprocessing of spent fuel is valuable for fuel in power reactors.

Table 10.1. Estimated quantities of materials of construction of water-cooled nuclear power plants

Material	Approximate quantity used in plant[a] (metric tons)	World production[b] (metric tons)	U.S. consumption[b] (metric tons)	U.S. reserves[b] (metric tons)	Strategic and critical material[c]
Aluminum	135	9,089,000	4,227,000	8,165,000	Yes
Asbestos	135	2,985,000	712,000	1,800,000	Yes
Beryllium	0.9	288	308	72,700	Yes
Cadmium	0.067	17,000	6,800	86,000	Yes
Chromium	450	1,590,000	398,000	2,000,000	Yes
Copper	6,000	6,616,000	1,905,000	77,564,000	Yes
Gold	0.0015	1,444	221	9,238	No
Lead	22.5	3,329,000	1,261,000	32,024,000	Yes
Manganese	1,200	7,711,000	1,043,000	907,000	Yes
Mercury	0.045	9,837	2,727	703	Yes
Molybdenum	7.5	64,770	23,420	3,858,000	No
Nickel	300	480,000	129,000	181,000	Yes
Platinum	0.003	46.5	16.0	93.3	Yes
Silver	3	8,989	5,005	41,057	Yes
Steel	30,000	574,000,000	128,000,000	2,000,000,000	No
Tin	0.15	454,200	82,100	47	Yes
Tungsten	0.015	35,000	7,300	79,000	Yes
Zinc	300	5,001,000	1,630,000	30,600,000	Yes

[a]Quantities used are compiled from various sources for two-unit plants of about 2300 MW extrapolated to Cherokee Nuclear Station, Units 1, 2 and 3.

[b]Production, consumption, and reserves were compiled, except as noted, from the U.S. Bureau of Mines publications *Mineral Facts and Problems* (1970 ed., Bur. Mines Bull. 650) and the *1969 Minerals Yearbook*. They are expressed in terms of contained element, regardless of the form. "Production" usually includes material recovered from both primary ores and secondary sources such as scrap recovery. Production and consumption figures are for 1969 unless otherwise noted. Estimates of reserves were published in 1969 but are based on data compiled over a number of years. The reserves stated are the quantities extractable at currently competitive prices; they include inferred as well as measured and indicated ores, when such information was available. Usually, resources recoverable with advanced methods or at greater cost are much greater than the reserves listed.

[c]Designated by G. A. Lincoln, "List of Strategic and Critical Materials," Office of Emergency Preparedness; *Fed. Regist.* 37(39): 4123 (Feb. 26, 1972).

If the three units of this plant operate at 80% of capacity, about 15,000 metric tons of contained natural uranium in the form of U_3O_8 must be produced to feed the plant for 40 years. The assured U.S. reserves of natural uranium recoverable at a cost of $8 or less per pound of U_3O_8 are 200,000 tons of uranium.[4]

In addition to the assured reserves, the amount of natural uranium recoverable at $10 or less per pound of U_3O_8 is estimated to be 315,000 tons, but this increment will require a major effort in exploration and development to bring it into production.[4] The long-term uranium resource situation in the U.S. will depend on the larger expected reserves of ore recoverable at greater cost and on utilization of breeder reactors.

The 15,000 metric tons of mined natural uranium required to feed the fuel cycle for this three-reactor plant consists of 110 metric tons of U-235, with the balance consisting of U-238. In the power plant itself, 77 metric tons of U-235 and 71 metric tons of U-238 will be consumed by fission or transmutation. In this process, 23 metric tons of recoverable fissionable plutonium will be produced. The staff has estimated the additional irretrievable losses of uranium in other portions of the fuel cycle to amount to 2.3 metric tons of U-235, and 180 metric tons of uranium depleted to about 0.2% of U-235 would remain. In the long term, this stock of depleted uranium may be used as feed material in other reactor fuel cycles. In consideration of the reserves of all depletable fuels, uranium consumption in the proposed operation is a reasonable productive use of this resource.

In view of the quantities of materials in natural reserves, resources, and stockpile and the quantities produced yearly, the expenditure of such material for the power plant is justified by the benefits from the electrical energy produced.

10.3.5 Water and air resources

A maximum of about 1.9 x 10^{10} gpy of water will be consumptively used by the station. However, the use of the water can be viewed as an irreversible loss only in the same sense as is natural evaporation from water bodies. The staff does not consider that such usage will have a long-term effect.

The effect of construction and operation of the proposed plant will have little effect on air resources beyond the minimal damage caused by the various equipment emissions.

10.3.6 Land resources

About 3000 acres of land would be committed to the construction and operation of this power station for the years the plant would be licensed to operate. The staff does not expect this land to be returned to present usage after decommissioning of the station. The applicant will probably continue to use the land for some form of power production.

10.4 COST-BENEFIT BALANCE

10.4.1 Benefit description of the proposed facility

The major direct and indirect benefits are discussed below and are tabulated in Table 10.2.

10.4.1.1 Expected average annual generation

The principal benefit of the proposed facility will be the availability to the applicant's service area of 3840 MWe of base-load capacity and of an annual expected generation of electrical energy of 25,565,000,000 kWhr (assuming a plant factor of 0.76). Station output at plant factors of 0.8, 0.7, and 0.6 are presented in Table 9.1.

10.4.1.2 Expected proportional distribution of electrical energy

The power generated by this facility will go directly into the applicant's transmission grid to supply the electrical power needs within its service area. This electrical energy is expected to be distributed to the several categories of the applicant's customers as shown in Table 10.2. These estimates are based on the observed 1973 distribution of sales in these categories (ER, Table 8.1.1-2). Operation of this station will increase the reliability of the applicant's and the region's power supply and will help satisfy the area's electrical energy requirements, thereby making possible some of the commercial and economic activities and residential amenities that the people of this area demand.

10.4.1.3 Other products from the facility

The applicant does not plan to sell steam or other beneficial products from this facility.

10.4.1.4 Taxes

Federal, State, and local (county) taxes have been estimated by the applicant to be about 71.4, 44.6, and 16.4 million dollars annually, respectively (ER, Sect. 8.1.2.2).

10.4.1.5 Local purchases during construction

Although most of the large capital investment for the station will be spent outside the area, the applicant has estimated that during construction, an average of about $700,050 would be spent for regional and local materials, services, and supplies (ER, Sect. 8.1.2.4).

10.4.1.6 Research

Other than the required monitoring programs, the applicant does not plan any specific research program in conjunction with the operation of this facility. The staff considers that the ecological research conducted as necessitated by the pre- and postoperational monitoring programs will be of some benefit.

Table 10.2. Benefits from the proposed Cherokee Nuclear Station

Direct benefits		
Capacity, MWe		3,840
Electrical energy generation		
Average annual electrical energy generation, GWhr (0.76 plant factor)		25.57
Proportional distribution of electrical energy		
	Percent	
Residential	23.9	
Industrial	44.2	
General service	17.1	
Other	14.8	
Other products		None
Indirect benefits		
Employment		
Construction, man-years		18,149
Construction payroll (total), millions of dollars		424
Operation, number of employees		250
Operation, annual payroll, millions of dollars		8.2
Taxes		
Federal, annual, millions of dollars		71.4
State, annual, millions of dollars		44.6
County, annual, millions of dollars		16.4

10.4.1.7 Environmental enhancement

The applicant has indicated that station operation would permit the retirement of older, less environmentally pleasing fossil-fueled generating units (Table 8.4).

10.4.1.8 Employment

An average of 1395 employees per year over an expected 8-year construction period is expected to result in a total construction payroll of $424 million. Permanent station operation will require an estimated 250 employees, with an expected annual payroll of $8,200,000.

10.4.2 Cost description of the proposed facility

10.4.2.1 Power generation costs

The staff has estimated that the station's capital costs would average about $536/kWe for the three proposed units. Fuel and operating and maintenance costs were estimated by the staff to be about $196 million per year at a plant factor of 0.76. This information, along with information on operating and maintenance costs at plant factors of 0.6 and 0.8, is presented in Table 9.1.

10.4.2.2 Environmental costs

The major unavoidable environmental impacts expected to be incurred by construction and operation of the proposed station are summarized in Table 10.3.

Table 10.3. Environmental costs of Cherokee Nuclear Station

Effect	Reference section	Summary description
Land use		
Land required for station	4.1	1272 acres within site boundary fence. 751 acres to be cleared.
Land required for transmission lines	4.1	654 acres. 550 acres to be cleared.
Railroad spur	4.1.4	83 acres (73 acres to be cleared)
Access roads	4.1.5	23 acres
Loss of agricultural production	4.1.1	772 acres at station. Minor elsewhere
Erosion	4.3.1.1, 4.3.1.2	Can be minimized by good construction practices
Visual	5.1.1.1, 5.3.2.1	Extensive visibility of cooling tower plumes
Water use		
Evaporative consumption	5.2.1	112 cfs maximum evaporative and drift losses. (4.5% of mean monthly flow, 23.8% of low flow)
Chemical discharges to Broad River	3.6, 5.2.1	22 ppm maximum increase in TDS
Thermal discharges to Broad River	5.2.3, 5.3.1	River temperature rise generally less than 5F°
Cooling tower plumes	5.1.1.1, 5.3.2	Minimal fogging and icing effects
Social and economic effects		
During construction	4.4	Some potential impact on local communities
During operation	5.6	Minor adverse effects on local communities
Radiological impact		
Cumulative U.S. population dose	5.4.2.5	210 man-rems/year
Occupational	5.4.2.5	1400 man-rems/year
Integrated dose to construction personnel	4.4.1	60 man-rems
Ecological impacts on aquatic life		
Construction	4.3.2	Temporary increase in turbidity of about 50% of Ninety-Nine Islands Reservoir

Table 10.3. Environmental costs of Cherokee Nuclear Station (Cont'd)

Effect	Reference section	Summary description
Ecological impacts on aquatic life (Cont'd)		
Entrainment	5.5.2.1	Will range from 2 to 23.8% of river flow. Potential adverse effect due to ichthyoplankton losses.
Impingement	5.5.2.1	Intake velocity less than 0.5 fps.
Chemical discharges	5.5.2.2	Minimal effects if EPA standards and staff requirements for total residual chlorine in discharge are met.
Thermal discharges	5.5.2.2	Effect may be significant. Applicant must take steps to meet state standards.
Ecological impacts on terrestrial life		
Construction of station	4.3.1.1	Some losses. Minor lasting impact.
Construction of transmission lines	4.3.1.2	Some losses. Minor lasting impact.
Operation of station	5.5.1.2	Minimal if vegetative cover is reestablished after construction
Operation of transmission lines	5.5.1.3	No significant impacts if proper maintenance procedures are followed.

10.4.2.3 <u>Decommissioning costs</u>

No specific plan has been developed for decommissioning this station, but estimated decommissioning costs range from $1 million plus an annual maintenance charge of about $100,000 to a cost of about $70 million for complete restoration of a station (Sect. 10.2.4).

10.4.2.4 <u>Other costs</u>

The environmental costs associated with the nuclear fuel cycle have been treated generically (see also Table 5.5).[5] The contribution to environmental effects associated with the uranium fuel cycle are sufficiently small as not to affect significantly the conclusion of the cost-benefit balance.

10.4.3 <u>Cost-benefit balance of Commission's RM-50-2, "as low as practicable"</u>

Since issuance of the Draft Environmental Statement, the Commission on April 30, 1975, issued its opinion in RM-50-2, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Reactor Effluents, CLI-75-5, NRCI-75-4/R p. 227. The Commission's opinion has put an interim value of $1000 per man-rem dose reduction that can be achieved by use of additional radioactive waste treatment equipment. The total dose to the U.S. population annually (total body plus thyroid) from operation of the Cherokee Nuclear Station is estimated as 210 man-rems as an upper bound (see Table 5.4). At $1000 per man-rem, an additional annual expenditure of $210,000 could be justified. However, for each $1000 spent, the dose must be reduced by at least 1 man-rem. This upper-bound figure of $210,000 (0.21 million dollars) per year for CNS for dose reduction costs can be compared to the total annualized cost difference of $378 million between a coal-fired station (with SO_2 removal equipment) and the above station calculated from the data in Table 9.1, using a 0.7 plant factor. Even this $0.21 million per year additional cost would not change the staff's original conclusions as shown in Sect. 9.

10.4.4 <u>Summary of the cost-benefit balance</u>

In 10 CFR 51, the NRC has required that a cost-benefit analysis be prepared for each nuclear station considered for licensing. In this analysis, all of the potentially significant benefits and costs (or risks) expected to accrue if the proposed station is constructed and operated according to the applicant's proposal (on which is superimposed the conditions to be required by the staff) are identified and described. Regulation 10 CFR 51 (and the spirit and language of the National Environmental Policy Act which it implements) requires consideration of all potentially adverse effects on the broadly defined environment. No method for assigning dollar values to many of the diverse considerations now commands general acceptance or has even been developed; therefore, it is not possible to rest the required cost-benefit balance on a simple monetary balance. However, in this environmental statement, the staff has described, to the extent practicable, the environmental costs and benefits in quantitative terms by indicating, for example, expected ranges of percentage losses of affected biota, specifically affected land uses in relation to the total land in the area currently so used, and the incremental effects of the station's thermal and chemical discharges on the Broad River. Those costs and benefits identified by the staff and considered to be of the most importance in reaching a conclusion with respect to the proposed action have been summarized in the earlier portions of Sect. 10.

Overall, the major benefit of CNS is the electric power to be generated by the station, which will allow economic growth (assuming that this base-load power is necessary in the time frame projected) in the applicant's service area during the period of station operation. Most of the costs are diffuse; they will be borne unequally by people according to when, where, and how they live. Construction activities will cause some inconvenience and costs to local communities. Station operation should cause only minor inconvenience to local residents. The increased tax base as a consequence of the large capital investment in the station will benefit Cherokee County.

Construction of the station and transmission lines will cause some damage to aquatic and terrestrial biota. However, this construction should not result in the long-term disturbance of any major ecosystem. Station operation will be in accordance with staff requirements such that no significant adverse effect is expected on aquatic or terrestrial biota.

As indicated in Sect. 9, the staff considers that there would be no reduction in overall costs of base-load power by the use of an alternate site, the use of alternative fuels, or any combination of alternatives.

The staff concludes, on the basis of the assessments summarized in this environmental statement, that the construction and operation of Cherokee Nuclear Station, as conditioned in the Summary and Conclusions and as predicated on the assumption that base-load power in this amount is needed by the applicant's service area in the time frame projected, will have accrued benefits that outweigh the economic and social costs. The staff concludes that the distribution of costs and benefits does not place unreasonable costs on any segment of the population.

REFERENCES FOR SECTION 10

1. Atomic Energy Clearing House, 17(6): 42 (Feb. 8, 1971); 17(18): 7 (May 3, 1971); and 16(35): 12 (Aug. 31, 1970).

2. Pacific Gas and Electric Company, *Supplement No. 2 to the Environmental Report, Units 1 and 2, Diablo Canyon Site,* Docket Nos. 50-275 and 50-323, July 28, 1972.

3. U.S. Department of the Interior, Bureau of Mines, *Mineral Facts and Problems*, 1970, p. 230.

4. "ERDA Weekly Announcements," vol. 1, No. 1, March 26, 1975, p. 2.

5. U.S. Atomic Energy Commission, "Environmental Survey of Nuclear Fuel Cycle," November 1972.

11.0 DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR 51.25 the Draft Environmental Statement for the Cherokee Nuclear Station, Units 1, 2 and 3 was transmitted with a request for comments to:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Energy Research and Development Administration
Environmental Protection Agency
Federal Energy Administration
Federal Power Commission
State of South Carolina Clearing House
Chairman, Board of Commissioners, Cherokee County, Gaffney, South Carolina

In addition, the NRC requested comments on the Draft Environmental Statement from interested persons by a notice published in the Federal Register on April 4, 1975 (40 FR 15138). Comments in response to the requests referred to above were received within the specified 45 day comment period from:

Department of the Army, Corps of Engineers (ARM)
Department of Agriculture, Agricultural Research Service (AGRS)
Department of Agriculture, Soil Conservation Service (AGSC)
Department of Interior (DOI)
Energy Research and Development Administration (ERDA)

Comments were received after the expiration of the comment period from:

Department of Commerce (DOC)
Department of Agriculture, Forest Service (AGFS)
Department of Health, Education and Welfare (HEW)
State of South Carolina
- Wildlife and Marine Resources Department (SCWMR)
- State Land Resources Conservation Commission (SCLRC)
- Department of Archives and History (SCAH)
- Public Service Commission (SCPSC)
- Department of Health and Environmental Control (SCHEC)

State of North Carolina Department of Administration (NCDA)
Duke Power Company (DPC)
Environmental Protection Agency (EPA)
Federal Power Commission (FPC)

The staff consideration of comments received and the disposition of the issues involved are reflected in part by text revisions in other sections of the Final Environmental Statement (FES) and in part by the following discussion which will reference the comments by use of the abbreviations indicated above. As noted earlier, all comments received are included in Appendix A of this statement.

11.1 RESPONSES TO COMMENTS BY THE APPLICANT

Following publication of the Draft Environmental Statement (DES), the applicant issued an Amendment 3 to the Environmental Report which made extensive changes in the parameters used in the staff's analysis for the DES. The applicant then filed comments on the DES which reflected these changes. Since most of the changes (and therefore responses to the applicant's comments) were reflected by textual revisions of the DES, the list of such revisions would be inordinately lengthy and only those comments which required a non-texual response are presented in Section 11.

11.1.1 Land Use Impacts (DPC-A19, A24, A25)

The staff has re-examined its acreage figures, which were based on maps and figures supplied by the applicant, and is of the opinion that its original data are essentially correct. Minor adjustments in acreage data and also minor text revisions have been made to update the material presented in this FES to conform to information furnished by the applicant after the publication of the DES. The 3000 acres reported in Section 10.3.6 is the sum of the 2263 acres to be controlled by the applicant for the site, the 654 acres for transmission lines and the 83 acres for the rail spur.

11.1.2 Turbidity Tolerance of Blue Gill and Largemouth Bass (DPC-A20)

In the context of the type of spawning cycle for the above fish species, the staff remains of the opinion that they are turbidity intolerant during the spawning period and possible decreases in specie populations could occur.

11.1.3 Duck Radiological Ingestion Dose (DPC-A21)

The staff estimate is based upon the duck's tissue at equilibrium with aquatic plants in the radwaste discharge region and, as such, is a conservative estimate.

11.1.4 Sensitivity of Analysis for I^{131} in Milk (DPC-A22)

The analytical sensitivity for radioiodine in milk should be the same in the pre-operational and operational programs. The staff considers an I^{131} sensitivity of 0.5 pCi/liter of milk to be necessary for validation of the grass-cow-milk pathway model.

11.1.5 Improved Understanding of Doses Received from Accidents by Reference to the χ/Q Values Used (DPC-A23)

The guidance in the proposed Annex to Appendix D, 10 CFR Part 50, which is intended to approximate the 50 percentile χ/Q values, was followed for Section 7.1 of the Cherokee DES. The weighting of the Consequences by wind direction is performed only for the man-rem estimates to obtain average man-rem. The site boundary consequences are calculated in the downwind direction assuming 50 percentile meterological conditions. The relative concentration value used at this boundary for short term releases was 1.02×10^{-4} sec/m^3. This is one-tenth the relative concentration given in the regulatory guide for a ground level release with no building wake effect considered. It should be noted that the staff does not consider the precise meteorological dispersion values critical because increasing the computed dose by even a factor of ten would not alter the conclusions as to the low environmental risk due to those accidents.

11.1.6 Table 7.2 Should Show a Greater Difference in Dose from Large and Small LOCA's (DPC-A23)

There is not a greater difference between the two estimates largely because the staff calculation assumes in the case of the small line break that the containment may be purged after about four days so that access to the containment and clean-up may begin.

11.1.7 Comment on Table 8.12 (DPC-A23)

The staff analysis in Section 8.5.2, which references Table 8.12, makes the point that, at an extreme lower limit growth rate of 6% in the peak load, the Cherokee schedule could slip by two years and still have adequate reserves maintained. The Table therefore reflects this slip and shows no capacity additions for 1989 and 1990.

11.1.8 Alternative Base-Load Energy Sources and Sites (DPC-A24)

The applicant has objected to the staff's characterization of its non-base-load-capacity stations as being not "designed for nearly continuous base-load operation." Although this objection may be valid for some of the applicant's coal-fired plants which were initially operated base-load, the original statement would apply to the combustion turbine, conventional oil, combined-cycle and diesel units which were listed in Tables 1.1.2-1 and 1.1.2-2 of the applicant's ER as being for intermediate and peaking duty. Thus, applied to these units, the statement was correct as written. Also the applicant has indicated to the staff that Cliffside Unit 5, listed in ER Table 1.1.2-2 as being a base-load coal-fired station, was designed to operate in the future as an intermediate-type plant (since it is not designed for "supercritical" conditions) and thus would be an example of a coal-fired plant not designed for base-load duty throughout its lifetime. Thus, the staff believes that, in general, its original characterization of difficulties with operating intermediate or peaking units as base-load was correct.

