Docket Room Extra

Final

environmental statement

related to operation of

oconee nuclear station units 1, 2 and 3

DUKE POWER COMPANY

DOCKET Nos. 50-269, 50-270, 50-287

ATOMIC ENERGY COMMISSION · UNITED STATES OF AMERICA

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UNITED STATES ATOMIC ENERGY COMMISSION

DIVISION OF RADIOLOGICAL AND ENVIRONMENTAL PROTECTION

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FOREWORD

This final detailed statement on environmental considerations associated with the proposed issuance of an operating license for the Oconee Nuclear Station Unit 1 (AEC Docket 50-269) and continuing construction of Units 2 and 3 (AEC Docket No. 50-270, and 50-287) b Duke Power Company (applicant) has been prepared by the Division of Radiological and Environmental Protection (the staff) of the U.S. Atomic Energy Commission (AEC) in accordance with the Commission's regulation revised 10 CFR Part 50, Appendix D, implementing the requirements of the National Environmental Policy Act of 1969.

This statement is based in part on information available in the Duke Power Company Environmental Report, dated July 1970, and its Supplement, dated October 1971, submitted in conjunction with a request for an operating license for its Oconee Nuclear Station; the Final Safety Analysis Report (FSAR) on Oconee Units 1, 2, and 3; the Preliminary Safety Analysis Report (PSAR) on Oconee Units 1, 2, and 3; Safety Evaluations, dated August, 1967 and December, 1970; and a Detailed Statement on Environmental Considerations dated February, 1971. Copies of these documents are available in the AEC Public Document Room, 1717 H Street, N.W., Washington, D.C. 20006, and in the Office of the County Supervisor at the Oconee County Court House, Walhalla, South Carolina.

The environmental impact of the Oconee Nuclear Station was assessed in independent calculations and studies by the staff with the close collaboration of members of the Environmental Impact Program of the Oak Ridge National Laboratory. In addition, some of the information was gained from a visit to the Oconee Nuclear Station site and surrounding areas on August 31 and September 1, 1971, by several Regulatory Staff members.

The draft environmental statement, issued on December 13, 1971, was sent to Federal, State and Local agencies with a request for comments. In preparing this final environmental statement, all the comments received were considered and the draft was revised and supplemented. Those sections that were completely rewritten are as follows:

Section II.F (Ecology of the site and environs).

Section III.D.1c and 1d (Plant heat dissipation system; temperature and oxygen effects).

Section III.D.2 (Plant radioactive waste systems).

Section V.C. (Biological impact of plant operation)

Section V.D. (Radiological impact of plant operation)

Section VII (Adverse effects which cannot be avoided)

Section X (Alternatives to the proposed action and cost-benefit analysis of their environmental effects)

In addition, the following appendices were expanded:

Appendix II-1, previously designated as Appendix II-2 (Oconee meteorological data for computer)

Appendix II-2, previously designated as Appendix II-3 (Biota of the Keowee-Toxaway area).

New appendices were added with details to support the revised text:

Appendix II-3 (Commercial forestry productivity of Oconee and Pickens counties and nearby counties of the South Carolina Piedmont region affected by the project)

Appendix II-4 (Aquatic communities in Lake Keowee)

Appendix III-1 (Expected surface temperatures and vertical profiles for Lake Keowee and the Hartwell Reservoir)

Appendix III-3 (Assumptions used in estimating radioactive release rates)

Appendix V-1 (Estimation of internal radiation dose to organisms)

Appendix X-1 (Details of cost-benefit analysis)

Texts of all the comments and a tabulation that summarizes and identifies each comment and indicates the action taken in response are included in Appendix I of this Final Statement.

Although the licensing action with which this environmental statement is concerned is the operation of Unit 1 of the Oconee Nuclear Station, the statement itself is based on consideration of the simultaneous operation of Units 1, 2, and 3 at the Station. The statement does not, however, take into account the environmental effects of other power plants that may be built in the future on the Jocassee-Keowee-Hartwell lake system.