The applicant has also commented that it is not correct to lump conventional hydro capacity with pumped-storage hydro. The staff did so because both were listed in ER Table 1.1.2-2 as being used for peaking purposes. If the pumped-storage hydro capacity is more accurately characterized as intermediate-type capacity, ER Table 1.1.2-2 should be corrected to reflect this for Jocassee Units 1-4 and the proposed Bad Creek facility.

11.1.9 Visible Plumes from Cooling Tower Operation (DPC-A24)

The basis for the staff's statement that cooling tower operation will produce visible plumes that may extend for as much as 15 miles was Figure 5.1.4-2 of the applicants original ER. Figure 5.1.5-1 of Amendment 2 to the ER is not directly comparable since it is apparently based on an annual average and is not for the winter months. Thus, the staff has no basis to change its original evaluation.

11.1.10 Reservoir Turbidity Increase during Construction (DPC-A24, A25)

The basis for the statement in the DES that 50% of the Ninety-nine Islands Reservoir would be affected by increased turbidity during construction was the staff's assessment (which is unchanged in the FES) as given in Section 4.3.2.1 of the DES.

11.1.11 Annual Property Taxes for the Station (DPC-A24)

The statement in Section 10.2.3.1 of the DES that the annual property taxes for the station would be $38 million was based on the presentation of that figure on page 8.1-3, Section 8.1.2.2 of the original ER. The figure has been changed in accordance with recently-revised estimates submitted by the applicant. Later estimates by the applicant may change these values again.

11.2 RESPONSES TO COMMENTS BY FEDERAL AND STATE AGENCIES

11.2.1 Introduction

11.2.1.1 Dredge or Fill Permit (EPA-A32)

The applicant has stated that a clarification on the status of such a permit will be requested from the Corp of Engineers.

11.2.1.2 Use of FPC Projects Lands and Waters

The applicant filed a request on September 8, 1975 with FPC to grant approval to the revised exhibits reflecting changes in the Ninety-Nine Islands Reservoir Project due to construction of the Cherokee Nuclear Station. This request also includes permission to withdraw water from Ninety-Nine Islands Reservoir.

The applicant has also petitioned FPC to shorten procedures for granting of this approval pursuant to Section 1.32(b) of Rules of Practice and Procedure (18 CFR Section 1.32(b)).

11.2.2 The Site

11.2.2.1 Site Streams (SCWMR-A11)

The construction of the site ponds will inundate the lower portion of the two site streams, not "totally destroy" them.

11.2.2.2 Reference for the Joint Distribution of Wind Speed and Wind Direction (EPA-A35)

One full year (September 11, 1973 through September 11, 1974) of onsite joint frequency distributions of wind speed and direction at the 33-ft level by atmospheric stability (as defined by vertical temperature gradient between 30-ft and 130-ft) are presented in ER Table 2.6.2-1. Similar distributions with wind speed and direction from the 135-ft level are presented in ER Table 2.6.3-2.

11.2.3 Facility Description

11.2.3.1 Discharge of Radioeffluents by Volatilization (SCHEC-A14)

The staff's evaluation of the applicant'sproposed liquid radwaste system design found it acceptable. Therefore no consideration was given to alternate designs.

11.2.3.2 Filtration on Downstream Side of the Gas Decay Tanks (SCHEC-A14)

Based on the staff's source term analysis, filtration of this stream is not necessary. Therefore, the provision of additional filtration equipment was not considered.

11.2.3.3 Exhausts of Radioactive Noble Gases (DOC-A3)

The staff's source term and calculated exposures from releases of noble gases are based on the premise that a large number of nonaccidental releases from the Gaseous Waste Processing System (GWPS) occur under normal operating conditions over the projected 40-year plant life. On this basis, the staff has assumed that the releases occur randomly and that average χ/Q values apply.

While the staff recognizes that unfavorable dispersion conditions could arise during any given release, the assumption is made that the average value for χ/Q for a large number of releases occurring randomly over the 40-year plant life will approach the annual relative concentration (χ/Q) and, therefore, this value has been used.

There a number of factors which substantiate this assumption;

(1) Discrete releases of gaseous effluents will be governed by the limiting conditions of the Environmental Technical Specifications. It will be incumbent upon the plant operator to establish procedures for the control of gaseous releases to assure that the technical specifications limiting conditions are not exceeded. The procedure usually employed to control doses at or beyond the site boundary from releases of noble gases is that of permitting release only under favorable meteorological conditions.

(2) The typical mode of release of gases from waste gas storage tanks is by a slow bleed, e.g., 1 to 2 scfm, into the plant vent. This provides a dilution factor prior to release which increases the effective dispersion. Release of the contents of a 700 ft^3 tank containing gases at 345 psig would require approximately 6 days at a release rate of 2 scfm or approximately 12 days at 1 scfm.

(3) Staff calcualtions show that the GWPS has adequate capacity to permit holding one tank in reserve for back-to-back shutdowns. There should be no reason to require the operator to dispose of GWPS tank contents over a short period of time, i.e., less than one hour.

From the above, the staff concludes that releases will occur randomly during the year because the releases will be made during more favorable meteorological conditions, that individual releases will be of several hours duration, and that substantial dilution of tank gases will occur prior to discharge from the plant vent. For these reasons, the staff considers that the use of the annual average relative concentration (χ/Q) in determining annual dose to the population is appropriate and is valid for the purposes of the Environmental Statement.

11.2.3.4 "Waters of the United States" for Treating Waste Waters (EPA-A27, A31)

In Amendment 3 to the applicant's Environmental Report, the Waste Water Treatment System has been modified (FES, Section 3.6). Under the new design, "waters of the United States" will not be used for waste treatment. All treatment will be provided prior to release.

11.2.3.5 Discharge of Vent Gases (EPA-A28)

Waste gases displaced from aerated tanks, demineralizers, BRS and waste evaporators will exhaust to the gas collection header which will be vented through the auxiliary building exhaust vent. The auxiliary building exhaust air will be continuously monitored prior to release to the environment. The staff calculates the iodine-131 releases from the auxiliary building exhaust air, including the waste gases from the gas collection header, to be 0.008 Ci/yr/reactor.

11.2.3.6 Collection of Liquid Leakage to the Turbine Building (EPA-A28)

The applicant has stated that he will transfer the liquid waste contents of the turbine building sump to the MLWMS whenever primary to secondary leakage exists as determined by continuous monitoring of the steam jet air ejector and the steam generator blowdown effluent release lines. The turbine building sump contents will be sampled and monitored prior to release.

11.2.3.7 Documentation of Effluent Release Points (EPA-A28)

In view of the fact that staff-approved design changes occur during plant construction, the staff believes that final documentation of effluent release points should be deferred until the applicant applies for his operating license.

11.2.3.8 Liquid Source Term (EPA-A34)

Although the staff calculates the waste output from each subsystem during evaluation, the wastes may be combined for sampling and will be released through a common discharge line. During sampling and discharge, the identity of wastes by subsystem is lost. It is the combined total waste release from the discharge line which is considered in the dose calculations. Therefore, the staff considers it appropriate that the total system, rather than subsystem, releases be given in the FES.

11.2.3.9 Treatment of Containment Cooler Condensate Liquid (EPA-A34)

The Figure 3.7 was in error and has been corrected in the FES.

11.2.3.10 Applicant Estimate of Gaseous I^{131} Discharge (EPA-A34)

The applicant calculated the turbine building iodine-131 releases to be 0.002 Ci/yr/reactor. The value of 0.007 Ci/yr/reactor was in error and has been corrected in the FES.

11.2.3.11 Radioactive Liquid Waste Dispersion Models (EPA-A34)

These models were discussed in Section 3.5 not 2.5 as was indicated in the DES and are presented in Section 3.5 of the FES.

11.2.3.12 Meteorological Data for the ORFAD Program (EPA-A35)

The meteorological data used in the ORFAD analysis of ground level fogging are recorded on U.S. Weather Bureau tape and consists of 10 years of observations from the Charlotte Weather Station. The FES has been revised to show that the additional cooling tower data needed are listed in Table 3.2.

11.2.4 <u>Environmental Impacts of Construction</u>

11.2.4.1 Geologic Information and Erosion Control (DOI-A5, SCLRC-A12)

The NRC staff in the environmental statement describes in general and with minimal detail the geologic features of a site since such information will be covered in much greater detail in the staff's Safety Evaluation Report from information presented with applicant's ER and particularly in the PSAR. This information together with the visit to the site has resulted in an evaluation for potential erosion considered valid by the staff. The applicant plans to limit runoff according to EPA standards (Sect. 4.3.1.1) and the staff will require the applicant to submit a detailed control plan prior to initiation of construction activities (p iii).

11.2.4.2 Site Vegetation Management (DOI-A7)

Although the applicant has not developed a wildlife management program for the site, a commitment to clean up and appropriately landscape the site as expediously as possible after construction has been made (Section 4.5.1). In Section 4.3.1.3 the staff has made recommendations concerning implementation of the above commitment.

11.2.4.3 Noise Impacts (EPA-A33)

The staff continues to be of the opinion (Section 4.4) that noise will not be a major impact to the human environment. The applicant has committed (Section 4.5) to reduce construction noise to acceptable levels and to equip motor-powered equipment with noise reducing devices.

11.2.5 Environmental Impacts of Facility Operation

11.2.5.1 Fish Impingement (SCWMR-A11)

The applicant has redesigned the water intake structure to conform to staff recommendations which will minimize fish impingement (Sect. 3.4) and has indicated that data on fish impingement based on monitoring of the intake will be furnished to SCWMR upon request. Robinson is not a Duke Power Company project.

11.2.5.2 Discharge Temperature (SCWMR-A11)

The applicant in Amendment 3 to the ER has changed the point at which the cooling tower blowdown is discharged. The staff has examined this change and concluded in Section 5.5.2.2 that environmental effects from the thermal discharge will be minimal.

11.2.5.3 Radiation Exposure from Drinking Water (SCHEC-A14)

The staff has developed a quantitative estimate of the maximum annual population-ingested dose which could be delivered to the U.S. population by both liquid and gaseous radioactive emissions of the Cherokee Nuclear Station. These estimates are presented in Section 5.4.2 of the FES.

11.2.5.4 Medical Care and Emergency Care (HEW-A8)

Medical care for employees and all information related to emergency planning are described in Section 13.3 of the applicant's PSAR. Names and locations of hospitals with which arrangements have been made to cope with emergencies are also described.

Emergency planning is reviewed by NRC as part of the safety review and the conclusions will be reported and made public in the Safety Evaluation Report. The scope and depth of the NRC review at the Construction Permit (CP) application stage provides assurance that a responsible plan of action can be developed for protection of the public in the event of a serious reactor accident.

Appendix E to 10 CFR Part 50 describes NRC minimum requirements regarding emergency plans which the applicant must meet. The applicant has met the requirements for the CP stage contained in sub-part II of Appendix E to 10 CFR Part 50.

11.2.5.5 Water Level Fluctuation in Ninety-Nine Islands Reservoir (DOI-A6)

This comment is partially addressed in Section 5.2.1. Additionally, Ninety-Nine Islands Reservoir normally fluctuates between 175 and 325 acres. The maximum increase in reservoir drawdown that would be produced by consumptive CNS water losses would be 0.2 foot. This small increase in drawdown should not create any additional stress to benthic organisms or fish. There is very little recreational use of this reservoir. The primary recreational use, fishing, will not be affected.

11.2.5.6 Environmental Dose Commitment (EPA-A29)

The staff does not believe that the environmental dose commitment concept need be introduced into the assessment of environmental impact of a nuclear power reactor. The annual population dose estimates, which embody individual dose commitments to the U.S. population are given in Section 5.4.2. It has been the staff's experience that information indicating the 'maximum effect' in terms of annual population dose (man-rem) adequately characterizes the impact of a nuclear power reactor.

11.2.5.7 Chemical Effects (EPA-A31, 32)

The staff is of the opinion that the WWTS proposed by the applicant will reduce the amounts of chemicals before release to values which will not exceed EPA Effluent guidelines. The WWTS is capable of treating these wastes by coagulation, precipitation, pH adjustment and sedimentation as suggested in the EPA Development Document.

The applicant has stated that the WWTS will meet the following effluent characteristics:

1) pH - 6.0 to 9.0
2) Total Suspended Solids - 30 mg/l average and 100 mg/l maximum
3) Oil and grease - 15 mg/l average and 20 mg/l maximum
4) Settleable Solids - <0.1 mg/l
5) Iron, total - 1 mg/l
6) Copper, total - 1 mg/l

A summary of the staff's conclusions is given in Section 5.3.3.

EPA effluent limitations for cooling tower blowdown include a 24 hour average concentration of 5.0 mg/l for phosphorus (as P). Referring to Table 3.7, the CNS cooling tower blowdown will release an average of 7.2 mg/l of phosphate (PO_4). This is equivalent to about 2.4 mg/l of phosphorus (as P) and, therefore, the EPA effluent limitations will not be exceeded.

11.2.5.8 Radiation Doses - Additional Comments 1, 2, 3 and 7 (EPA -A34)

The NRC staff is presently reassessing assumptions and evaluating models for projecting radioactive effluent releases and calculated doses in order to reflect the Commission's guidance in its opinion issued April 30, 1975, in the rulemaking proceeding RM-50-2. The revised specific models for a detailed assessment of individual and population doses have not been completed. For the interim, it can be said that the individual doses associated with the radioactive releases of the Cherokee Nuclear Power Station will be in accord with the requirements stated in Appendix I. Upper bound population dose estimates are presented in Section 5.4.2 of the FES.

11.2.5.9 Emissions from the Diesel Generators (EPA-A34, 35)

Air pollutants from diesel generator operation are presented in the applicant's ER (ER, Section 3.7.7). Fuel use corresponding to each one hour test period is estimated by the applicant at 2000 pounds.

11.2.5.10 Damage to Ichthyoplankton from Pumping Radewaste Dilution Water (EPA-A35)

The applicant's Amendment 3 to the ER, which was issued after the DES was published, indicates that radwastes will not longer be diluted by a system involving pumps. FES Figure 3.1 shows the station water use.

11.2.5.11 Effects of CNS on FPC Project No. 2331 (FPC-A40)

The applicant has stated that "These items and their environmental impact are discussed in the Environmental Report and the Draft Environmental Statement. The DES describes the Broad River as being wide and shallow and the Ninety-Nine Islands reservoir as a run-of-the-river hydroelectric reservoir which was constructed about 1910. Further, the reservoir has virtually no remaining storage capacity. Therefore, the portions of the reservoir removed from the project by construction of the dams will have a very minor impact on project operations. The effect of the consumptive water use will result in a small loss in energy output of the project but will not affect its peaking power. However, the loss in output is insignificant compared to the additional base load generation provided by Cherokee Nuclear Station."

The staff agrees with this evaluation.

11.2.6 <u>Environmental Measurements and Monitoring Programs</u>

11.2.6.1 Environmental Sampling Program (HEW-A8)

The staff concluded that the preoperational program of the applicant was generally acceptable. As noted in the comment, wildlife is prevalent in the area and thus sampling of this medium would not represent a significant pressure on the community. Thus, the staff has included in its recommendations in Section 6.1.3 that the applicant periodically sample terrestrial animals and food items in the pathway to man.

11.2.6.2 Groundwater Sampling for Salt Accumulation (DOI-A6)

The natural deposition of solids in precipitation is about 53 lb/acre-yr, and the maximum additional deposition due to tower drift is expected to be 23 lbs/acre-yr (Section 5.3.2.3). This addition of solids to natural input is not expected to have any significant effect on ground waters and the staff will not require the applicant to establish monitoring programs for total dissolved solids in ground water unless significant damage to dominant native vegetation in the area is observed during vegetation monitoring programs required by the staff.

11.2.6.3 Dose Assessment (EPA-A28)

The applicant will be required to take periodic census of animals producing milk for human consumption. This requirement will be included as part of the environmental radiological technical specifications to be written before the facility goes into operation.

11.2.6.4 Preoperational and Permanent Meteorological Tower Location (EPA-A35)

Amendment 3 to the applicant's ER, which was issued after the DES was published, shows in Figure ER 6.1.3-2 the location of the preoperational towers. In addition, the applicant stated in Section 6.1 of the ER that the tentative location of the permanent towers would be approximately 2000 ft. ENE of the plant. However, since three of the cooling towers have been relocated to that area, the applicant does not know the precise location of the permanent towers but does commit to locating them to comply with the Regulatory Standard Review Plan with respect to exposure and cooling tower effects.

11.2.6.5 Calculational Procedures for Computing Annual χ/Q Estimates (EPA-A35)

As stated in Section 6.1.1 of the draft statement, the calculational procedures used to compute annual average χ/Q estimates are presented in Regulatory Guide 1.42, "Interim Licensing Policy On As Low As Practicable For Gaseous Radioiodine Releases From Light-Water-Cooled Nuclear Power Reactors," Rev. 1, March 1974, and consist of a Gaussian diffusion model spread uniformly over 22 1/2° sector with adjustments for building wake effects.

11.2.7 Environmental Impact of Postulated Accidents Involving Radioactive Materials

11.2.7.1 Waste Disposal (AGFS-A4)

The solid wastes will be shipped to Chem-Nuclear Services in Barnwell, South Carolina (Section 7.2). This facility is licensed by the state. The concerns with respect to the license provisions, existing environmental analysis report for the site, surveillance and monitoring required, etc. were examined by the state before the license was issued for this burial site.

11.2.7.2 Consequences of a Postulated Class 9 Accident (DOI-A5)

The current staff position on Class 9 accidents is stated in Section 7.1 of this Environmental Statement. The applicability of the draft Reactor Safety Study (DRSS) to any specific site is also discussed in Section 7.1. The Commission's interim general statement of policy on the DRSS states, in part, that " ... the contents of the draft study are not an appropriate basis for licensing decisions."; therefore, the staff does not use the DRSS in making a determination as the potential environmental impact of postulated accidents at any site.

11.2.7.3 Probability Distribution of χ/Q Estimates (EPA-A35)

The guidance in the Annex to Appendix D, 10 CFR Part 50, is intended to approximate the 50 percentile χ/Q values. The weighting of the consequences by wind direction is performed only for the man-rem estimates to obtain average man-rem. The site boundary consequences are calculated in the downwind direction assuming 50 percentile meteorological conditions. It should be noted that the staff does not consider the precise meteorological dispersion values critical because increasing the computed dose even by a factor of ten would not alter the conclusions as to the low environmental risk due to these accidents.

11.2.8 The Need for Power-Generating Capacity

11.2.8.1 Southeastern Electric Reliability Council (SERC) Responsibilities (FPC-A38)

The applicant is of the opinion that the statement that SERC "coordinates the planning of the members' generation and transmission facilities" is not accurate because, as a reliability council, one of SERC's stated objectives is to "encourage the development of reliability agreements among the systems within the region." The applicant further states that SERC has no authority, per se, to effect such coordination.

11.2.8.2 Total Capacity for Summer Peak-MW for 1983 (FPC-A40)

The "total capacity for summer peak-MW" of 18,233 for 1983 is correct in Table 8.4 of the DES. There were, however, three other errors in that table which have been corrected in the FES.

11.2.9 Cost-Benefit Analysis of Alternatives

11.2.9.1 Plutonium Recycle (SCHEC-A15)

In making the cost comparisons shown in Table 9.1 of the FES, the staff takes no economic credit for plutonium recycle.

11.2.10 Evaluation of Proposed Action

11.2.10.1 Compensation to Downstream Water Users (FPC-A40)

It appears to the staff that compensation to downstream water users involves the application of local State law and is not properly a subject within the jurisdiction of this licensing proceeding.

11.3 LOCATION OF PRINCIPAL CHANGES IN THE STATEMENT IN RESPONSE TO COMMENTS

Topic Commented Upon	Section Where Topic is Addressed
Placement of the Discharge Structure (SCWMR-A10)	3.4, 3.5
Soil Classification (AGSC-A2)	2.7.1.1
Transmission Facilities (SCLRC-A12)	4.3.1.2
Solid Waste Disposal Site (SCHEC-A-15)	7.2
Land Clearing (AGFS-A4)	4.1.1
Topography of Site (DOI-A5)	2.7.1.1
Acreage Estimates (DOI-A6)	i, 1.1
Number of Site Dams (DOI-A6)	4.3.2.3
Fish Impingement from Intake Structure (DOI-A6)	3.4.2, 5.5.2.1
Effect of Chlorine on Aquatic Communities (DOI-A6)	3.6.1, 5.5.2.1
Entrainment Losses (DOI-A6,7)	5.5.2.1
Site Impoundments (EPA-A30,31)	4.3.2.4, Table 4.3
Construction Effects Involving Runoff (EPA-A32)	4.3.1.1, 5.3.3
Alternate Biocide (EPA-A32)	5.5.2.2
Windrose for the 135 ft. Level (EPA-A35)	2.6.2, Fig. 2.3

APPENDIX A

COMMENTS ON

DRAFT ENVIRONMENTAL STATEMENT

Contents

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 919
CHARLESTON, S.C. 29402

SANGR

8 April 1975

Mr. William H. Regan, Jr.
Chief, Environmental Projects,
Branch 4
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

STN-50-491
492
493

Dear Mr. Regan:

This is in response to your letter dated 1 April 1975 requesting our comments on your draft environmental statement for the Cherokee Nuclear Station Units 1, 2, and 3.

We have reviewed the draft statement and have no comment at this time.

Sincerely,

HARRY S. WILSON, JR.
Colonel, Corps of Engineers
District Engineer

DALE P. GREGG
Lt Colonel, Corps of Engineers
Deputy District Engineer

Copy furnished:
HQDA (DAEN-CWP-V)
WASH DC 20314

Division Engineer, South Atlantic
ATTN: SADYN

General Counsel (10 cys)
Council on Environmental Quality
Executive Office of the President
722 Jackson Place, N. W.
Washington, D. C. 20006

4107

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
901 Sumter Street, Columbia, South Carolina 29201

STN-50-491
50-492
50-493

April 21, 1975

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

We have reviewed the Draft Environmental Impact Statement for the Cherokee Nuclear Station Units 1, 2 and 3 transmitted with your letter of April 1, 1975.

In paragraph 2.7.1.1 you have referred to our old classification of Red-Yellow Podzolic of the great soil group. Under present day classification we refer to this group as the Hopludults.

We have no other comments on the statement.

Sincerely yours,

G. E. Huey
State Conservationist

4526

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

April 21, 1975

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

In response to your letter of April 1, the Agricultural Research Service has reviewed the Draft Environmental Statement related to the proposed Cherokee Nuclear Station, Units 1, 2, and 3, of the Duke Power Company.

We concur in the recommendations of your staff and have no additional comments.

Sincerely,

H. L. Barrows
Acting Deputy
Assistant Administrator

4557

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

May 20, 1975 50-491/492/493

RECEIVED MAY 27 1975 U.S. ATOMIC ENERGY COMMISSION Mail Section

Mr. Wm. H. Regan, Jr.
Chief, Environmental Projects
Branch 4
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

The draft environmental impact statement for "Cherokee Nuclear Station Units 1, 2, and 3," which accompanied your letter of April 1, 1975, has been received by the Department of Commerce for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

General Comments

There are no geodetic control survey monuments located within the project area. However, there may be geodetic monuments in the transmission line routes. If there is any planned activity along the transmission line routes which will disturb or destroy these monuments, the National Ocean Survey (NOS) requires not less than 90 days notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for the project includes the cost of any relocation required for NOS geodetic monuments.

Specific Comments

Page 3-12, paragraph 2. Strictly speaking, the "infrequent exhausts" of radioactive noble gases from one of the three decay tanks of the gaseous waste management system should not be averaged over the entire year as was done in table 5.3 through the use of an annual average concentration factor (chi/Q). However, as a practical matter, since these releases constitute about 25 percent of the total released through

5755

other mechanisms (75 percent being released more or less continuously to the atmosphere), the effect of the GWMS gases on the cumultative individual doses due to gaseous effluents will not be great.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving two copies of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Southeastern Area, State and Private Forestry
1720 Peachtree Road, N.W.
Atlanta, Georgia 30309

May 21, 1975

Mr. Wm. H. Regan, Jr.
Chief, Environmental Projects Branch 4
Division of Reactor Licensing
United States Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

Here are U. S. Forest Service, State and Private Forestry comments on the draft environmental statement for Cherokee Nuclear Station Units 1, 2, and 3, Duke Power Company.

Land Clearing - The forest products removed from the 1373 forested acres to be cleared in construction activities are important to the local economy and should be placed in commerce through local sales. Current advice on local market conditions is available from the S. C. Forestry Commission.

Restoration of Vegetative Cover - Erosion and water pollution will be major construction impacts in the area selected. The staff is to be commended for requiring immediate revegetation of denuded sites and applicant surveys every two months for compliance.

Decommissioning of the Facility - Although in accord with current Commission regulations, deferment of concrete planning for decommissioning until near the end of the reactor's useful life is contrary to NEPA Section 101(b)(1) and places the cost burden on subsequent, non-benefiting generations.

Off-Site Waste Disposal - The 1050 drums of solid radioactive waste per each reactor which will be shipped off-site, annually, is a major operational impact and should be more completely described and evaluated in this statement. More information is needed on the disposal site: Location, license provisions, existing environmental analysis report for the site, surveillance and monitoring required, etc.

Thank you for the opportunity to review and comment on this draft environmental statement.

Sincerely,

For PAUL E. BUFFAM
Area Environmental Coordinator

5803

6200-11b (4/74)

36776

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

PEP ER 75/332

MAY 16 1975

Dear Mr. Regan:

Thank you for your letter of April 1, 1975, requesting our review and comment on the draft environmental impact statement for the Cherokee Nuclear Station, Units 1, 2, and 3, Cherokee County, South Carolina.

Our comments are presented according to the statement format and according to subject.

Geology and Mineral Resources

The brief description of geology, plus an introductory reference to the applicant's Environmental Report and Preliminary Safety Analysis Report (p. 2-4, par. 2.4.1), are not adequate as a basis for estimating geologic-related impacts of construction of three nuclear reactors, entailing 9.3 million cubic yards of excavation in hilly terrain. A detailed review of the applicant's Environmental Report reveals that it contains little more geologic information than the draft environmental statement, although it does provide a geologic map and cross section. Because of the recognized erosion hazard and the requirement for an erosion-control plan as a condition of permit issuance (p. ii, #7b), it would be advisable to provide more information on the distribution and physical properties of geologic materials, particularly of surficial deposits in the 750 acres that would be most severely disturbed.

Adequate information on the foregoing subjects is presumed to be available, as reference has been made to 60 test borings completed in the immediate site area (p. 2-5, par. 2.5.2). The applicant has also referred to geologic studies at the site such as test borings, test pits, in situ permeability tests, refraction profiling, in-hole wave velocity measurement, static and dynamic laboratory tests, and analyses of bearing capacity and settlement (ER, p. 6.1-29). Although results are evaluated in the PSAR, some of the subsurface data is also pertinent to an evaluation of potential environmental impacts of plant construction, at least insofar as the data reveal the

CONSERVE AMERICA'S ENERGY

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properties of the nine million cubic yards of subsurface materials to be excavated during construction, and to be emplaced as fill within the site boundaries. However, little or no such data has been provided, with the exception of rock permeability test results from borings (ER, Table 2.5.4-1).

Topography of the site, which is intimately related to potential erosion problems, has been described in a highly generalized and not wholly consistent manner and should be revised. For example, the first mention of topography noted in the draft environmental statement is "the topography of the site . . . consists mostly of gentle slopes" (p. 2-6, par. 2.7.1.1). Topographic maps provided in the applicant's Environmental Report suggest that this statement is misleading. However, without benefit of any photography or detailed topographic map in the environmental statement, it is difficult to obtain an impression of site topography from the generalized statements provided. Later it is stated that "most of the land is gradually to steeply sloping" (p. 2-7, last par.), and still later the site is described as "located in hilly terrain" (p. 3-1, par. 1).

The most serious postulated accident has not been evaluated, but instead reference is made to the Reactor Safety Study (p. 7-2, par. 1), which includes an evaluation of impacts of Class 9 accidents based on average conditions at 100 reactor sites. However, any site posing special risks in the event of a core melt - through accident should be evaluated individually. The environmental statement for Cherokee Nuclear Station should evaluate whether consequences of a Class 9 accident would be more severe than at the average site, and if so, should evaluate site-specific impacts. In particular, our review of the Reactor Safety Study indicated that it did not include a detailed evaluation of core melt accidents on the ground and surface water environment. Further, it appeared from that report that the quantities of radionuclides entering the ground in any accident involving the core melting through the base of the reactor building would be so large as to require a detailed evaluation of the consequences on the water environment at each reactor site.

The average rate of accumulation of salt from cooling-tower operation is indicated as equivalent to that in runoff, assuming "no dilution or dispersion" (par. 5.2.2). However, the rate of horizontal or lateral movement for ground water is much lower than that of runoff or stream flow; thus there are repeated and prolonged opportunities for the infiltration of successive increments of precipitation or drift bearing salt within the period of time required for a given amount of ground water to move beyond the stipulated 25,000-foot radius. Computations based on data presented in the environmental report (pages 2.5-7, 8, 9, 10; figures 2.5.4-2, 3, 4; and tables 2.5.4-1, 2, and 5) suggest that the velocity of movement of ground water in the area is probably on the order of 2 to 3 feet per day. Vertical permeabilities appear to average about 15 percent of the horizontal rock permeabilities; presumably the vertical permeabilities for the fractured rocks underlying the soil horizon will be equal to or greater than those of the soil. With the high gradients of vertical percolation, infiltration rates should be reasonably rapid. Therefore, the accumulation of salt within ground water and probably within the unsaturated zone should be addressed in the statement.

Sampling of ground water for salt accumulation should be included in the cooling towers impact assessment (p.6-1 to 6-8, fig. 6.2). Effects, if any, will probably be apparent only after a considerable period of operation and after numerous periods of infiltration by precipitation (although downward movement through local, vertical rock fractures might also be surprisingly rapid). At any rate accumulations may build up over periods of years.

In addition to the ground water sampling of representative wells, periodic sampling of the lower portions of typical soil profiles to determine accumulation of salt from downward percolating soil moisture or from recirculating soil moisture would be advisable. This work in conjunction with a reasonable program of sampling of ground water may indicate the mechanism of concentration of salt in the subsurface and subsequently permit more efficient planning.

The reference to natural-draft cooling towers (p. 1-1, par. 1) should be changed to mechanical-draft cooling towers. The site is described as covering 2,263 acres on page i (par. 3a) but as 2,306 acres on page 1-1 (par. 1). A reference is made to a 450-acre exclusion area (p. 4-6, par. 1), elsewhere given as 736 acres by the applicant's information (p. 4-3, par. 2) and as 1,272 acres by the staff's estimate. Construction of two dams is referred to on page 4-11 (par. 7), but the number should apparently be three (fig. 2.4).

Mineral production in Cherokee County has been limited to stone, clays, and sand and gravel. The environmental statement provides sufficient information to adequately assess mineral resources and impacts. The proposed project should have no significant impact on local mineral production or resource potential.

Fish and Wildlife Resources

The proposed makeup water intake structure located in the Ninety-Nine Islands Reservoir has the potential for impinging a significant proportion of the fish population in the reservoir. Fish losses due to impingement could have a severe impact on this resource. Therefore, alternative less damaging intake structure designs should be explored. Provisions for the return of impinged fish should be considered.

The draft statement indicates that the potential exists for severe damage to the aquatic communities of the Broad River from the releases of chlorine during blowdown operations. Therefore, the Commission is requiring the applicant to limit the release of residual chlorine to meet applicable EPA standards. Procedures to effectively guarantee compliance with these standards should be described.

The discussion of fluctuating water levels in the Ninety-Nine Islands Reservoir caused by the consumption of makeup water during periods of low flow should be expanded. The final statement should include projections of the expected frequency of various reservoir drawdowns and potential effects on benthic organisms and the spawning of fishes, particularly centrarchids. The effects of drawdown on recreational uses of the reservoir should also be considered.

It is agreed that the potential for substantial entrainment losses of eggs and larvae of certain fishes in the makeup water intake exists if prolonged low river flows coincide with periods of high ichthyoplankton abundance. This situation could have a significant adverse impact on recruitment of fish downstream of the reservoir. Therefore, the data requested by the Nuclear Regulatory Commission staff concerning the abundance of ichthyoplankton in the river, periods of severe entrainment potential, and the expected percent losses of eggs, larvae, and juveniles of each fish species due to entrainment should be provided in the final statement.

Environmental Effects of Site Preparation and of Station and Transmission Facilities Construction

It is stated in this section that cleared areas replaced by lawns, shrubbery, and scattered groves of trees can, with proper management, support fairly dense populations of certain wildlife species and can provide attractive areas for migrating birds. A detailed discussion of the proposed management program for the Cherokee Station should be provided in the final statement.

We hope these comments will assist you in preparing the final environmental statement.

Sincerely yours,

Stanley B. Doremus

Deputy Assistant Secretary of the Interior

Mr. William H. Regan, Jr.
Chief, Environmental Projects
Branch 4
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

MAY 16 1975

MAY 21 1975

Wm. H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Regan:

This is in response to your letter dated April 1, 1975, inviting the U.S. Energy Research and Development Administration to review and comment on the Draft Environmental Statement, NUREG - 75/017 related to the proposed Cherokee Nuclear Station, Units 1, 2, and 3.

We have reviewed the subject statement and have no comments.

Thank you for the opportunity to review this Statement.

Sincerely,

W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research

cc: CEQ (5)

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

5603

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (G-WS/73)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

50-491/492/493

RECEIVED MAY 27 1975

MAY 22 1975

Mr. Wm. H. Regan, Jr.
Chief, Environmental Projects
Branch 4
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

This is in response to your letter of 1 April 1975 addressed to Mr. B. O. Davis concerning a draft environmental impact statement for Cherokee Nuclear Station, Units 1, 2, and 3, Cherokee County, South Carolina.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. We have no comments to offer nor do we have any objection to this project.

The opportunity to review this draft statement is appreciated.

Sincerely,

W. E. Caldwell

W. E. CALDWELL
Captain, U.S. Coast Guard
Deputy Chief, Office of Marine
Environment and Systems
By direction of the Commandant

5757

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

RECEIVED MAY 27 1975

MAY 23 1975

50-491/492/493

Mr. William H. Regan, Jr.
Chief, Environmental Projects Branch 4
Division of Reactor Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

We have reviewed the draft Environmental Impact Statement concerning the Cherokee Nuclear Station, Units 1, 2, and 3. On the basis of our review, we offer the following comments:

1. We recommend the sampling of poultry and eggs be included in the environmental monitoring program. Also, since deer, quail, and rabbits are prevalent in the area, they should be sampled, at least on an annual basis, during the pre-operational monitoring program preferably during the hunting season. Rabbits should also be sampled at random.

2. We found no specific mention in the statement of the impact on medical and health facilities during either the construction or the operational phase of the project. This should definitely be mentioned in the final statement. Also, the final statement should include a systematic section concerning the steps to be taken to assure adequate medical facilities will be available to personnel who may be injured, incur radiation injury, or be contaminated by radioactivity during the operational stage.

3. More information should be included in the statement concerning the impact of construction and operational staff requirements on community facilities and services with particular attention to public health and medical services within the affected area.

Thank you for the opportunity to review this document.

Sincerely,

Charles Custard

Charles Custard
Director
Office of Environmental Affairs

5758

JAMES B. EDWARDS
GOVERNOR

State of South Carolina

Office of the Governor

RECEIVED MAY 29 1975

DIVISION OF ADMINISTRATION
Edgar A. Brown Building
Columbia, South Carolina 29201

May 27, 1975

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Lecensing
United States Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Docket No. 50-491, 50-492, and 50-493.

Dear Sir:

The Draft Environmental Impact Statement related to the proposed Cherokee Nuclear Station, Units 1, 2, and 3 has been reviewed by the State Clearinghouse. The Statement was referred to the following agencies for comment:

Department of Archives & History
State Archeologist
Department of Health & Environmental Control
State Public Service Commission
Department of Wildlife & Marine Resources
S. C. Land Resources Conservation Commission
U. S. Forest Service
S. C. Department of Agriculture
S. C. Nuclear Advisory Council
S. C. Water Resources Commission

The Division of Radiological Health, South Carolina Department of Health and Environmental Control has not yet completed their comments. Their comments will be forwarded to you in the near future.

Enclosed for your information and consideration in preparing the final statement are comments from the Wildlife and Marine Resources Department, the State Land Resources Conservation Commission, the Department of Archives and History, and the Public Service Commission.

Thank your for the opportunity to review the Statement.

Sincerely,

Elmer C. Whitten, Jr.
State Clearinghouse

ECWjr/cs

Enclosures

5258

South Carolina
Project Notification & Review System

STATE APPLICATION IDENTIFIER
Clearinghouse Use Only
CONTROL NUMBER

DIST.	NO.	FY
01	2004	5

SUSPENSE DATE 4/30

PROJECT NOTIFICATION REFERRAL

TO: Wildlife and Marine Resources
Post Office Box 167
Columbia, SC 29202

RECEIVED
APR - 8 1975
S. C. WILDLIFE & MARINE RESOURCES DEPARTMENT

The attached project notification is being referred to your agency in accordance with Office of Management and Budget Circular A-95. This System coordinates the review of proposed Federal or federally assisted development programs and projects. Please provide comments below, relating the proposed project to the plans, policies, and programs of your agency. All comments will be reviewed and compiled by the State Clearinghouse. Any questions may be directed to this office by phone at 758-2946. Please return this form prior to the above suspense date to:

State Clearinghouse
Division of Administration
1205 Pendleton Street
Columbia, South Carolina 29201

Signature Elmer C. Whitten Jr.
Name Elmer C. Whitten, Jr.

RESULTS OF AGENCY REVIEW

JUL 03 1975
DIVISION OF ADMINISTRATION

☐ PROJECT CONSISTENT WITH AGENCY PLANS AND POLICIES

☐ AGENCY REQUESTS CONFERENCE TO DISCUSS COMMENTS

☒ AGENCY COMMENTS ON CONTEMPLATED APPLICATION AS FOLLOWS:

Personnel of the S. C. Wildlife and Marine Resources have reviewed the Draft Environmental Statement by the Office of Nuclear Reactor Regulation, U. S. Nuclear Regulatory Commission relating to the proposed Cherokee Nuclear Station and wish to comment as follows.

The Cherokee Nuclear Station is a Duke Power project to construct three nuclear units and plant in Cherokee County adjacent to the Broad River and Ninety-Nine Islands Reservoir.

Ninety-Nine Islands Reservoir is a three hundred acre river run reservoir used primarily for the production of hydroelectric energy. The lake is divided into two small backwater areas by the Broad River. The backwater areas contain large quantities of silt deposited by the river, particularly during periods of heavy flooding. Sedimentation is so advanced in many areas that the original lake has

(Use separate continuation sheets if necessary)

FOR THE REVIEWING AGENCY:
SIGNATURE: [signature] DATE: July 1, 1975
TITLE: EXECUTIVE DIRECTOR PHONE: 758-6536

Mr. Elmer C. Whitten, Jr.
Project Notification 01 2004 5

July 1, 1975

become inundated by brush and trees. The backwater areas are characteristic of a normal shallow impoundment except for greater than normal circulation. Turbidity in the impounded areas is reflective of the Broad River in being quite high. The Broad River above and below the reservoir is wide and shallow with alternate areas of pool and shoal habitat.

The water of both the river and impoundment is generally of high quality. Productivity in both areas is somewhat lower due to the high turbidity.

Recreational use of the lake and river is limited. Pleasure boating and duck hunting would occupy the lowest priority of uses. While fishing is the most common activity on the lake, it too is judged to be limited. The primary fishing pressure is toward the various species of Lepomis and Ictalurids with an occasional catch of large largemouth bass, Micropterus salmoides. According to local conservation officers, most people choose to travel to either Lake Greenwood, Wylie or Cherokee rather than fish the Ninety-Nine Islands Lake or the Broad River. There are no data available to determine if this is due to poor fishing or the somewhat low esthetic value of the area as opposed to others.

In addition to the lake and river, two small streams with flows of one and three cubic feet per second are to be effected by the project. These streams contain primarily Cyprinid and would be classified as dace-trickle streams.

The Cherokee Nuclear Station will consist of three nuclear reactors used to produce 3,817 MWt each. Steam turbine generators will utilize the heat to produce 1,280 MWt of electrical power for each unit. The cooling of exhaust steam will be by circular mechanical-draft wet cooling towers utilizing makeup water from the Broad River directly above the Ninety-Nine Islands Dam. Construction of the plant and the various ponds for storing nuclear service water and makeup water will involve 32 acres of backwater from the Ninety-Nine Islands Reservoir and the two small streams previously mentioned. "Low level" radioactive waste, diluted with river water and cooling tower blowdown water, will be discharged from a structure approximately 1200 feet down stream from the Ninety-Nine Islands Dam. The water discharged will have a summer temperature of 90°F but a winter temperature of 70°F. Construction of the discharge structure will require the placement of a temporary cofferdam.

During the construction phase of this project, siltation resulting from clearing and other construction activities will increase, but assurances are made that all means possible will be used to control and limit this. The adverse effects resulting from siltation should

Mr. Elmer C. Whitten, Jr. July 1, 1975
Project Notification 01 2004 5

be only short term to the biological community and longer for its habitat. Plant construction will totally destroy two dace-trickle streams.

Fish impingement data should be made available to the Wildlife Department for a minimum of one year's normal operation. Recent data from the Keowee and Robinson projects indicate that impingement is causing significant losses, and we should be aware of this in order to request changes when possible. Plankton losses due to entrainment are considered to be light and of minor significance. Losses in a river system should not be considered as critical as those in an impoundment.

State and Federal standards as related to discharge temperature are being met; however, it would be desirable to return the discharge temperature to an even lower level. The thermal plume particularly during the spring could have some adverse effects on spawning fish. It is requested that Duke Power justify or explain as to why this can't be done.