The applicant must comply with all requirements of Section 21(b) of the Federal Water Pollution Control Act under the terms stipulated in AEC-issued permits and licenses. The operating license will contain the conditions that:

> "The licensee shall observe such standards and requirements for the protection of the environment as are validly imposed pursuant to authority established under Federal and State law and as are determined by the Commission to be applicable to the facility covered by this operation license."

I. INTRODUCTION

A. SITE SELECTION

The applicant selected the site of the Oconee Nuclear Station to be near the expanding industrial load in the western sector of its utility district (Fig. I-1) and also to permit integration of the plant into the Keowee-Toxaway Project in an arrangement that provides ample cool condensing water as well as hydroelectric power for peaking purposes. This project presently consists of Lake Keowee and its completed hydroelectric station, the Oconee Nuclear Station with three pressurized water reactors, one completed and two under construction, and Lake Jocassee with its pumped-storage facility also under construction.

Lake Keowee was formed by impounding the water of the Little River and the Keowee River just above Hartwell Reservoir near Seneca, South Carolina, as shown in Fig. I-2. Lake Jocassee is just upstream from Lake Keowee on the Keowee River. The hydroelectric project was licensed (Project No. 2503) by the Federal Power Commission, September 26, 1966.

For the purposes of this statement, "The Project" includes Oconee Nuclear Station, Lake Keowee, and Lake Jocassee. "The Project Site" includes the area around Oconee Nuclear Station including Lake Keowee, Lake Jocassee, and the headwaters of Hartwell Reservoir. "The Nuclear Site Boundary" is the circle with a one-mile radius around the Oconee Nuclear Station.

The Station is located in Oconee County, near the western boundary of the applicant's system, in northwestern South Carolina near the North Carolina-South Carolina border. The site is 8 miles northeast of Seneca and about 25 miles west of Greenville, South Carolina.

One of the primary reasons for selecting the general location of the Station was to allow shorter transmission of power to the rapidly growing industrial and domestic load in the western portion of the applicant's service area. Another was the potential for a good supply of cooling water for the plant. A source of cool condensing water provides better thermal efficiencies and lower plant capital costs than if cooling towers are used. Not only were the existing streams and terrain in the vicinity of the site suited to the construction of a reservoir from which cool water could be

Table I-1

LIST OF GOVERNMENT AGENCIES INVOLVING KEOWEE-TOXAWAY PROJECT

Govt Body or Agency	Date Contacted or Application	Type of Agreement	Date Approved
Federal			
Federal Power Commission	1-4-65	FPC License for Construction of Keowee-Toxaway Project, FPC No. 2503 (8-16-66 Public Hearing Date)	9-26-66
U.S. Army Corps of Engineers	4-27-67	Filling and Operating Agreement	10-1-68
Fish and Wildlife Service, Dept. of Interior	3-22-65 7-28-65 8-26-65 12-13 & 14-65	Letter from Department of Interior Secretary to FPC commenting on Keowee-Toxaway Project	4-7-66
Southeastern Power Administration Dept of Interior	4-27-67	Filling and Operating Agreement	10-21-68
Bureau of Outdoor Recreation Dept of Interior	2-5-65	Duke forwarded copy of FPC License Application	-
	11-14-66	Letter approving in general Duke's reservoir clearing at Jocassee and Keowee	
U.S. Geological Survey, Dept of Interior	4-20-66 & 4-22-66	Letter confirming agreement between Duke & USGS to replace gages	11-7-66
Federal Aviation Authority	11-16-66 & 3-13-67	Approval of applications for Microwave Tower and Elevated Water Storage Tank	10-17-66 & 3-27-67
Federal Communication Commission	11-29-66, 8-23-68, 9-15-66 & 3-3-70	Approval of License for Construction Radio and Microwave for Oconee and Jocassee	4-12-67, 11-5-68, 10-17-66, 4-7-70

Table I-1 (continued)