After reviewing the draft statement as well as Duke Power Company's environmental statement, we can see little justification for objecting to the project other than those previously mentioned, which are considered important. If all EPA water quality requirements are met and the project is constructed and operated with a high degree of responsibility, then the adverse impacts to the freshwater fisheries resource should be at a minimum.

The proposed development site is in the Broad River division of the Central Piedmont Game Management Area and includes some very fine game lands that now support very good populations of both big and small game.

Clearing about 1,373 acres of mixed forest habitat, as is planned for this project, will have considerable detrimental effect on game populations in the immediate vicinity of the project.

Careful planning in plant materials used to stabilize transmission line right-of-way's road sides, and other areas to be planted after construction is completed, will help mitigate for the loss of natural wildlife habitat.

Planting of selected plant materials on the edges of ponds will be helpful to the Waterfowl population that use the Broad River.

JATjr:cs

South Carolina
Project Notification & Review System

PROJECT NOTIFICATION REFERRAL

STATE APPLICATION IDENTIFIER
Clearinghouse Use Only
CONTROL NUMBER
DIST. 01 NO. 2004 FY 5
SUSPENSE DATE 4/30

TO: St. Land Resources Conservation
Post Office Box 11708
Columbia, SC 29211

The attached project notification is being referred to your agency in accordance with Office of Management and Budget Circular A-95. This System coordinates the review of proposed Federal or federally assisted development programs and projects. Please provide comments below, relating the proposed project to the plans, policies, and programs of your agency. All comments will be reviewed and compiled by the State Clearinghouse. Any questions may be directed to this office by phone at 758-2946. Please return this form prior to the above suspense date to:

State Clearinghouse
Division of Administration
1205 Pendleton Street
Columbia, South Carolina 29201

Signature Elmer C. Whitten, Jr.
Name Elmer C. Whitten, Jr.

RESULTS OF AGENCY REVIEW

☐ PROJECT CONSISTENT WITH AGENCY PLANS AND POLICIES
☐ AGENCY REQUESTS CONFERENCE TO DISCUSS COMMENTS
☒ AGENCY COMMENTS ON CONTEMPLATED APPLICATION AS FOLLOWS:

ATTACHMENT

RECEIVED
APR 15 1975
DIVISION OF ADMINISTRATION

(Use separate continuation sheets if necessary)

FOR THE REVIEWING AGENCY:
SIGNATURE: Roger W. Rudd DATE: Apr. 14, 1975
TITLE: Div. Chief, Land Acquisition PHONE: 758-7197

A Form 7 (4/15/74)

April 14, 1975

Page ii, paragraph 7.b. This statement could be considered to be all-inclusive in so far as erosion is concerned. It is a very general statement implying good intentions to control erosion whenever and wherever it develops.

4.3.1.1 The Site. One needs a detailed contour map and a good understanding of the construction plans (including the construction schedule) plus a visit to the site to adequately judge the erosion control plans presented in this section. Both temporary and permanent erosion control measures need to be presented in more detail before their adequacy can be determined. There measures could be mechanical or vegetative or a combination of the two.

4.3.1.2 Transmission Facilities. This section needs to state more specifically the temporary and permanent erosion control measures that will be used and where they will be applied. Strip maps of the areas to be cleared and treated could be used to good advantage. Seeding mixtures and schedules developed in cooperation with local authorities are likely to be more effective and practical than the seedings listed. Local mixtures and schedules would have the advantages of being better adopted to local soil and site conditions, of being designed for more specific purposes, and of being better suited for the time of year the vegetation is to be planted. Such information should be used with mechanical erosion control practices. The net result should be more efficient planning and quicker establishment of erosion control. Topsoiling may not always be necessary and can be uneconomical. Special attention must be given to drainageways crossing or paralleling access roads, especially those on steep slopes and which are likely to be heavily traveled.

APR 15 1975
DIVISION OF
ADMINISTRATION

South Carolina
Project Notification & Review System

PROJECT NOTIFICATION REFERRAL

STATE APPLICATION IDENTIFIER

Clearinghouse Use Only
CONTROL NUMBER

DIST.	NO.	FY
01	2004	5

SUSPENSE DATE 4/30

TO: Public Service Commission
P. O. Box 11649
Columbia, SC 29211

The attached project notification is being referred to your agency in accordance with Office of Management and Budget Circular A-95. This System coordinates the review of proposed Federal or federally assisted development programs and projects. Please provide comments below, relating the proposed project to the plans, policies, and programs of your agency. All comments will be reviewed and compiled by the State Clearinghouse. Any questions may be directed to this office by phone at 758-2946. Please return this form prior to the above suspense date to:

State Clearinghouse
Division of Administration
1205 Pendleton Street
Columbia, South Carolina 29201

Signature Elmer C. Whitten Jr.

Name Elmer C. Whitten, Jr.

RESULTS OF AGENCY REVIEW

APR 14 1975
DIVISION OF
ADMINISTRATION

[X] PROJECT CONSISTENT WITH AGENCY PLANS AND POLICIES

[ ] AGENCY REQUESTS CONFERENCE TO DISCUSS COMMENTS

[ ] AGENCY COMMENTS ON CONTEMPLATED APPLICATION AS FOLLOWS:

The Catawba Nuclear Station is included in the 10-20 year forecast requirement of Duke Power Company, and the Public Service Commission is of the opinion that the Station should be constructed to provide electric service to be required on planned completion date for the facility.

(Use separate continuation sheets if necessary)

FOR THE REVIEWING AGENCY:
SIGNATURE: [signature] DATE: April 10, 1975

TITLE: Director-Administrative Services PHONE: 758-3565

DOA Form 7 (4/15/74)

South Carolina
Project Notification & Review System

PROJECT NOTIFICATION REFERRAL

STATE APPLICATION IDENTIFIER
Clearinghouse Use Only
CONTROL NUMBER
DIST. 01 NO. 2004 FY 5
SUSPENSE DATE 4/30

RECEIVED APR 10 1975 S. C. DEPARTMENT OF ARCHIVES & HISTORY

TO: Dr. Charles Lee
Dept of Archives & History
Post Office Box 11669
Columbia, SC 29211

The attached project notification is being referred to your agency in accordance with Office of Management and Budget Circular A-95. This System coordinates the review of proposed Federal or federally assisted development programs and projects. Please provide comments below, relating the proposed project to the plans, policies, and programs of your agency. All comments will be reviewed and compiled by the State Clearinghouse. Any questions may be directed to this office by phone at 758-2946. Please return this form prior to the above suspense date to:

State Clearinghouse
Division of Administration
1205 Pendleton Street
Columbia, South Carolina 29201

Signature [signature]
Name Elmer C. Whitten, Jr.

RESULTS OF AGENCY REVIEW

☐ PROJECT CONSISTENT WITH AGENCY PLANS AND POLICIES
☐ AGENCY REQUESTS CONFERENCE TO DISCUSS COMMENTS
☑ AGENCY COMMENTS ON CONTEMPLATED APPLICATION AS FOLLOWS:

No National Register properties appear to be affected by this project. We know of no other historical properties, including those eligible for the National Register, that need to be taken into account.

(Use separate continuation sheets if necessary)

FOR THE REVIEWING AGENCY
SIGNATURE: Charles E. Lee DATE: 5/12/75
TITLE: Director, State Historic Preservation Officer PHONE: 758-5816

A Form 7 (4/15/74)

01-2004-5

SOUTH CAROLINA NUCLEAR ADVISORY COUNCIL

COLUMBIA

The State House
P. O. Box 142
Columbia, S. C. 29202

April 14, 1975

RECEIVED APR 15 1975 DIVISION OF ADMINISTRATION

Mr. Elmer Whitten, Jr.
S. C. State Clearinghouse
Office of the Governor - Div. of Administration
Room 455 - Edgar A. Brown Building
1205 Pendleton Street
Columbia, South Carolina 29201

Dear Mr. Whitten:

Enclosed are copies of the following information:

1. Minutes of the March 4, 1975, meeting.
2. A GE Summary of the Fuel Recovery Industry.
3. LWR Spent Fuel Disposition Capabilities.

I have also include exerpts from the NRC Draft Environmental Statement for the Duke Cherokee Nuclear Station. The full copy we received will be at DHEC. Mr. Whitten has asked for comments by April 30. I will notify Mr. Whitten by copy of this letter that we will discuss at our meeting of May 6, and return any comments after that meeting.

Very truly yours,

W. Willoughby /bo
W. Willoughby
Chairman

WW:bo

Enclosures

North Carolina Department of Administration

OFFICE OF INTERGOVERNMENTAL RELATIONS
EDWIN DECKARD
DIRECTOR

JAMES E. HOLSHOUSER, JR., GOVERNOR • BRUCE A. LENTZ, SECRETARY

June 3, 1975

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Cherokee Nuclear Station, Units 1, 2, and 3, Docket Nos. STN 50-491, 50-492, & 50-493., SCH No. 038-75

Dear Mr. Regan:

The above referenced draft environmental impact statement has been reviewed by the Departments of Natural and Economic Resources, Human Resources, Military and Veterans Affairs, and Southwestern Planning and Development Commission - Region A.

At this time, the State Clearinghouse has no objection to this project.

Sincerely,

Jane Pettus/mw

Jane Pettus (Miss)
Clearinghouse Supervisor

JP:mw

7228

118 WEST JONES STREET RALEIGH 27603 (919) 829-2594

STN-50-491-493

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

E. KENNETH AYCOCK, M.D., M.P.H., COMMISSIONER
J. MARION SIMS BUILDING — 2600 BULL STREET
COLUMBIA, SOUTH CAROLINA 29201

June 5, 1975

Director
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sirs:

Having reviewed the document entitled, "Draft Environmental Statement related to the proposed Cherokee Nuclear Station Units 1, 2, and 3," the State of South Carolina's Division of Radiological Health has the following inquiries and/or comments:

1. In one of the more recent nuclear licensing actions we have encountered an argument to the effect that discharge of liquid radioactive effluent by volatilization rather than as a liquid discharge has less detrimental environmental effects, particularly when downstream usage of water includes drinking water supplies. Is such a concept more practicable with the Cherokee facility?

2. Referencing Figure 3.7a we would inquire whether or not it is practicable to install filtration on the downstream side of the gas decay tanks prior to discharge through the unit vents?

3. The discussion on page 5-15 concerned with exposure to population deriving their drinking water from the Broad River is limited to those persons within a 50 mile radius. This seems quite arbitrary when the City of Columbia, South Carolina, derives its water supply from the Broad River at a point several miles below the 50 miles radius. Total man-rem contribution should include this population center. Consistent with comment one above, it may be more practicable to avoid liquid discharge for an alternate vapor discharge.

8340

4. As a matter of correction on page 7-4 Morehead, Kentucky, is mentioned as the nearest radioactive waste disposal site, in actuality the nearest disposal site is at Barnwell, South Carolina.

5. In the discussion of alternatives, we note that it seems to be a conclusion that plutonium recovered in the nuclear fuels cycle will be utilized as fuel in subsequent fuel loads. It is not clear how much of the economic advantage realized from nuclear versus fossil generation depends upon plutonium recycle. We think that this should be made explicit in view of the Commission's present indecision with respect to plutonium recycle.

We appreciate the opportunity afforded to comment upon the draft environmental impact statement. Should further clarification of our comments be desired, please feel at liberty to contact us.

Very truly yours,

Heyward G. Shealy, Director
Division of Radiological Health

SB:bo

cc: Mr. Elmer Whitten
S. C. State Clearinghouse
Office of the Governor

DUKE POWER COMPANY
GENERAL OFFICES
422 SOUTH CHURCH STREET
CHARLOTTE, N. C. 28201
P. O. BOX 2178
TELEPHONE: AREA 704 374-4011

June 6, 1975

RECEIVED JUN 1975 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
United States Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Project 81
Cherokee Nuclear Station
Docket No's STN 50-491, 50-492, and 50-493
File No. CK-1444.00

Dear Mr. Regan:

Please refer to your letter of April 1, 1975, enclosing the Notice of Availability of the NRC Draft Environmental Statement for Cherokee Nuclear Station.

Pursuant to 10 CFR Part 51, we are enclosing our comments on the subject document.

We appreciate the opportunity to comment on the Draft Environmental Statement and trust that the Commission will deem it fit to include these comments in the Final Environmental Statement.

Yours very truly,

L. C. Dail, Chief Engineer
Civil-Environmental Division

LCD/DBB/sm

Enclosures - 10 copies

325

DUKE POWER COMPANY

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT

CHEROKEE NUCLEAR STATION

Docket Nos. STN 50-491, 50-492, and 50-493

June 6, 1975

SUMMARY AND CONCLUSIONS

DES, Item 3, Page i

c. The heat dissipation system, including NSW Cooling Towers, will require a maximum water make up of 55,814 gpm of which 50,514 gpm will be consumed for drift and evaporation losses. (ER Figure 3.3.0-1, Amendment 3.)

d. The DES in this paragraph states, "The applicant will not withdraw make up water when river flows are less than 470 cfs". It, however, fails to mention that under low flow conditions, i.e., when the natural stream flow is less than about 470 cfs (the 7Q10 flow at the Gaffney gage), augmentation of river flow equal to plant consumptive requirements will be provided through releases from existing Duke owned upstream reservoirs.

DES, Item 7, Page ii

c. The intake structure is designed to conform to EPA guidelines. (Details submitted in Amendment 3, Subsection 10.2.2.)

d. A selected railroad route will be determined by a comparative route study.

1. INTRODUCTION

1.1 THE PROPOSED PROJECT

Page 1-1

Condenser cooling will be accomplished through the use of circular mechanical draft cooling towers and not natural draft cooling towers as stated in the DES.

2. THE SITE

2.2 REGIONAL DEMOGRAPHY, LAND AND WATER USE

Page 2-1

The DES states that a house count was made in Cherokee County in November, 1974. The house count was actually made in November, 1973.

The DES states that population projections for the years 1983 and 2022 were made. Population projections are made for the years 1984 and 2024.

2.6 METEOROLOGY

Page 2-5

The DES states that climatological data from Charlotte, Greenville-Spartanburg Airport, and onsite data have been used. Climatic data from Greenville Airport and from Spartanburg Airport have been used in addition to data from sources noted.

The DES states that on-site wind data for the period September 11, 1973, through April 30, 1974 have been used. All analyses based on on-site data have been updated to include one full year of data. This comment refers to all references to on-site meteorological data in DES.

The DES incorrectly states that the "fastest mile" wind speed recorded at Charlotte was 74 mph. The "fastest mile" wind speed recorded at Charlotte through 1974 was 59 mph. The ER has been amended to include the "fastest mile" wind speed recorded at Greenville Airport -- 79 mph.

2.7 ECOLOGY OF THE SITE AND ENVIRONS

The DES states that the Applicant has provided only preliminary data on plant species composition of forests. Applicant has provided additional data in Amendments 2 and 3 of the ER.

Page 2-8

The DES states that lowest flows in the Broad River occur from June through September. As shown in ER Figure 2.5.1-5, the period of lowest flow is July through September.

Page 2-11

The DES states that a list of zooplankton taxa collected is presented in Table 2.7.2-3. The list is actually presented in Table 2.7.2-4.

Additional technical corrections should be made as noted:

P. 2-11. Paragraph 1. Reference 1 does not address aquatic ecology

P. 2-11. Paragraph 4. The chironomid, Demicryptochironomus sp., is actually nr. Demicryptochironomus sp. n. which is an undescribed genus.

P. 2-11. Paragraph 8. Ictalurus sp. should be Ictalurus spp.

P. 2-11. Paragraph 8. Clupeids should not be capitalized. Centrarchids is misspelled.

P. 2-11. Paragraph 9. Dorosoma sp. should be Dorosoma spp. and Notropis sp. should be Notropis spp. Shiners are not abundant in the reservoir except for Notropis niveus in the main channel where current exists.

P. 2-12. Table 2.2. The following names are misspelled: Clinostomus funduloides, Hybognathus nuchalis, and Etheostoma thalassinum.

P. 2-13. Paragraph 2. Eliminate n. sp. after Hybopsis. Etheostoma thalassinum is misspelled twice. The Hybopsis n. sp. appears to be uncommon rather than common.

3. THE STATION

3.3 STATION WATER USE

Page 3-1

ER Figure 3.3.0-1 and Table 3.3.0-1, referenced in the DES, have been revised per Amendment 3.

3.4 HEAT DISSIPATION SYSTEM

Page 3-2

The DES states that blowdown will be discharged about 1200 feet downstream of the Ninety-Nine Islands Dam. This location has been changed to downstream and adjacent to the west abutment of the dam, as shown in ER Figure 3.1.0-2, ER Figure 3.1.0-4, ER Figure 3.4.1-3, Amendment 3.

The DES states that the nine towers will be located immediately west of the reactor buildings. The location of the towers has been revised to six immediately west of the reactor buildings and three immediately east, as shown in ER Figure 3.4.0-1 and ER Figure 3.4.1-1, Amendment 3.

Page 3-3

The DES states that the three units at CNS may use a total of 600-1200 pounds of chlorine per day. The three units at CNS may use 1600-3200 pounds of chlorine per day, as discussed in Subdivision 3.6.1.1 of ER

The conceptual design of the intake structure, shown in Figure 3.4 and 3.5 of the DES, has been revised per ER Figure 3.4.4-1, ER Figure 3.4.4-2 and ER Figure 3.4.4-3, Amendment 3.

Page 3-6

The discharge structure, shown in Figure 3.6 DES. has been redesigned per ER Figure 3.4.1-4, Amendment 3.

3.5 RADIOACTIVE WASTE SYSTEMS

Page 3-9a

Figure 3.7 indicates the presence of four 112,000 gallon holdup tanks, whereas one 450,000 gallon tank will be provided.

Page 3-11

The DES states that the Applicant has estimated the normal releases to be 177 Ci/year per reactor of tritium. The Applicant's estimate is 77 Ci/year per reactor.

Page 3-14

The DES states that the turbine bypass capacity will be 40 percent. The turbine bypass capacity is 55 percent, as stated in Subdivision 10.4.1.3, PSAR

3.6 CHEMICAL AND BIOCIDAL EFFLUENTS

Page 3-15

Discharges from the CNS Waste Water Treatment System have been revised. Details are provided in ER Amendment 3.

Page 3-17

The DES states that the biocide is added to the suction side of the CCW pumps. The biocide will be added to the cooling tower basin outlets.

The DES states that the Applicant is required to restrict the discharge of total residual chlorine to not more than 2 hr/day. Applicant's contacts with EPA and state water quality people have produced verbal interpretations of chlorination limitations in terms of 2 hr/day/unit. EPA officials recognize that some plants may require chlorination at higher concentrations and for periods of time that exceed 2 hr/day/unit.

Operating experience with cooling towers on Cliffside Unit 5 demonstrates the summer season need for a free chlorine residual of 1.5 ppm maintained for one hour. Time requirements for buildup and for disappearance of a total chlorine residual will exceed a period of 2 hours/day/unit. Biocidal requirements for CCW at Cherokee probably will exceed the requirements at Cliffside because Cliffside uses coagulated, clarified water, while Cherokee will use settled water from a more polluted part of Broad River.

Since EPA is considering chlorination requirements on a case by case basis, the restrictions on the use and discharge of chlorinated effluents should not be finalized in the language of Section 3.6.1, page 3-17 paragraph 3. Compliance with Section 3.6.1 in the Draft Environmental Statement and Table 5.11 would require treatment of cooling tower blowdown.

3.9 TRANSPORTATION CONNECTIONS

Page 3-20

A comparative study of four alternative rail routes is being made to determine the selected route.

3.10 CONSTRUCTION PLAN

Page 3-2

The construction plan has been revised. Construction activities at the site are now scheduled to begin in November 1976, with the pouring of first permanent concrete foundations starting in September 1978. The revised construction manpower requirement is presented in ER Table 4.1.1-3, Amendment 3.

4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND OF STATION AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 IMPACTS ON LAND USE

Page 4-1

The DES states that the impacts on land use are based on approximations. Applicant's estimates indicate that the total land area involved in actual construction of temporary and permanent facilities will be about 1441 acres categorized as follows:

Station and Facilities (including three access roads and three ponds)	661 acres
Transmission line right-of-way	695 acres
Railroad spur right-of-way	85 acres
	1441 acres

The area within the site boundary fence is 1209 acres, while acreage owned by the Applicant is 1560 acres.

The DES states that a total of about 751 acres of possible wildlife habitat will be completely cleared during construction. Applicant's estimate is 661 acres.

The DES states that grading and site excavation will involve approximately 9,700,000 $yd.^3$ in the station yard. Applicant estimates the quantity to be 9,340,000 cubic yards.

Page 4-2

Figure 4.1 has been revised. Details are provided in ER, Amendment 3.

Page 4-4

The DES states that the total acreage cleared will reduce the total forested acreage within five miles by 3.7 percent.

A total of 1296 acres will be cleared for station construction and operation; transmission lines (550 acres), station site (661 acres), and access railroad (85 acres). This will reduce the forest acreage (36,725) within a five mile radius by 3.5 percent.

4.3 EFFECTS ON ECOLOGICAL SYSTEMS

Page 4-6

The DES recommends the relocation of construction buildings closer to the center of the exclusion area.

Due to the facts that the Unit 3 Cooling Tower Yard has been relocated to the east side of the plant and that there will be excess excavation material to spoil (ER Subsection 4.1.1), Applicant feels that the selected locations of the cleared areas and construction buildings are suitable to adequately support construction activities.

Other factors that will prevent Applicant from moving the construction buildings closer to the generation station are:

1. The slopes are laid back during excavation so that much of the area around the buildings cannot be used until the backfill can be placed against the buildings.

2. Applicant is trying to keep most of the construction buildings on the east side to better isolate Units 1 and 2 after they are operating from the units that are still under construction.

3. Construction buildings located under high voltage transmission lines will have to be moved before the lines can be energized. To prevent moving the buildings around, Applicant has not located any under transmission lines.

4. Many construction buildings are scheduled to be built before much yard piping is complete. Applicant has located the buildings so that only a small amount of yard piping interferes with the locations.

Page 4-8

Applicant has developed its right-of-way seeding practices through many years of experimentation with different cover species and feels that the current use of fescue, millet, Sericea lespedeza, etc., is the best mixture for achieving rapid growth over the corridor while keeping erosion at a minimum. Also, this mixture provides suitable food and cover for certain wildlife species.

However, the Applicant does modify its seeding mixture depending on terrain, soil type, climate, etc., and will consider these factors when clearing the Cherokee rights-of-way.

Applicant feels that Bicolor lespedeza, in large amounts, is not particularly suitable right-of-way cover because its tall growth may interfere with the operation of the lines.

Page 4-10

Largemouth bass and bluegill are tolerant of turbidity. It is doubtful that much change will occur in species composition because of temporary turbidity increases.

The DES states that all domestic sewage will be pumped to the Waste Water Treatment System during the construction period. All treated construction sewage will not be pumped to the Waste Water Treatment System because:

1. The WWT System is not scheduled to be complete in time to meet this requirement.

2. The cost of running sewer pipe over such a distance would be very high.

Applicant feels that the effluent from an extended aeration-type sewage treatment is suitable to discharge into the NSW Pond or the Intake Sedimentation Basin through the yard drainage system. The effluent will, at all times, meet Cherokee County and South Carolina State Standards.

Page 4-11

The DES states that suspended solids will settle out of the backwaters of the Ninety-Nine Islands Reservoir. Applicant believes that the sedimentation will occur in the west backwaters of the reservoir. Those to the east should be little affected.

4.4 IMPACT ON PEOPLE

Page 4-12

The DES states that the total construction payroll will be over $224-million. Applicant estimates the payroll at over $424-million.

4.5 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

Page 4-14

The DES states that solid construction wastes will either be buried or transported offsite. Solid construction waste will be either burned, buried or transported offsite.

5. ENVIRONMENTAL EFFECTS OF OPERATION OF THE STATION AND TRANSMISSION FACILITIES

5.2 IMPACTS ON WATER USE

Page 5-2

The DES states that the maximum consumptive use of 110 cfs of Broad River water will be caused by the operation of CNS. According to the revised estimates of station water use (ER Table 3.3.0-1, Amendment 3 and ER Table 3.3.0-2, Amendment 3), the maximum consumptive use by evaporation and drift is about 112 cfs. This amounts to 4.5% of the average flow and 23.8% of the 7Q10 flow. As stated in comments on paragraph d, Item 3, Page i, DES, when the natural stream flow at Gaffney gage on Broad River is less than the 7Q10 flow, augmentation of the river flow equal to the plant consumptive requirements will be provided.

The DES refers to the South Carolina Water Classification Standards System and states that the temperature of heated and normal waters shall not exceed 90°F. According to the referenced Standards, Section III, rule [illegible], the temperature of heated and normal water in the portion of Broad River above its junction with Kings Creek shall not exceed 84°F. monthly average.

5.3 PERFORMANCE OF THE HEAT DISSIPATION SYSTEM

Page 5-3

The point of discharge for the blowdown has been changed as shown in ER Figure 3.4.1-3, Amendment 3. The thermal plume analysis has now been performed by plug flows. (ER Subdivision 5.1.2.1, Amendment 3)

5.4 RADIOLOGICAL IMPACTS

Page 5-10

The X/Q values as well as the locations of the farms, dairies, and goats noted in Table 5.3 have been revised. Details are presented in ER Subsection 2.6.3.2, Amendment 3.

The DES states the duck ingestion dose was calculated to be 2.4 X 10^2 millirads/year. Duke's estimate is 0.6 millirads/year (ER Table 5.2.3-1). Staff's estimate is too high.

Page 5-13

Table 5.5 does not conform to Appendix I. References to proposed Appendix I should be changed throughout the chapter.

5.5 NONRADIOLOGICAL EFFECT ON ECOLOGICAL SYSTEMS

Page 5-17

The DES recommends that the Applicant consider selective herbicide

treatment. The Applicant does keep current files on the use of herbicides for controlling undesirable vegetation on rights of way and has used herbicides in the past. Applicant agrees that herbicides are effective in brush control and may in the future implement the selective use of herbicides as a right of way maintenance tool.

Page 5-18

In the revised design of the make up water intake structure (ER Figure 3.4.4-2, Amendment 3), the training wall and the submerged weir have been eliminated in accord with the comments of the Staff.

5.6 IMPACTS ON PEOPLE

Page 5-26

The DES states that cooling tower noise levels are in Section 5.1.5 of the ER. Noise levels are presented in Subsection 5.1.6.

The DES states that about 200 permanent employees with an annual payroll of about \$5.6-million will be required to operate the station. About 250 full-time employees with an annual payroll of about \$8.2-million will be required to operate the station. (Subdivision 8.1.2.3, Amendment 2)

6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL PROGRAMS

Page 6-1

The DES states that onsite joint frequency distributions were submitted with wind data from the 1350 ft. level of the onsite tower. The data is from the 135 ft. level.

In regard to the terrestrial monitoring program as addressed in the DES, the Applicant has the following comments:

Section 6.1.2.1
Paragraph 1 - Applicant is developing a monitoring program to assess cooling tower drift effects.

Paragraph 2 - Data on density, dominance and frequency have been submitted in ER Tables 2.7.1-4, 2.7.1-6, 2.7.1-8, 2.7.1-10, 2.7.1-11, 2.7.1-13, 2.7.1-15, 2.7.1-17 and 2.7.1-19. Placement of plots on a transect is essentially a regularized multiple plot method (Cain and Castro 1970). Orientation along such a transect is prudent in a disturbed or variable area to insure sampling within a single community.

Paragraph 6 - Length of the cruise line in the strip method of bird census (Pettingill 1970) is dictated by uniformity of vegetation and size of stands.

Paragraph 8 - Bird characteristics of the site begin to breed in late March or early April in the Carolinas (Pearson, Brimley and Brimley 1959; Sprunt and Chamberlain 1970) and continue through June, July or later. Therefore, the dates on which birds were censused are appropriate.

Paragraph 9 - Mammals presence was estimated on the basis of signs as well as trap data.

Page 6-3

In regard to the aquatic sampling program as addressed in the DES, Applicant has the following comments:

Section 6.1.1.2
Paragraph 1 - The DES states that sampling has been completed through April 1974. Applicant's Year I Study, through October 1974, has been completed. Data previously submitted should be used and referenced. A Year II program was started prior to ending the Year I study.

Paragraph 4 - Ichthyoplankton samples are taken weekly, during the major spawning period, within and below Ninety-Nine Islands Reservoir to provide information on the magnitude of potential entrainment of these organisms by CNS operation.

Paragraph 5 - Monthly sampling of invertebrate drift at two areas within the reservoir (Stations 11 and 12), and two areas in the Broad River below the reservoir (Stations 15 and 17) is being conducted by the Applicant. The composition and magnitude of invertebrate drift are being studied.

Paragraph 6 - Data on fish densities, relative abundances, and seasonal changes in the Broad River and Ninety-Nine Islands Reservoir are being collected on a monthly basis.

Paragraph 7 and 8 - The Applicant has reduced the number of stations being sampled. Biological data are being collected at Stations 8, 9, 11, 12, 15, 16 and two new stations. The new stations are located at the proposed intake area, and in the Broad River approximately 6-7 km downstream of Ninety-Nine Islands Reservoir. Applicant does not deem it necessary to collect at 4, 13, 14, 21 and 23. Area 4 is far out of the area of influence. The new station at the intake is sampled instead of Stations 13 and 14.

Page 6-3

In regard to preoperational radiological monitoring program, the Applicant feels that a sensitivity of 0.5 pCi/l for I^{131} in milk is no longer appropriate based on adoption of 10CFR50 Appendix I by the NRC. A more appropriate number would be 1.5 pCi/l.

7. ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

Page 7-1

Applicant believes that the doses presented would be more easily understood if reference was made to the X/Q values used.

In Table 7.2, reference should be made to Appendix I and not proposed Appendix I.

Based on assumptions in the Cherokee ER and Regulatory Guide 4.2, (ER Table 7.0.0-1, Amendment 3) the difference in the dose from the large and small LOCA's should be greater than those presented in Table 7.2.

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

Page 7-4

The DES states that wastes will be shipped to the nearest disposal site, Morehead, Kentucky. The nearest disposal site is Barnwell, South Carolina, (Chem-Nuclear Services), 170 miles distant, not Morehead, Kentucky

8. THE NEED FOR POWER GENERATING CAPACITY

8.1 APPLICANTS SERVICE AREA AND REGIONAL RELATIONSHIPS

Page 8-4

The energy forecast shown in the Table 8.1 has been revised in a forecast dated March 17, 1975. The values given in ER Table 1.1.1-1, Amendment 3, are as follows:

Year	10^6KWhr
1974	45,240
Forecast	
1975:	47,734
1976:	52,387
1977:	56,851
1978:	61,346
1979:	65,942
1980:	70,637
1981:	75,699
1982:	81,041
1983:	86,719
1984:	92,746
1985:	98,715
1986:	105,239
1987:	112,096
1988:	119,629

Note: The only change is for the energy. The demand figures are correct as shown.

Page 8-5

The last paragraph in Section 8.2.1 should be revised to agree with revised Table 8.1.

Page 8-9

The DES states that improved air-conditioners ".... could hypothetically save electric utilities almost 58,000 MW in 1980." This statement seems to be in error.

8.6 SUMMARY AND CONCLUSIONS

Page 8-18

Table 8.12 is based on an assumption of no capacity additions after 1988, which is not realistic.

9. COST-BENEFIT ANALYSIS OF ALTERNATIVES

9.1 ALTERNATIVE BASE-LOAD ENERGY SOURCES AND SITES

Page 9-1

The DES states, "Therefore, although postponed retirement of existing units is not an alternative, a delay in the reclassification of some coal-fired units from base-load to intermediate-type operation should be considered."

The DES seems to have misconstrued the operation of coal-fired units. There is no classification procedure whereby a base-loaded unit is officially designated to intermediate-type operation. All units are dispatched on an economic basis, with the lowest cost unit operated in base. If a new unit can produce energy at a lower cost than any other unit on the system, then it operates in base, and pushes higher cost units up in the load curve. Delaying a Cherokee unit would inherently require the existing units to produce a greater amount of energy, or, in effect, keep base-loaded units in base.

Applicant believes that Section 9.1.1.3 is not completely accurate. Most of the coal-fired intermediate-type units on the Duke system operated in base during their first few years of operation, but were displaced by units producing energy at a lower cost. The statement" . . . since these units are not designed for nearly continuous base-load operation." is not correct, and should be deleted. Cost is the predominating reason for not operating these units in base. Also, it is not correct to lump conventional hydro capacity with pumped-storage hydro. Conventional hydro capacity is limited by the water supply; pumped storage hydro can operate in a load-cycling mode similar to intermediate steam. Section 9.1.3 of the ER lists peaking capacity as composed of" . . . hydro, combustion turbines, and small, older, conventional steam units." Presumably, the staff interpreted this to include pumped hydro. It does not.

Page 9-3

Applicant has evaluated the cost effectiveness of the CNS and its fossil fueled alternative and agrees with the DES that the lower generating costs associated with the nuclear station warrent its selection. Applicant's cost estimates have been revised and are presented in Tables 9.3.1.1 and 9.3.4.1, Amendment 3.

Page 9-5

The DES states that there is one hydroelectric site in Applicant's service area suitable for base-load service. Applicant's ER has been revised to correctly indicate that there are no hydroelectric sites in the service area suitable for base-load service. (ER page 9.2-4)

9.2 ALTERNATIVE PLANT DESIGNS

Page 9-13

With regard to the proposed railroad spur location, the Applicant is evaluating four alternative routes. Comparative factors that will be considered for each route include: (1) length of track (2) earth grading (3) land costs (4) environmental impacts on existing land use.

10. CONCLUSIONS

10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Page 10-1 (Subsection 10.1)

The DES states cooling tower operation will produce visible plumes that may extend as much as 15 miles for 5% of the time during winter months. The basis for this statement is not indicated. However, as shown in ER Figure 5.1.5-1, Amendment 2, Duke estimates that the isopleth of 5% visible plume frequency extends to 5 miles southwest of the cooling tower location.

Page 10-2 (Subdivision 10.1.2.2)

The DES states that about 50% of the reservoir's backwater areas will be affected with increased turbidity to some extent by runoff from the site during construction, however, the basis for the percentage impact is not given. Applicant believes that the construction operations will cause insignificant increase in turbidity.

Page 10-2 (Subdivision 10.1.2.2)

In the revised design of the intake structure (ER Figure 3.4.4-2, Amendment 3), the training wall has been eliminated in accord with DES recommendations.

Page 10-2 (Subdivision 10.2.3.1)

The DES states that approximately 2340 acres will be required for the CNS site with approximately another 655 acres being required for transmission. Applicant's comments on page 4-1, DES, show that actual land requirement for CNS is 1441 acres, which includes 695 acres for transmission lines.

Page 10-2 (Subdivision 10.2.3.1)

The DES states that property taxes are estimated to be $38 million annually, however, no basis is given. Applicant estimates that property taxes would be $16.4 million annually (ER Subdivision 8.1.2.2, Amendment 3).

Page 10-2 (Subdivision 10.2.3.2)

The DES states that CNS will consumptively use 1.7×10^{10} gpd of water. Based on average evaporation and drift values noted in ER Table 3.3.0-1, Amendment 3, consumptive water use at CNS will be approximately 53 million gallons per day.

Page 10-6 (Subsection 10.3.5)

The DES states that a maximum of 1.7×10^{10} gpd of water will be consumptively used by the station. Applicant estimates, based on ER Table 3.3.0-1, Amendment 3, that maximum consumption will be 72.7 million gallons per day.

Page 10-6 (Subsection 10.3.6)

The DES states that about 3000 acres of land would be committed to the construction and operation of the station. The Staff has previously (Section 4.1) estimated the total land area involved in the actual construction of CNS to be 1490 acres. Applicant estimates total land use to be 1441 acres (Comment on DES Page 4-1).

Page 10-6 (Subsection 10.4.1)
Table 10.2

The total revenues from the station should be reevaluated. Table 9.3.1-1 and Table 9.3.4-1, Amendment 3, indicate a revised cost estimate of $613/KW which results in estimated annual fixed charges of 409 million and annual fuel and operating and maintenance costs of $195 million for the station. The reference to ER Section 10.4.2.1 for annual fuel and operating and maintenance costs is in error. Subdivision 10.4.2.1 of the DES refers to the cost of $150 million. The basis for estimating cost for transmission, distribution, and other expenses at an assumed 25 percent of total production expenses is not presented in DES.

The Staff has assumed Applicant's rate of return on investment to be 12 percent. Applicant believes that a fair and reasonable rate of return on investment is 14 percent. Applicant estimates that total taxes for the station are about $116 million annually (ER Table 8.1.1-1, Amendment 3).

Under the heading "Indirect Benefits" in DES, Table 10.2, Applicant submits the following which summarizes changes made in Amendment 3:

		ER Reference
Employment		
Construction, man-years	3,149	Table 8.1.2-3
Construction payroll (total), millions of dollars	424	Subdivision 8.1.2.3
Operation, number of employees	250	Subdivision 8.1.2.3
Operation, annual payroll, millions of dollars	8.2	Subdivision 8.1.2.3
Taxes		
Federal, annual, millions of dollars	71.4	Subdivision 8.1.2.2
State, annual, millions of dollars	44.6	Subdivision 8.1.2.2
County, annual, millions of dollars	16.4	Subdivision 8.1.2.2

Page 10-6 (Subdivision 10.4.1.4)

Estimated taxes to Federal, State, and local governments have been revised and should be 71.4, 44.6, and 16.4 million dollars annually, respectively (ER Subdivision 8.1.2.2, Amendment 3).

Page 10-7 (Subdivision 10.4.1.8)

ER Amendment 3, Subdivision 8.1.2.3 and Table 8.1.2-3 indicate that an average of 1395 employees over the thirteen year construction period will result in a total construction payroll of over $424 million and that the annual operating payroll for the 250 employees will be $8.2 million.

Page 10-7 (Subdivision 10.4.2.1)

Applicants revised cost estimates (ER Tables 9.3.1-1 and 9.3.4-1, Amendment 3) of $613/KW capital cost and $194.8 million fuel and operating and maintenance costs are based on Applicant's construction and operating experience and indicate that the Staff evaluation of costs is somewhat low.

Page 10-8 (Subdivision 10.4.2.2)

Applicant's comments for Table 10.3 are presented in tabular form below.

EFFECT	APPLICANT'S COMMENT
Land Use	
Land required for station	1209 Acres within site boundary fence 661 Acres to be cleared (ER Section 4.1)
Land required for transportation lines	695 Acres (ER Section 3.9)
Water Use	
Evaporative consumptive	82 cfs average (ER Section 3.3) basis for 14% of low flow is not stated
Chemical discharges to Broad River	16.2 ppm maximum increase (ER Table 3.6.2-1) 22 ppm increase (DES Subdivision 5.5.2.2)
Radiological Impact	
Radioiodine and particulate close to thyroid from all pathways	10 millirems/year (DES Table 5.5)
Ecological Impacts on aquatic life	
Construction	Basis for 50% increase in turbidity is not stated
Entrainment	Basis for 21% of river flow is not stated

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

13 JUN 1975

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Muller:

The Environmental Protection Agency has reviewed the draft environmental statement for the Cherokee Nuclear Station Units 1, 2, and 3 prepared by the U.S. Nuclear Regulatory Commission (NRC) and issued April 1975. Our detailed comments are enclosed.

EPA's independent analysis of the information in the draft statement and the Applicant's environmental report indicate that the proposed gaseous and liquid waste management systems are capable of limiting radioactive releases to within the "as low as practicable" guidance of the recently issued Appendix I to 10 CFR Part 50. Therefore, we conclude that the anticipated radiological impact of normal plant operations will be acceptable.

Cherokee Nuclear Station is expected to be able to be operated in general compliance with the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) relative to the discharge of thermal effluents. However, sufficient data have not been presented in the draft statement on chemical effluents to determine whether appropriate chemical discharge guidelines will be achieved. Also, construction of the Final Wastewater Holdup Basin for the purpose of chemical waste treatment appears to be inconsistent with the intent of Section 301 of the FWPCA, that no waters of the United States be utilized directly for treating wastewaters. Discharges to the Final Wastewater Holdup Basin, which would be created by impounding waters of the United States, must meet EPA's effluent guidelines before discharge.

-2-

In light of our review and in accordance with EPA procedure, we have classified the project as ER (Environmental Reservations) and rated the draft statement Category 2 (Insufficient Information). If you or your staff have any questions concerning our comments or classification, we will be happy to discuss them with you.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

Enclosure

EPA-D-NRC-A0652-SC

ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

June 1975

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Cherokee Nuclear Station

Units 1, 2, and 3

TABLE OF CONTENTS

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental statement issued in conjunction with the application of Duke Power Company for a permit to begin construction of the Cherokee Nuclear Station, Units 1, 2, and 3. This facility is proposed to be situated on a site adjacent to the Broad River, in Cherokee County, South Carolina. The following are our primary conclusions.

1. The proposed radioactive waste management systems for Cherokee Nuclear Station are expected to be capable of limiting normal releases of radioactive effluents to "as low as practicable" discharges. The radiation doses are expected to be maintained to levels within those specified in the recently published Appendix I to 10 CFR Part 50. Therefore, we conclude the radiological impacts of routine operation are expected to be acceptable.

2. EPA believes that Cherokee Nuclear Station Units 1, 2, and 3 can be operated in general compliance with Federal Water Pollution Control Act Amendments of 1972 (FWPCA) as regards thermal effluents. However, sufficient data have not been presented on chemical effluents to determine whether appropriate discharge guidelines can be met. In addition, construction of the Final Wastewater Holdup Basin for the purpose of chemical treatment appears to be inconsistent with the intent of Section 301 of the FWPCA, that no waters of the United States be utilized directly for treating wastewaters. Discharges to the Final Wastewater Holdup Basin, which would be created by impounding "waters of the United States," must meet EPA's effluent guidelines before discharge.

RADIOLOGICAL ASPECTS

Radioactive Waste Management Systems

Based on our evaluation of the draft statement and the environmental report, the proposed gaseous and liquid waste management systems appear capable of limiting the radioactive releases and the resulting doses to within the "as low as practicable" guidance of the recently published final version of Appendix I to 10 CFR Part 50. As a consequence, we conclude that the radiological impacts of routine plant operation are expected to be acceptable. Even though we believe the plant radioactive effluent control technology will be capable of limiting discharges to acceptably low levels, several important aspects which need clarification are discussed below.

According to the draft statement, vent gases from the boron recycle system and miscellaneous waste system evaporators will be discharged to the atmosphere without treatment. The contribution of this source relative to radioiodine discharges is uncertain due to lack of detail in the draft statement as to the frequency of venting and the quantities of I-131 involved. The final statement should provide these details as well as the basic assumptions used in the development of these source-terms.

According to pages 3.8 and 3.10 of the draft statement, liquid leakage to the turbine building will be collected in the turbine building floor drain system and will be released without treatment. However, the schematic diagram, Figure 3.1, indicates that the turbine building drain system is intertied with the miscellaneous liquid waste management system. While it may not always be necessary to provide treatment for these wastes in order to achieve the design basis objective given in Appendix I, the interties would provide the plant operator improved waste treatment flexibility. Also, Figure 3.7 indicates that the turbine building drains will be released to the Broad River via the River Discharge Structure without radiation monitoring or control isolation. The final statement should clarify whether such interties and monitoring and control systems for the turbine building liquids will be included in the plant design.

We believe the plant design stage is the best time to ensure that anticipated plant effluent release points will be adequately monitored and that sufficient effluent sampling points will be

provided to ensure documentation of plant effluent releases. We urge NRC to ensure that these provisions are included according to the guidance of Regulatory Guide 1.21.

Dose Assessment

The thyroid dose via the grass-milk pathway, based on exposure via the nearest pasture currently grazed, is expected to be within the guidance of Appendix I to 10 CFR Part 50. The existence of several cow herds within two miles of the site makes it important to closely monitor this potential exposure pathway. We concur with the NRC staff that the Applicant's milk analyses sensitivity for measuring I-131 should be 0.5 pCi/l. Furthermore, the Applicant should undertake periodic audits of the location of and number of lactating cows and goats so that the critical exposure pathway will be known throughout the lifetime of the plant.

EPA expects that the results from current EPA/NRC and industry cooperative field studies in the environs of operating nuclear power facilities will greatly increase knowledge of the processes and mechanisms involved in the exposure of man to radiation produced through the use of nuclear power. We believe that, overall, the cumulative assumptions utilized to estimate various human doses are conservative. As more information is developed, the models used to estimate human exposure will be modified to reflect the best data and most realistic situations possible.

Reactor Accidents

EPA has examined the NRC analyses of accidents and their potential risks which the NRC has developed in the course of its engineering evaluation of reactor safety in the design of nuclear plants. Since these issues are common to all nuclear plants of a given type, EPA concurs with the NRC approach to evaluate the environmental risk for each accident class on a generic basis. The AEC has in the past and NRC continues to devote extensive efforts to ensure safety through plant design and accident analyses in the licensing process on a case-by-case basis.

For the past two years, AEC sponsored an effort to examine reactor safety and the resultant environmental consequences and risks on a more quantitative basis. We have strongly encouraged this effort and continue to do so. On August 20, 1974, the AEC issued for public comment the draft Reactor Safety Study (WASH-1400), which is the culmination of the extensive effort to quantify the risks associated with light-water-cooled nuclear power plants. EPA is conducting a review of this document, including in-house and contractual efforts through June 1975, after which we will issue a final set of comments. Initial comments, issued November 27, 1974, indicate the AEC's efforts represent an innovative step forward in concept and methodology in the evaluation of risks associated with nuclear power plants. The study appears to provide an initial meaningful basis for obtaining useful assessments of accident risks.

If future NRC efforts in this area indicate unwarranted risks are being taken at the Cherokee Nuclear Station, we are confident the NRC will ensure appropriate corrective action. Similarly, if EPA efforts identify any environmentally unacceptable conditions related to reactor safety, we will make our views known. Until our review of the Reactor Safety Study is completed, we believe there is sufficient assurance that no undue risks will occur as a result of the continued planning for the Cherokee Nuclear Station.

Transportation

EPA, in its earlier reviews of the environmental impacts of transportation of radioactive material, agreed with the AEC that many aspects of this program could best be treated on a generic basis. The NRC has codified this generic approach (40 F.R. 1005) by adding a table to their regulations (10 CFR Part 51) which summarizes the environmental impacts resulting from the transportation of radioactive materials to and from light-water reactors. This regulation permits the use of the impact values listed in the table in lieu of assessing the transportation impact for individual reactor licensing actions if certain conditions are met. Since this nuclear power plant appears to meet these conditions and EPA has agreed that the transportation impact values in the table are reasonable, this approach appears adequate for this action.

While the impact resulting from the routine transportation of radioactive materials was chosen at that level within which the impact of 90% of the reactors currently operating or under construction fell, the basis for the impact, or risk, of transportation accidents is not as clearly defined. There are current efforts by both EPA and ERDA (the Energy Research and

Development Administration) (and/or NRC) to more fully assess the radiological impact of transportation accidents. As the quantitative results of these analyses become available, EPA intends to conduct reviews to ascertain the acceptability of the potential transportation risks. If EPA efforts identify any environmentally unacceptable conditions related to transportation, we will make our views known. Until our reviews of the transportation accident analyses are completed, we believe there is sufficient assurance that no undue risks will occur as a result of transportation accidents for this nuclear power plant.

Fuel Cycle

The NRC's predecessor, the AEC, issued a document (WASH-1248) titled, "Environmental Survey of the Uranium Fuel Cycle" in conjunction with a regulation (10 CFR 50, Appendix D) for application in completing the cost-benefit analyses for individual light-water reactor environmental reviews (39 FR 14188). The information therein is employed in NRC draft statements to assess the incremental environmental impacts that can be attributed to fuel cycle components which support nuclear power plants. In our opinion, this approach appears adequate for plants currently under consideration, and such estimates of the incremental impacts for the Cherokee Nuclear Plant are reasonable. However, as suggested in our comments on the proposed rulemaking (January 19, 1973), if this is to continue for future plants, it is important for the NRC to periodically review and update the information and assessment techniques used. EPA intends to monitor developments in the fuel cycle area closely and will bring to the NRC's attention any factor or concerns we believe relevant to continued improvement in assessing environmental impacts.

The concept of environmental dose commitment is a recent development which we believe should be included in the assessment of the environmental impact of the fuel cycle. The information presented in the draft statement indicates the "Maximum Effect" in terms of annual person-rems (man-rems) within a 50-mile radius. As many of the radionuclides involved persist in the environment over extremely long periods, their impact is not adequately represented by an annual dose. Instead, we recommend that the maximum effect for fuel cycle releases be indicated by an environmental dose commitment, that is, by the projected person-rems which will be accumulated over several half-lives of the radioisotopes released annually from these facilities. (This would involve decades for very long-lived isotopes.) Also, such evaluations should be done for the total U.S. population exposure. Radionuclides of importance in this approach include Kr-85, I-129, tritium, radium, C-14, and the actinides.

High-Level Waste Management

Environmental impacts will arise as a consequence of the techniques and procedures utilized to manage high-level radioactive wastes. These impacts have some relevance to the environmental considerations regarding each nuclear power plant in that the reprocessing of spent fuel from each will make some contribution to the total waste. EPA concurs, however, with the NRC's approach of handling waste management impacts on a generic basis rather than by including a specific, in-depth analysis in each nuclear power plant's environmental statement. As part of this effort the AEC, on September 10, 1974, issued for comment a draft statement titled "The Management of Commercial High-Level and Transuranium-Contaminated Radioactive Waste" (WASH-1539).

Though a comprehensive long-range plan for managing radioactive wastes has not yet been fully demonstrated, acceptance of the continued development of commercial nuclear power is based on the belief that the technology to safely manage such wastes can be devised. EPA is available to assist the NRC and ERDA in their efforts to assure that an environmentally acceptable waste management program is developed to meet this critical need. In this regard, EPA provided extensive comments on WASH-1539 on November 21, 1974. Our major point of criticism was that the draft statement lacked a program for arriving at a satisfactory method of "ultimate" high-level waste disposal. We believe this is a problem which should be resolved in a timely manner, since the country is committing an increasingly significant portion of its resources to nuclear power and wastes from operating plants are already accumulating. ERDA now intends to prepare a new draft statement which will more broadly discuss waste management and emphasize ultimate disposal. EPA concurs with this decision and we will review the new draft statement when it is issued and will provide public comments.

NON-RADIOLOGICAL ASPECTS

General

EPA will be responsible for issuance of a discharge permit for Units 1, 2, and 3 under the National Pollutant Discharge Elimination System (NPDES)—Section 402 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA). Issuance of the permit will be based upon review and analysis of all relevant information supplied by the Applicant. Consideration will be given to requirements of Section 301, of 316(b), and all other provisions of the FWPCA and the final permit will be conditioned accordingly.

Section 301 of the FWPCA stipulates that effluent limits for various point source discharges to navigable waters shall require the application of "Best Practicable Control Technology Currently Available" no later than July 1, 1977, and "Best Available Technology Economically Achievable" no later than July 1, 1983. The levels corresponding to these terms were defined in EPA's "Steam Electric Power Generating Point Source Category Effluent Guidelines and Standards," Federal Register, of October 8, 1974.

Cherokee Units 1, 2, and 3, employing nine circular, mechanical-draft, wet cooling towers for the dissipation of waste heat from the closed-cycle condenser cooling system, can operate in conformance with these guidelines and standards and, in most instances, in compliance with Federally approved State water quality standards in regards to thermal effluents. However, there remains some question concerning compliance with chemical effluent standards.

Intake and Wastewater Impoundments

Duke Power Company proposes the construction of two earth-fill dams to form a sedimentation basin and a Final Wastewater Holdup Basin. These impounded waters will be considered as "waters of the United States," since they were so considered prior to damming.

Although neither the sedimentation basin nor the Nuclear Service Water Pond directly conflicts with requirements of the FWPCA, the construction of these impoundments, as well as the Final Wastewater Holdup Basin, will destroy and/or remove approximately 20 percent of the aquatic resources of the existing reservoir. The final statement should provide an assessment of this action and of the removal of the two feeder streams on the remaining fishery resources, including breeding areas. Consideration should be directed at impacts on rare or endangered species, in particular darters.

However, use of "waters of the United States" for the purposes of final wastewater treatment is inconsistent with the FWPCA. Consideration must be given to providing treatment equivalent to that provided by the Final Wastewater Holdup Basin, if required to meet effluent limitations, prior to discharge to any "waters of the United States."

In reviewing the draft statement's sections dealing with these proposed site impoundments, it appears that there are several conflicting estimates of the land/reservoir areas to be included in the three impoundments. Specifically, page 4-11 under "Construction Activities," page 4-1, paragraph 4.1.1; and page 4-3, paragraph 4.1.2 provide acreage data on one or more of the impoundments. However, it is not possible to extract a clear estimate of the actual impounded areas for each case. Therefore, the final statement should provide clarification of the information, possibly via a table, which characterizes each proposed onsite impoundment and the existing and modified Ninety-nine Islands Reservoir for acreage, extreme water level and volume conditions.

Chemical Effects

The regulations in EPA's effluent guidelines for steam electric power generating point sources include effluent limitations for such waste streams as low volume, metal cleaning, boiler (steam generator) blowdown and cooling tower blowdown which are applicable to the Cherokee Nuclear Station. Pollutants from these discharges which are specifically limited include total suspended solids, oil and grease, pH, free available and total residual chlorine, total iron and/or total copper. The draft statement, however, failed to discuss and/or evaluate these parameters, the proposed waste treatment facilities and their operation, and the expected effluent concentrations to be discharged. Since Duke Power Company has not yet submitted its application for an NPDES permit, EPA has not been provided adequate information to allow independent determination as to whether the proposed waste discharges will comply with applicable Federal regulations. Therefore, the final statement should

provide adequate information, evaluation and discussion of these waste streams.

Low volume wastes, as defined in the effluent guidelines, are generally equivalent to the normal waste discharged to the wastewater treatment system. Such wastes are subject to limitations on total suspended solids, oil and grease, and pH. Data presented in Table 3.6 and elsewhere in the draft statement do not include expected discharge concentrations for these parameters. Consideration should be given to providing oil traps in floor drains which may be subject to oil leakage and at other points where oil could exist in high concentrations. This would allow significantly greater oil removal than the proposed wastewater treatment system.

Metal cleaning wastes are not discussed in the draft statement and are subject to limitations on total suspended solids, oil and grease, pH, total copper, and total iron. (Iron and copper are included as indicator parameters.) Treatment of these wastes is subject to requirements for two-state coagulation, precipitation, pH adjustment and sedimentation, or equivalent as indicated in the effluent guidelines. This will be a requirement of the NPDES permit.

The proposed treatment of pre-operational cleaning wastes does not appear adequate in that significant and unacceptable quantities of phosphorus will be released to Ninety-nine Islands Reservoir. About 850 gallons of liquid detergent will be used for degreasing and spray cleaning of pipe assemblies and will be discharged to the temporary sewage system for treatment. Phosphorus removal by this system will be minimal. Additionally, 36,000 pounds of trisodium phosphate and 138 gallons of liquid detergent will be used for condenser degreasing and cleaning of each of the three units. The proposed treatment includes dilution and neutralization over a 14-day release period. Again, this treatment will be inadequate for phosphorus removal. However, if facilities (as indicated above) for chemical waste treatment are provided, treatment with lime to an initial pH of 11 to 11.5, followed by subsequent coagulation, pH adjustment and sedimentation would result in phosphate removals to as low as 1.0 mg/l, or less. Such treatment is recommended to minimize releases of phosphorus to the reservoir.

Steam generator blowdown is subject to limitations on total iron, total copper, and total suspended solids in accordance with the "boiler blowdown" limitations of the effluent guidelines. Although pollutant concentrations from this plant could be anticipated to be significantly below effluent guideline limitations, no estimate of effluent iron and copper concentration is presented.

The cooling tower design generally appears to meet the requirements of the effluent guidelines as to cold side blowdown and minimization of blowdown. However, it is to be noted that conditions of 76°F wet-bulb and 93°F dry-bulb temperature (tower design 76/92) are exceeded 2-1/2 percent of the time during the summer months in the Spartanburg, South Carolina, area and that a wet-bulb temperature of 77°F is exceeded 1 percent of the time. Therefore, the blowdown temperature may be expected, in such circumstances, to exceed calculated values. Even though instantaneous temperatures greater than those evaluated in the draft statement may occur, we concur that the discharge can be expected to meet the thermal requirements of the South Carolina Water Quality Standards.

Chemical discharges in the cooling tower blowdown are of concern. EPA's effluent guidelines limit the discharge of free available chlorine to a 0.5 mg/l maximum and 0.2 mg/l average concentration during a maximum of two hours per day per unit and do not allow free available or total residual chlorine to be discharged from more than one unit at a time. Less stringent limitations may be imposed if the Applicant can demonstrate that the units in a particular location cannot operate at or below this level of chlorination, and if such higher concentration limits will meet applicable requirements of water quality standards. However, more stringent limitations can be required for water quality protection. Since free residual chlorine concentrations of up to 0.3 mg/l and chlorine reaction products of up to 19 mg/l (some of which may be highly toxic) can be anticipated, unacceptable concentrations of total residual chlorine can be expected under low-flow conditions in the Broad River. EPA recommends that all practicable methods be instituted to minimize chlorine discharges, including discontinuation of cooling tower blowdown during chlorination and subsequent periods of high chlorine concentration. EPA further recommends that total chlorine residual be limited to 0.20 mg/l for a period not to exceed two hours per day at the edge of a limited mixing zone, or such higher concentrations which will protect aquatic organisms if present for more than two hours per day.

Effluent guideline limitations for cooling tower blowdown also include 24-hour average concentrations of 1.0, 0.2, and 5.0 mg/l for zinc, chromium, and phosphorus, respectively. Although it appears that no zinc or chromium containing chemicals will be added to the cooling tower water, phosphorus concentrations may exceed allowable limitations (see Table 3.7). Available data on toxicity to aquatic organisms of the proposed corrosion-deposit inhibitor, aminomethylene phosphonate, and the proposed alternate biocide, dodecylguanidine hydrochloride is inadequate. Additional toxicity data, especially on indigenous fish species which might be attracted to the heated discharge in winter, is necessary before final definitive conclusions can be reached as to the toxic effects. Prior to approval of use of these chemicals, adequate 96-hour median tolerance limit (TLM 96) data for indigenous aquatic organisms at various levels of the food web must be provided to assure that releases are within acceptable limits.

Construction Effects

Effluent guideline limitations for point sources of construction runoff are defined in Subpart D of EPA's "Steam Electric Power Generating Point Source Category Effluent Guidelines and Standards," Federal Register, of October 8, 1974, as 50 mg/l of total suspended solids and pH values in the range of 6.0 to 9.0. These limitations are applicable to all flows up to that resulting from a 10-year, 24-hour rainfall. Duke Power Company apparently has not provided a detailed erosion control plan to the Nuclear Regulatory Commission but has proposed to minimize erosion by providing detention ponds and berms. Any point sources of construction runoff from the vicinity of the power plant site are subject to the foregoing limitations. Assurances by Duke Power Company that such limitations will be met should be provided in the final statement.

Although the Broad River has not been considered to be within the jurisdiction of the Army Corps of Engineers, they have recently published new determinations regarding definition of navigability of streams which may result in a need for a Section 404 permit for Cherokee Station. (See CFR Vol. 40 No. 88 Part 3 pp. 19766-19794.) The Applicant, therefore, should request further clarification from the Corps as to whether a "dredge or fill" permit will be required. Regardless of whether such a permit is required, all available precautions, techniques and equipment should be utilized to minimize any further siltation of

Ninety-nine Islands Reservoir due to plant and facility construction. Further siltation will have serious effects on the aquatic populations of the reservoir. Specific and detailed plans should be provided in the final statement to allow interested Federal and State agencies to comment on the erosion control plan.

Noise Impacts

The potential noise impact from this project was inadequately discussed in the draft statement. Noise problems are generally associated with the construction and operation of this type of project. In both instances, concern focuses on occupational noise hazards as well as the noise which propagates from the project into the surrounding community. There are insufficient details in Figure 2.4 to enable identification of the impact of environmental noise on the surrounding land uses. The site plan should show the location of major noise generators on the site; and the map of the surrounding area should show standard land-use categories (e.g., residential, commercial, industrial, etc.), population densities, and the location of specific sensitive receptors, such as hospitals. A map showing the location of all major roadways should also be included. The noise analysis should then indicate the extent the noise levels in Table 1 are exceeded for specific land uses. While levels indicated in Table 1 do not constitute a standard, they should be used as a benchmark or reference for describing the magnitude of the noise impact.

Noise generated by traffic resulting from the project can be significant sometimes. With respect to this project, it appears that the only potential problem which might result would be during construction. Truck traffic generation during construction should be indicated and the potential noise problems addressed.

Construction workers and plant operating personnel should not be exposed to noise levels in excess of those specified in Table 2. The final statement should demonstrate that such noise levels will not be exceeded, and that plans exist to reduce human exposure in high noise level areas to levels below those indicated. In addition, impulse noise from equipment such as jackhammers and pile drivers should not exceed the limits established in Figure 1. During plant operation potential noise sources will be associated with transformers, turbines, ventilating systems, and circulating water pumps. Anticipated noise emission levels from each of these sources should be included in the final statement.

For your convenience, Table 3 lists basic information on sound levels associated with various types of construction equipment. Since these levels are averages, actual noise levels will vary somewhat from those indicated. In particular, noise levels will generally be higher than those in Table 3 for products within each category having a higher than average capacity. Level 1 indicates current, quiet products, and Level 2 lists equipment which can be quieted by the use of best demonstrated technology.

ADDITIONAL COMMENTS

1. The final statement should provide the cumulative population and annual cumulative population doses (person-rem) for the period of plant operation (1982-2022).
2. The final statement should provide an estimate of the cumulative population doses to persons within 50 miles of Cherokee from radioactive effluents predicted to be discharged from the Cherokee, McGuire, and Catawba nuclear plants in order to consider the cumulative regional impacts.
3. The final statement should reflect pertinent dose evaluations based on atmospheric dispersion data representing a complete year of on-site meteorological data, as given in the environmental report.
4. The liquid release source-term for all subsystems should be given as has been presented for the turbine building sources.
5. The final statement should clearly indicate the normal treatment to be provided the containment cooler condensate liquid. The text of the draft statement indicates it will be filtered and discharged, while Figure 3.7 indicates the normal flow path will include evaporation.
6. The final statement should clarify the Applicant's estimate of gaseous I-131 discharges. For example, page 3-14 of the draft statement (paragraph 1) indicates the Applicant has estimated 0.007 Ci/yr/unit of I-131 from the turbine building only, but subsequently in paragraph 4 the total estimated release is given as 0.004 Ci/yr/unit.
7. The final statement should indicate the bases for utilizing 700 ml/day goat's milk consumption as contrasted to the 1000 ml/day cow's milk intake in calculating potential thyroid doses for children.
8. The draft statement (p. 5-12) indicates the radioactive liquid waste dispersion models are discussed in Section 2.5. However, no such discussion was found. The bases for the river dispersion calculations should be presented in the final statement.
9. The draft statement (page 3-18) concludes that the gaseous

emissions from the diesel generator would be within the limits set in State regulations. Even though the impact on air quality may be minimal, emissions of air pollutants from the diesel generators should be calculated and presented in the final statement. Also, the final statement should include the fuel use rate so that independent assessments can be made.

10. A map indicating the locations of the pre-operational and permanent meteorological-instrument tower(s) together with the proposed site buildings should be included in the final statement so that possible terrain or building effects may be independently evaluated.

11. A windrose for the 135-ft. level should be included to evaluate the site meteorology and potential impact of elevated source emissions including those from the cooling towers.

12. The meteorological data used as input to the ORFAD program and referenced as being Section 5.3.2 was not located in the draft statement and should be provided.

13. The joint distribution of wind speed and wind direction for the various stability categories needs to be either included in the final statement or referenced from the environmental report.

14. The calculational procedures used to compute the annual average X/Q estimates presented in Table 5.3 should be indicated in the final statement. In addition, the probability distribution of X/Q estimates for appropriate time periods following an accidental release should be presented.

15. No discussion is presented on the effects to fish eggs and larvae from the intermittent use of 150 cfs of water for dilution of radwastes. Recent data indicate significant damage to these life stages due to the mechanical effects of pumping. This should be evaluated and discussed in the final statement.

TABLE 1

YEARLY AVERAGE* EQUIVALENT SOUND LEVELS IDENTIFIED AS REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

	Measure	Indoor: Activity Interference	Indoor: Hearing Loss Consideration	To Protect Against Both Effects (b)	Outdoor: Activity Interference	Outdoor: Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)}$(d)	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)}$(d)		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity. (See Figure D-2 for noise levels as a function of distance which allow satisfactory communication.)
b. Based on lowest level.
c. Based only on hearing loss.
d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

Source: EPA Document 550/9-74-004 (March 1974) "Levels Document" -- Table 4

TABLE 2

NOISE EXPOSURE LEVELS, STEADY STATE

Duration (per day) in hours	EPA Max. Sound Level (dBA)
8	85
4	88
2	91
1	94
1/2	97
1/4 or less	100

Source: EPA's Recommended Occupational Noise Exposure <u>Federal Register</u> dated December 18, 1974

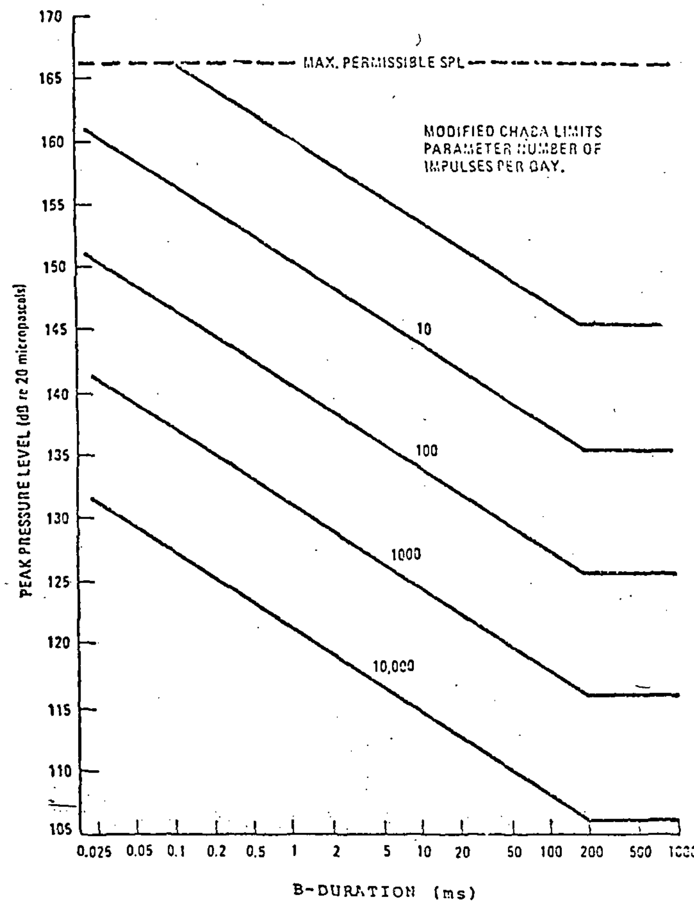

Figure 1 Set of Modified CHABA Limits for Daily Exposure to Impulse Noises Having B-Durations in the Range 25 Microseconds to 1 Second. (Parameter: number (N) of impulses per daily exposure. Criterion: NIPTS not to exceed 5 dB at 4 kHz in more than 10% of people.)

Source: EPA Document 550/9-74-004 (March 1974) "Levels Document" --Figure 4

ABLE 3 BASIC INFORMATION ON CONSTRUCTION EQUIPMENT (1972).

Equipment Types	Present		Quiet Products Level 1		Best Technology Level 2		
	Sound Level (a)	Average Unit Price	Sound Level (a)	Average Unit Price	Sound Level (a)	Average Unit Price	Units Produced Per Year (b)
Air Compressor	81	$ 5,500	71	$ 5,500	65	$ 12,000	12,000
Backhoe	85	15,000	80	15,500	76	19,800	15,000
Concrete Mixer	85	25,000	83	25,400	75	27,500	7,000
Concrete Pump	82	50,000	80	50,650	75	55,000	500
Concrete Vibrator	76	2,000	70	2,050	66	2,200	6,000
Crane, Derrick	88	110,000	80	111,000	75	113,000	2,200
Crane, Mobile	83	50,000	80	51,000	76	53,000	4,300
Dozer	87	25,000	83	28,600	73	30,800	12,000
Generator	78	1,000	71	1,100	65	1,400	70,000
Grader	85	22,000	80	22,600	76	24,200	7,000
Jackhammer (P.B.)	88	800	80	850	75	950	(20,000)(c)
Loader	84	20,000	80	20,600	75	22,000	30,000
Paver	89	42,000	80	43,000	76	44,200	500
Pile Driver	101	33,000	90	33,500	80	37,000	350
Pneumatic Tool	85	300	75	320	65	400	(100,000)
Pump	76	430	71	450	65	580	50,000
Rock Drill	98	35,000	90	36,000	80	39,000	(1,000)
Roller	80	11,000	75	11,330	70	12,100	6,000
Saw	78	100	70	110	65	150	(500,000)
Scraper	88	70,000	83	71,500	78	75,000	5,000
Shovel	82	71,000	80	72,000	76	74,000	3,000
Truck	88	18,000	83	18,250	75	19,500	75,000

a. Sound level refers to average level during operation in dBA at 50 ft.

b. Estimated from Department of Commerce published data and industry sources (sales may include other industries).

c. Parenthesis enclose preliminary estimate.

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

JUL 22 1975

RECEIVED 7-29-75 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Mr. William H. Regan
Chief, Environmental Projects Branch No. 4
Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Regan:

This is in response to your letter dated April 1, 1975, requesting comments on the NRC Draft Environmental Statement related to the proposed issuance of a construction permit to the Duke Power Company (Applicant) for the construction of the Cherokee Nuclear Plant Units 1, 2, and 3 (Docket Nos. STN 50-491, STN 50-492, and STN 50-493), located in Cherokee County, South Carolina. The proposed Cherokee Units 1, 2, and 3 are scheduled for commercial operation in January 1984, January 1986, and January 1988, respectively.

These comments by the Federal Power Commission's Bureau of Power staff are made in compliance with the National Environmental Policy Act of 1969, and the August 1, 1973, Guidelines of the Council on Environmental Quality, and are directed to the need for the capacity represented by the proposed units and matters related thereto and effects on hydroelectric projects licensed by FPC.

In preparing these comments, the Bureau of Power staff has considered the Draft Environmental Statement; the Applicant's Environmental Report; related reports made in accordance with the Commission's Statement of Policy on Reliability and Adequacy of Electric Service (Docket No. R-362); and the staff's analysis of these documents together with information from other FPC reports. The staff generally bases its evaluation of the need for a specific bulk power facility upon long-term considerations as well as upon the load-supply situation for the peak load period immediately following the availability of the new facility. Each proposed unit is expected to have a useful life of 30 years or more; during that period, each unit will contribute significantly to the reliability and adequacy of electric power supply in the Applicant's service area.

The Applicant is one of several utility systems located in the Virginia-Carolinas (VACAR) area of the Southeastern Electric Reliability Council (SERC). The Applicant's system is interconnected with

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the utility systems in the SERC area. SERC coordinates the planning of the members' generation and transmission facilities to assure reliability of the members' bulk power supply.

The Federal Power Commission has found that many power systems plan for reserve generating capacity margins between 15 and 25 percent of annual peak load. The actual planned reserve margin for a particular system depends on such factors as the number, size, and types of units, and interconnections with adjacent utility systems.

The following tabulations show the Applicant's and VACAR's projected capabilities, peak loads, and reserve margins for the 1984, 1986, and 1988 summer peak periods, and the effect of the capacity of the Cherokee Units 1, 2, and 3 on the reserve margins.

1984 Summer Peak Load-Supply Situation

With Cherokee Unit 1 (1,280 Megawatts)	Applicant 1/	VACAR 2/
Total Peak Capability - Megawatts	19,785	57,472
Peak Load- Megawatts	17,226	50,398
Reserve Margin - Megawatts	2,559	7,074
Reserve Margin - Percent of Peak Load	14.9	14.0
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	2,584	7,560
Reserve Deficiency - Megawatts	25	486
Without Cherokee Unit 1		
Reserve Margin - Megawatts	1,279	5,794
Reserve Margin - Percent of Peak Load	7.4	11.5
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	2,584	7,560
Reserve Deficiency - Megawatts	1,305	1,766

1/ Data Source: NRC Draft Environmental Statement, Tables 8.1 and 8.4.

2/ Data Source: SERC's response to FPC Docket No. R-362 (Order 383-3) dated April 1, 1975.

1986 Summer Peak Load-Supply Situation

With Cherokee Units 1 and 2 (2,560 Megawatts)	Applicant 1/	VACAR 2/
Total Peak Capability - Megawatts	22,491	66,649
Peak Load - Megawatts	19,598	58,300
Reserve Margin - Megawatts	2,893	8,349
Reserve Margin - Percent of Peak Load	14.8	14.3
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	2,940	8,745
Reserve Deficiency - Megawatts	47	396
With Only Cherokee Unit 1 (1,280 Megawatts)		
Reserve Margin - Megawatts	1,613	7,069
Reserve Margin - Percent of Peak Load	8.2	12.1
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	2,940	8,745
Reserve Deficiency - Megawatts	1,327	1,676
Without Cherokee Units 1 and 2		
Reserve Margin - Megawatts	380	5,789
Reserve Margin - Percent of Peak Load	1.9	9.9
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	2,940	8,745
Reserve Deficiency - Megawatts	2,560	2,956

1/ Data Source: NRC Draft Environmental Statement, Tables 8.1 and 8.4.

2/ Data Source: SERC's response to FPC Docket No. R-362 (Order 383-3) dated April 1, 1975.

1988 Summer Peak Load-Supply Situation

With Cherokee Units 1, 2, and 3 (3,840 Megawatts)	Applicant 1/	VACAR 2/
Total Peak Capability - Megawatts	25,051	77,379
Peak Load - Megawatts	22,217	66,991
Reserve Margin - Megawatts	2,834	10,388
Reserve Margin - Percent of Peak Load	12.8	15.5
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	3,333	10,049
Reserve Deficiency - Megawatts	499	-
With Only Cherokee Units 1 and 2 (2,560 Megawatts)		
Reserve Margin - Megawatts	1,554	9,108
Reserve Margin - Percent of Peak Load	7.0	13.6
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	3,333	10,049
Reserve Deficiency - Megawatts	1,779	941
With Only Cherokee Unit 1 (1,280 Megawatts)		
Reserve Margin - Megawatts	274	7,828
Reserve Margin - Percent of Peak Load	1.2	11.7
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	3,333	10,049
Reserve Deficiency - Megawatts	3,059	2,221
Without Cherokee Units 1, 2, and 3		
Reserve Margin - Megawatts	-507	6,548
Reserve Margin - Percent of Peak Load	-2.3	9.8
Minimum Reserve Margin (Based on 15 Percent of Peak Load) - Megawatts	3,333	10,049
Reserve Deficiency - Megawatts	3,840	3,501

1/ Data Source: NRC Draft Environmental Statement, Tables 8.1 and 8.4.

2/ Data Source: SERC's response to FPC Docket No. R-362 (Order 383-3) dated April 1, 1975.

If the Cherokee Units 1, 2, and 3 are available as planned, the Applicant's reserve margins for the 1984, 1986, and 1988 summer peaks will be 14.9 percent, 14.8 percent and 12.8 percent, respectively. VACAR's reserve margins for 1984, 1986, and 1988 will be 14.0 percent, 14.3 percent and 15.5 percent, respectively. In every instance except one, the projected reserve margins would not lie in the range of reserve margin values (15 to 25 percent) the Federal Power Commission has found to exist for most systems in the United States.

Without the Cherokee units, the Applicant's projected reserve margins for 1984, 1986, and 1988 summer peaks would be 7.4 percent, 1.9 percent and negative 2.3 percent, respectively. VACAR's reserve margins for 1984, 1986, and 1988 will be 11.5 percent, 9.9 percent and 9.8 percent, respectively. In every instance, the projected reserve margins would not lie in the 15 to 25 percent reserve margin range. Although the tabulations use 15 percent as a minimum reserve margin for the Applicant and VACAR systems, a reserve margin of about 20 percent is considered to be more appropriate for systems in the Southeast Region. Part I of the FPC's 1970 National Power Survey projected the reserve margin for the Southeast Region to be 20 percent and 21 percent for 1980 and 1990, respectively.

In Table 8.4 of the Draft Environmental Statement, the number corresponding to the "Total Capacity for Summer Peak - MW," for 1983 should read 18,153 megawatts and not 18,233 megawatts.

The Cherokee Nuclear Station would be located adjacent to and would affect Applicant's Ninety-Nine Islands Hydroelectric Project (FPC No. 2331) located on the Broad River, a navigable water of the United States, in South Carolina. The Federal Power Commission issued a license for Project No. 2331 on July 15, 1964. The FPC granted the Applicant's request for rehearing on September 9, 1964.

According to the Draft Environmental Statement, Project No. 2331 would be affected by:

1. Construction of dams creating subimpoundments (NSWP, Sedimentation Basin, and Holding Pond) within the limits of the project reservoir.

2. Withdrawal of reservoir water.

3. Construction of intake structure (including training wall and weir).

4. Construction of transmission lines across project lands and waters.

5. Dredging and filling within the project boundary.

NRC did not, however, discuss the effect of the proposed Cherokee Plant on the operation and maintenance of Project No. 2331, particularly any loss of energy and dependable capacity which may result from evaporative losses.

Modification and use of project lands and waters, as indicated above, require prior FPC approval. The Applicant is required to file an application requesting approval from the Commission. Such application would include, inter alia: revised Exhibits, as appropriate, pursuant to FPC Regulations (18CFR4.41); an assessment of the safety and adequacy of the existing hydroelectric facilities and subimpoundment dams, taking into consideration the additional storage created by the subimpoundments; changes in project operation and generation; and an environmental assessment of all proposed changes affecting the project. Such changes and effects on Project No. 2331 should be specifically addressed in the Final Environmental Statement. In addition, the Final Environmental Statement should consider any effects on downstream hydroelectric projects that may result from the projected evaporation loss of 110 cfs of water. Such effects should include possible loss of generation and dependable capacity, and the value thereof, at the following plants:

Name	FPC Project No.	Owner
Lockhart	2620	Lockhart Power Company
Neal Shoals	2315	South Carolina Electric and Gas Company
Parr	1894	South Carolina Electric and Gas Company
Columbia	1895	South Carolina Electric and Gas Company
Santee-Cooper	199	South Carolina Public Service Authority

It would appear that any permit or subsequent license issued for the Cherokee Nuclear Station should require the Applicant to adequately compensate Lockhart Power Company, South Carolina Electric and Gas Company and South Carolina Public Service Authority for any loss of energy and capacity.

The Bureau of Power staff concludes that additional capacity equivalent to that represented by the Cherokee Units 1, 2, and 3 is needed to maintain the adequacy and reliability of the Applicant's and VACAR's bulk power system.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

North Carolina Department of Administration

OFFICE OF INTERGOVERNMENTAL RELATIONS

EDWIN DECKARD
DIRECTOR

JAMES E. HOLSHOUSER, JR., GOVERNOR • BRUCE A. LENTZ, SECRETARY

June 4, 1975

Mr. William H. Regan, Jr., Chief
Environmental Projects Branch 4
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: H. B. Robinson Unit No. 2
Docket No. 50-261; North
Carolina SCH File No. 039-75

Dear Mr. Regan:

Enclosed you will find comments on the above reference, for your use and file.

Sincerely yours,

Jane Pettus/mw

Jane Pettus (Miss)
Clearinghouse Supervisor

JP:mw

Enclosure

72

116 WEST JONES STREET RALEIGH 27603 (919) 829-

STATE OF NORTH CAROLINA
DEPARTMENT OF HUMAN RESOURCES
325 NORTH SALISBURY STREET
RALEIGH 27611

JAMES E. HOLSHOUSER, JR.
GOVERNOR

DAVID T. FLAHERTY
SECRETARY

TELEPHONE
919/829-4534

April 23, 1975

MEMORANDUM

TO: Jacob Koomen

ATTENTION: Howard Ellis
Health Services

FROM: Louis G. Christian, Chief
Grants Management Section
Division of Plans and Programs

SUBJECT: Draft Environmental Statement, H.B. Robinson Nuclear Steam-Electric Plant Unit 2, Carolina Power & Light Co. Docket No. 50-261; SCH File No. 039-75

Draft Environmental Statement, Cherokee Nuclear Station Units 1, 2, and 3, Duke Power Company, Docket Nos. STN 50-491, 50-492, and 50-493; N.C. SCH File # 038-75

Please review the above referenced document(s) and furnish this office with your comments by May 9, 1975.

Our engineers have reviewed the referenced document in relation to its impact on the environment with respect to those matters for which our agency has responsibility. In our opinion, the referenced document is satisfactory; and have no comments to offer with regard to inclusion of additional information revision of ~~the~~ information presented.

LGC/ap
attachment

JIM WOODALL 5/7/75
PLANNING OFFICER

Louis G. Christian
5/8/75

APPENDIX B

APPLICANT's COMMITMENT LETTER

RELATING TO THE STAFF'S "UPPER BOUND"

RADIOLOGICAL DOSE ANALYSIS

DUKE POWER COMPANY

POWER BUILDING, BOX 2178, CHARLOTTE, N. C. 28242

W. H. OWEN
VICE PRESIDENT,
DESIGN ENGINEERING

August 8, 1975

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Division of Reactor Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C.

Re: Project 81
Application of 10CFR50, Appendix I
Duke File: P81-1412.06

Dear Mr. Muller:

This is in response to your letter of July 30, 1975 requesting confirmation of our intent to satisfy the requirements of Title 10, Chapter 1, Code of Federal Regulations, Part 50, Appendix I.

The proposed design for which we seek a construction permit includes the radwaste equipment presently described in the Project 81 PSAR Section 11.0. We do not intend, in connection with our construction permit application, to remove any presently proposed equipment or systems.

In connection with the hearings, to consider the radiological safety aspects of the facilities, we will provide such additional equipment determined to be necessary to meet the requirements of 10CFR50, Appendix I. We understand that the determination will be a realistic and detailed assessment based on best available data. Furthermore, the upper bound estimates of radiological impact referred to in your letter of July 30, 1975 have no bearing on the assessment required by 10CFR50, Appendix I, but will be used with respect to the radiological environmental impact assessment required by NEPA which is discussed in your Environmental Statement.

Very truly yours,

SKBlackley Jr.
For W. H. Owen

RMW/bjg

Appendix C

DESCRIPTION OF THE UPPER-BOUND PROCEDURE FOR CALCULATING POPULATION DOSES

This appendix describes the models and assumptions used to make upper-bound estimates of population dose for interim assessment of the potential radiological impact from normal operation of nuclear power stations in the United States.

DOSE DEFINITIONS

Individual doses from specific radionuclides were estimated using standard internal dosimetric techniques in accordance with the recommendations of the ICRP.[1,3] All internal dose conversion calculations have been made using the maximum permissible concentrations listed in ICRP Publications 2 and 6. Data on breathing rates, organ masses, and other physiological parameters are those implied by the standard man of ICRP 2.

The isotopic concentration levels in the environment used in the dose calculations were conservatively assumed to be those which would exist during the final year of plant life. A 30-year plant operational lifetime was assumed for calculating buildup of long-lived radioactivity in the environment. Calculated doses represent a 50-year dose commitment which would be received by the population during 1 year of exposure to radioactive releases from the facility at the levels described; that is, the calculated doses reflect the dose that a person would receive over 50 years from radioactive materials to which that person was exposed for 1 year. For isotopes with a short effective half-life, essentially all the exposure occurs in the year of the intake. For isotopes with a longer effective half-life, the dose resulting from intake in any one year may be spread over a long period. The 50-year dose commitment method computes the dose associated with any given year's intake, even if that dose is due to a long-lived isotope and is spread out over the lifetime of the person exposed.

RECEIVING WATER

The liquid effluent population doses previously used by the staff were conservative. For example, fish were assumed to have come to equilibrium with the radioactivity content of the water in which they were caught. Thus, the man-rem developed previously has been accepted for this evaluation and incorporated into the sum. In any case, the liquid effluents contribute only small fractions of the total impact of the station.

ATMOSPHERIC EFFLUENTS

For a uniform population density the population dose may be written as

$$\text{population dose} = K\,\overline{\Psi}\,P \quad ,$$

where $\overline{\Psi}$ is the spatially averaged concentration time integral appropriate for a population of P individuals.

ATMOSPHERIC EFFLUENTS THAT DEPOSIT (RADIOIODINE AND PARTICULATES)

At any point, the concentration time integral, Ψ, will be related to the ground concentration, w, and the deposition velocity, V_g, by

$$V_g = w/\Psi \quad .$$

Thus the population dose can be expressed as

$$\text{population dose} = K\,\overline{W}\,P/V_g \quad ,$$

where $\overline{W}$ is the average ground concentration appropriate for the population P. In the above equation, only the average ground concentration, $\overline{W}$, is needed. Noting that whatever is released will eventually settle, we can define the average $\overline{W}$ over a large arbitrary area as

$$\overline{W} = Q/A ,$$

where Q is the total source released. This gives

$$\text{population dose} = (K\ Q\ P)/(A\ V_g) ,$$

where P/A is the average population density (people/m^2), Q is the total source released (Ci), V_g is the deposition velocity (m/sec), and K is the dose conversion factor (rem/Ci-sec/m^3). The above equation was used to determine upper-bound population doses for the generic case.

The doses resulting from ground-plane irradiation of the population were primarily based on the Oak Ridge EXREM III Code.[4] Data on certain other isotopes were based on Batelle studies.[5] Basically, the method used consists of determining the gamma energy at 100 cm above an assumed infinite ground plane. Buildup of long-lived radioactivity on the ground from 30 years of continuous deposition includes ingrowth of radioactive daughter products. No beta doses from ground-plane irradiation were treated because vegetation on the ground, clothing, and the travel distance in air all combine to make this dose contribution very small. In any case, the contribution to the total U.S. population dose from ground-plane radiation is negligible.

FOOD UPTAKE

Population exposure from airborne radioisotopes resulting from food uptake is determined, not by the density of people in the area of the food crop, but by the number of persons that can be fed by the affected crop. We have considered the exposure associated with three principal pathways: direct ingestion of affected vegetation, consumption of meat from animals fed on affected vegetation, and consumption of milk from animals fed on affected vegetation.

For our interim estimates, ground deposition was computed as described above. Vegetation density used was 2300 g of vegetation per square meter and 440 g of grass per square meter of pasture,[6] which is typical of average agricultural and pasture land.

Concentrations of isotopes on the soil assumed buildup of the isotope from continuous deposition over the facility lifetime (30 years). Also included was ingrowth of radioactive daughter products. Isotopes were assumed to be deposited directly on vegetation as well as on soil and to be taken up by plant roots. No loss of radioisotopes from soil by weathering or other removal mechanisms is included; so the calculated results tend to be conservative.

Concentrations of isotopes deposited directly on vegetation assumed an effective 13-day weathering-removal half-life from plant leaves in addition to the radiological half-life. Since both soil deposition and vegetation deposition are treated assuming the full original airborne concentration (i.e., deposition of isotopes on the soil was not depleted to account for the isotopes deposited on vegetation before they reach the soil), material weathered from the plants to the soil has already been accounted for. Thus, the doses do not need to be treated separately. Of the amount directly deposited on vegetation, 30% was assumed to be absorbed by the plant.

This results in a computed concentration of radioisotopes in agricultural vegetation in the affected area. For that portion of the vegetation that is assumed to go directly to human consumption, a decay time of 7 days was assumed in the transfer of foodstuffs from the field to ultimate consumption.

In addition to the portion going directly to human consumption, vegetation containing radioisotopes as computed above is assumed to be fed to meat and milk animals. Cattle were assumed to have ingested at a rate equivalent to 200 kg "grass" per day.[7] Assuming a grass dry matter content of 25%, the above rate corresponds to 50 kg dry "grass" per day. This ingestion rate is not to be considered as the daily mass intake of feed, but only the "grass equivalent" intake. The development of this estimate is outlined below.

To maintain a high productivity, animals are generally offered feeds, such as grains and harvested forages, to supplement or to totally replace their pasture intake.[7-9] The U.S. Department of Agriculture[9] has estimated that one-fifth of the diet of milk cattle is obtained from pasturing. This percentage is based on the energy requirements of milking animals.

REFERENCES FOR APPENDIX C

1. *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 2, Pergamon Press, Oxford, 1959.
2. *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 6, Pergamon Press, Oxford, 1962.
3. *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 10, Report of Committee IV, Pergamon Press, Oxford, 1968.
4. D. K. Trubey and S. U. Kaye, *The EXREM III Computer Code for Estimating External Radiation Doses to Populations from Environmental Releases*, ORNL-TM-4322, Oak Ridge National Laboratory, Oak Ridge, Tenn., December 11, 1973.
5. U.S. Atomic Energy Commission, *FES-ALAP-LWR Effluents*, WASH-1258, July 1973.
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In evaluating the transport of radioiodine (I-131) in the milk pathway, it is generally accepted that a pasture intake of 10 kg dry grass per day is applicable.[10-12] Assuming that the energy content of various feeds is equivalent to that of grass, the above statement implies a total daily intake rate of 50 kg dry "grass" or 200 kg wet "grass." Beef animals were assumed to be subject to the same feeding practices as milk cattle.

For the animal feed coming from stored feeds, a two-month delay was assumed, which results in decay of short-lvied isotopes. For the portion coming directly from pastureland uptake, no decay was assumed between deposition and animal uptake.

Transfer factors from animal uptake to milk and meat were taken from UCRL-50163.[13] For population dose estimates, a 1-day milk supply delay factor was used, and a 7-day meat supply delay factor was used between consumption of vegetation by the animal and ultimate consumption of meat or milk from that animal by persons in the population. This gives a concentration of radioisotopes in meat and milk from agricultural lands in the affected area.

To convert from concentration of radioactivity in foodstuffs to population dose, it has been assumed that the affected land has an average agricultural productivity equivalent to assuming that the entire U.S. population was fed from that portion of the land area of the U.S. east of the Mississippi River. Assuming an average daily diet for an adult of 400 g of vegetation, 250 g of meat, and 350 g of milk would result in an average daily land productivity of 100 kg of vegetation per square mile, 65 kg of meat per square mile, and 90 kg of milk per square mile.

This compares fairly conservatively with the daily agricultural land productivity for the United States of about 50 kg per square mile for milk[14] and 10 kg per square mile for meat.[15]

ATMOSPHERIC RELEASES THAT DO NOT DEPOSIT (NOBLE GASES, C-14, AND TRITIUM)

Short-lived noble gases were assumed to disperse to the atmosphere without deposition, but radioactive decay that limits spread of the gas was explicitly treated. The population dose, assuming an infinite integration along the plume pathlength, is given by

$$\text{population dose} = (K\ Q\ P)(\lambda L\ A)\ ,$$

which is the same form as used for particulate deposition, except that the deposition velocity is replaced by λL, where λ is the radioactive decay constant (sec^{-1}) and L is the height of the assumed vertical air mixing. An L value of 1000 m was used in the calculations.

The long-lived gaseous radioisotopes, K-85 and C-14, were assumed to be distributed by dilution in the earth's atmosphere. Both were considered to build up over 30 years of plant life. Carbon-14 was assumed to be released in oxide form, which maximizes its availability to the population via food chains. Other chemical forms such as methane would not be as readily available.

The C-14 was considered to be completely mixed in the troposphere with no removal mechanisms operating; that is, the absorption of carbon by the ocean and by long-lived biota not strongly coupled to man were neglected. In actuality, the atmospheric residence time of carbon is about 4 to 6 years,[16,17] with the ocean being the major sink. The neglect of carbon sinks yields an overestimate of the steady-state or end-of-plant-life (30-year plant life) atmospheric concentration by a factor of about 6.

Unlike radioactivity ejected into the stratosphere and then appearing in the high-latitude troposphere, as in weapon testing, the emission of concern here is directly introduced into the mid-latitudes of the troposphere. Transfer of tropospheric air between the two hemispheres, although inhibited by wind patterns in the equatorial region, is considered to yield a hemisphere average tropospheric residence time of about two years with respect to hemispheric mixing.[4] This time constant is quite short with respect to the expected plant lifetime, and mixing in both hemispheres can be assumed for end-of-plant-life evaluations.

Doses were calculated assuming that all carbon in the body reaches the same equilibrium ratio of C-14 to natural carbon as exists in the air.

TRITIUM

Tritium was assumed to mix uniformly in the world's hydrosphere. The hydrosphere was assumed to include all the atmospheric water and the upper 70 m of the oceans. Having determined this equilibrium concentration of tritium in the world, doses to man were calculated by assuming that all the hydrogen in the body reaches the same equilibrium ratio of tritium to hydrogen as exists in the air and water of the environment.

POPULATION DENSITY AND CHANGES — LOCAL IMPACT

The doses calculated for shine dose from radioactive materials deposited on the ground and for short-lived noble gases were based on a population density of 160 persons per square mile, which is characteristic of the U.S. population east of the Mississippi River. These components of dose would be increased if the close-in populations (the populations principally exposed) exceeded this value substantially. However, as noted, these components do not significantly affect the total and would be reviewed on an individual-case basis for the Appendix I cost-benefit analysis.

Local food uptake exposures are not based on population density but rather on agricultural productivity and consequently are not directly affected by population growth, but more by changes in land use. Similarly, the principal future impact on estimates from liquid effluents would result from changes in water use patterns in the nearby areas, for example, if a drinking-water intake for a large city were constructed near the plant discharge. Such future changes are difficult to predict.

To assure adequate control of releases while allowing for future changes in water or land use, the operating license Technical Specifications will provide for periodic reassessment of changes in land and water use patterns. This will provide a periodic reassessment of the adequacy of facility performance in order to maintain exposures to the public within the Appendix I guides.

CONCLUSIONS

The main contributions to the population dose to the United States is from C-14 and I-131. The generic estimates are about 2 man-rems/year for C-14 and about 300 man-rems/year for I-131 per curie released per year of plant operation for 30 years. All other releases and pathways are minor contributors.

Appendix D

COST ESTIMATES FOR ALTERNATIVE BASE-LOAD GENERATION SYSTEMS

A computer program was used to rough check the applicant's capital cost estimate for the proposed nuclear power station and to estimate the costs for fossil-fired alternative generation systems.

This computer program, called CONCEPT[1-3] was developed as part of the program analysis activities of the AEC Division of Reactor Research and Development, and the work was performed in the Studies and Evaluations Program at the Oak Ridge National Laboratory. The code was designed primarily for use in examining average trends in costs, identifying important elements in the cost structure, determining sensitivity to technical and economic factors, and providing reasonable long-range projections of costs. Although cost estimates produced by the CONCEPT code are not intended as substitutes for detailed engineering cost estimates for specific projects, the code has been organized to facilitate modifications to the cost models so that costs may be tailored to a particular project. Use of the computer provides a rapid means of calculating future capital costs of a project with various assumed sets of economic and technical ground rules.

DESCRIPTION OF THE CONCEPT CODE

The procedures used in the CONCEPT code are based on the premise that any central station power plant involves approximately the same major cost components regardless of location or date of initial operation. Therefore, if the trends of these major cost components can be established as a function of plant type and size, location, and interest and escalation rates, then a cost estimate for a reference case can be adjusted to fit the case of interest. The application of this approach requires a detailed "cost model" for each plant type at a reference condition and the determination of the cost trend relationships. The generation of these data has comprised a large effort in the development of the CONCEPT code. Detailed investment cost studies by an architect-engineering firm have provided basic cost model data for light water reactor nuclear plants,[4-5] and fossil-fired plants.[6-7] These cost data have been revised to reflect plant design changes since the 1971 reference date of the initial estimates.

The cost model is based on a detailed cost estimate for a reference plant at a designated location and a specified date. This estimate includes a detailed breakdown of each cost account into costs for factory equipment, site materials, and site labor. A typical cost model consists of over a hundred individual cost accounts, each of which can be altered by input at the user's option. The AEC system of cost accounts[8] is used in CONCEPT.

To generate a cost estimate under specific conditions, the user specifies the following input: plant type and location, net capacity, beginning date for design and construction, date of commercial operation, length of construction workweek, and rate of interest during construction. If the specified plant size is different from the reference plant size, the direct cost for each two-digit account is adjusted by using scaling functions which define the cost as a function of plant size. This initial step gives an estimate of the direct costs for a plant of the specified type and size at the base date and location.

The code has access to cost index data files for 20 key cities in the United States. These files contain data on cost of materials and wage rates for 16 construction crafts as reported by trade publications over the past fifteen years. These data are used to determine historical trends of site labor and material costs, providing a basis for projecting future costs of site labor and materials. These cost data may be overridden by user input if data for the particular project are available.

This technique of separating the plant cost into individual components, applying appropriate scaling functions and location-dependent cost adjustments, and escalating to different dates is the heart of the computerized approach used in CONCEPT. The procedure is illustrated schematically in Fig. 1.

ESTIMATED CAPITAL COSTS

The assumptions used in the CONCEPT calculations are listed in Table 1. Table 2 summarizes the total plant capital investment estimates for the proposed nuclear station with mechanical draft cooling towers.

Estimated costs for alternative fossil-fired plants are presented in Table 3. The estimated costs for SO_2 removal equipment are based on a study performed by Oak Ridge National Laboratory.[9]

As stated previously, the above cost estimates produced by the CONCEPT code are not intended as substitutes for detailed engineering cost estimates, but were prepared as a check on the applicant's estimate and to provide consistent estimates for the nuclear plant and fossil-fired alternatives.

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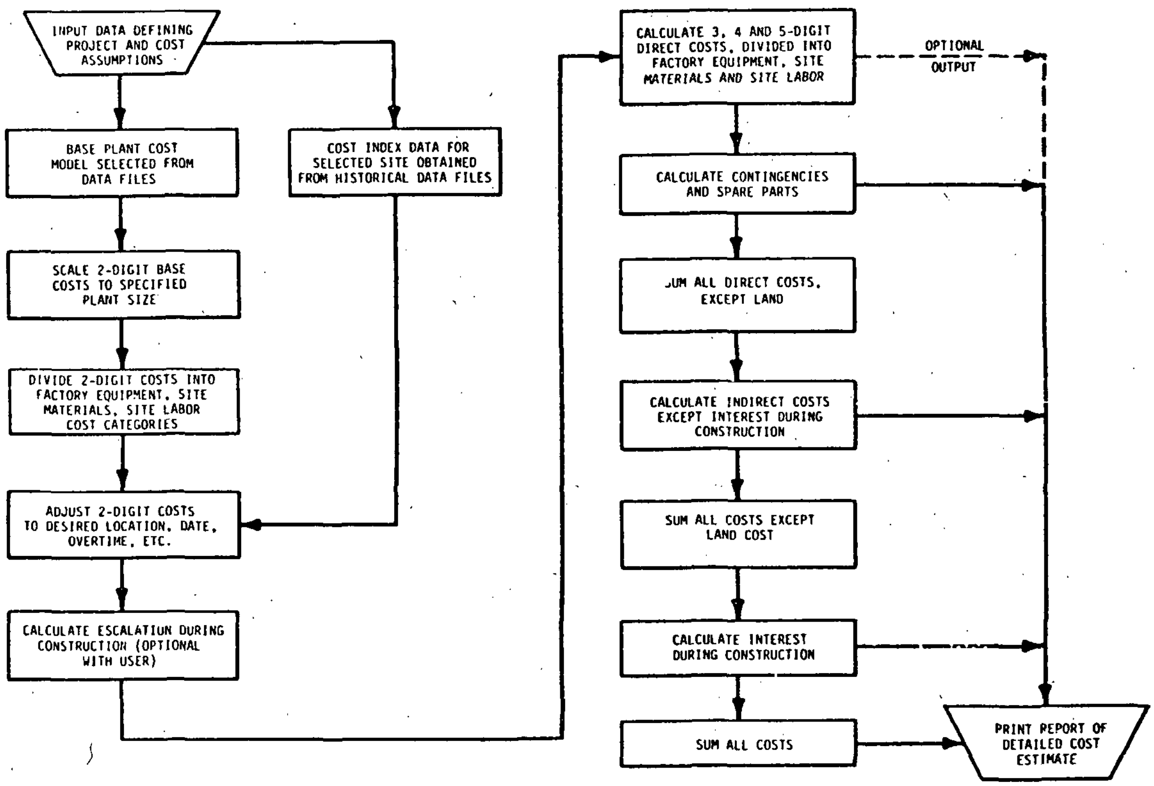

Fig. 1. Use of the CONCEPT program for estimating capital costs.

Table 1. Assumptions Used in CONCEPT Calculations

(Revised September 5, 1975)

Plant name	Cherokee Nuclear Station
Plant type	Three-unit PWR with mechanical draft cooling towers
Alternate plant types	Three-unit coal
Unit size	1280 MW(e)-net, each unit
Plant location	
Actual	Cherokee County, South Carolina
CONCEPT calculations	Atlanta, Georgia
Interest during construction	8%/year, compound
Escalation during construction	
Site labor	8.5%/year
Site materials	7.5%/year
Purchased equipment	7.5%/year
Site labor requirements	9.76 manhours/kW(e)
Length of workweek	40 hours
Start of design and construction date	
NSS ordered	April 1973
Fossil alternatives	January 1978
Commercial operation dates	
Unit 1	January 1984
Unit 2	January 1986
Unit 3	January 1988

Table 2. Plant Capital Investment Summary for 3840 MWe Pressurized-Water-Reactor Nuclear Power Plant Utilizing Mechanical Draft Evaporative Cooling Towers (Revised September 5, 1975)

(Duke Power Company, Cherokee Nuclear Station)

	Unit 1	Unit 2	Unit 3	Total
Net capability, MW(e)	1280	1280	1280	3840
Direct Costs (Millions of Dollars				
Land and land rights	3	0	0	3
Physical plant				
Structures and site facilities	48	40	40	128
Reactor plant equipment	88	87	87	262
Turbine plant equipment	90	88	88	266
Electric plant equipment	28	25	25	78
Miscellaneous plant equipment	5	3	3	11
Subtotal (physical plant)	259	243	243	745
Spare parts allowance	2	2	2	6
Contingency allowance	17	15	15	47
Subtotal (total pjysical plant)	278	260	260	798
Indirect Costs (Millions of Dollars)				
Construction facilities, equipment and services	18	12	12	42
Engineering and construction management services	44	33	33	110
Other costs	14	10	10	34
Interest during construction	167	179	218	564
Total Costs				
Plant capital cost at start of project				
Millions of dollars	524	494	533	1551
Dollars per kilowatt	409	386	416	404
Escalation during construction	271	339	444	1054
Plant capital cost at commercial operation				
Millions of dollars	795	833	977	2605
Dollars per kilowatt	621	651	763	678

Table 3. Total Plant Capital Investment Cost Estimated for a Three-Unit 3840-MW(e) Coal-Fired Plant with Mechanical Draft Evaporative Cooling Towers as an Alternative to the Cherokee Nuclear Station

(Revised September 5, 1975)

	Without SO_2 Abatement System	With SO_2 Abatement System
Direct Costs (Millions of Dollars)		
Land and land rights	3	3
Physical plant		
Structures and site facilities	98	117
Boiler plant equipment	320	414
Turbine plant equipment	285	291
Electric plant equipment	54	77
Miscellaneous plant equipment	11	11
Subtotal (physical plant)	768	910
Spare parts allowance	6	7
Contingency allowance	49	58
Subtotal (total physical plant)	823	975
Indirect Costs (Millions of Dollars)		
Construction facilities, equipment and services	38	69
Engineering and construction management services	64	75
Other costs	24	32
Interest during construction	361	447
Total Costs		
Plant capital cost at start of project		
Millions of dollars	1313	1601
Dollars per kilowatt	342	417
Escalation during construction	424	511
Plant capital cost at commercial operation		
Millions of dollars	1737	2112
Dollars per kilowatt	452	550

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