Govt Body or Agency	Date Contacted or Application	Type of Agreement	Date Approved
U.S. Public Health Service (HEW)	11-14-66	Letter approving in general clearing plan for Jocassee and Keowee	12-6-66
	8-28-70	Letter to Mr. Harold L. Price commenting on Duke's Environmental Statement for Oconee	-
Atomic Energy Commission	12-1-66	Construction Permit for Oconee Nuclear Station (8-29-67 Public Hearing Date)	11-6-67
Southeastern Basins Interagency Commission	8-13-65	Letter to FPC endorsing construction of Keowee-Toxaway Project	7-24-65
State			
South Carolina Highway Dept	12-30-64(meeting) 1-4-65 (letter)	General Agreement for relocation of highways (10-15-67 Act signed by Governor on 5-16-67 authorizing relocation work)	9-1-67
South Carolina Pollution Control Authority	1-4-65	Letter to FPC with resolution endorsing Keowee-Toxaway Project	3-8-65
	11-4-67	Sewage treatment permit for construction of facilities at Keowee	11-13-67
	7-17-70	Permit to construct Oconee intake and discharge structures	11-19-70
	9-9-70	Mr. Henry E. Gibson's letter to Mr. Clair P. Guess commenting on Duke's Environmental Statement	-
	9-28-70	Mr. Henry E. Gibson's letter to Dr. Peter Morris stating they have no objection to granting an operating permit to Duke for Oconee	-

Table I-1 (continued)

Govt Body or Agency	Date Contacted or Application	Type of Agreement	Date Approved
South Carolina Board of Health	3-11-66 6-23-67, 9-4-70	Letter authorizing construction of Keowee and Jocassee Reservoirs Permits for construction of sewage facilities at Oconee	3-15-66 7-24-67, 11-5-70
South Carolina Dept of Parks, Recreation & Tourism	3-6-69	Acceptance of Chapman Bridge as relocated by Duke (SCDPR&T)	1-25-71
		Acceptance of Chapman Bridge as relocated by Duke (SCHD)	2-22-71
South Carolina Highway Patrol	9-14-70	Permit to haul heavy and oversize loads on SC 130	9-23-70
Local			
Oconee County	2-20-67	Application for construction permit -- Oconee	
Pickens County	2-20-67	Application for construction permit -- Keowee & Jocassee	
Town of Seneca S.C.	5-10-66	Agreement to relocate sewage facilities and Agreement to relocate water facilities	3-31-69
Town of Walhalla S.C.	1-15-71	Letter confirming location of possible water intake and filtration plant site	6-28-71
City of Greenville S. C.	1-20-69	Location of Greenville water supply intake on Lake Keowee	10-9-70

Table I-1 (concluded)

Some of the additional agencies contacted by the applicant are:

Appalachian Regional Commission
U.S. Bureau of Public Roads
Department of Housing and Urban Development
Department of Defense
Soil Conservation Service, Department of Agriculture
U.S. Department of Agriculture
U.S. Forest Service
Federal Court of Appeals
U.S. Department of Justice
Equal Employment Opportunity Commission
National Labor Relations Board
U.S. Weather Bureau
South Carolina Public Service Commission
Attorney General of South Carolina
South Carolina Water Resources Commission
South Carolina Department of Archaeology
South Carolina State Museum
South Carolina State Development Board
South Carolina Wildlife Resources Department
South Carolina State Commission of Forestry
South Carolina Tax Assessment Board
Governor of South Carolina
Oconee County Health Officer
Oconee Memorial Hospital
Oconee County Sheriff
Resources Advisory Board, Southeastern River Basins
Civil Defense Agency, Oconee County
Civil Defense Agency, Pickens County
Oconee County Rural Fire System
East Seneca Water District

drawn, but also a hydroelectric turbine could be installed at the dam to provide peaking capacity. Further, a pumped-storage facility could be constructed upstream from the reservoir to provide additional peaking capability. The applicant examined possible arrangements and determined that there were important economic advantages to the multiple-purpose impoundment of the water. A secondary consideration was that the lakes would offer recreational benefits and enhance the area for residential use.

The Keowee hydroelectric station has an installed capacity of 140 megawatts, but the limited flow of water into the reservoir will normally allow generation at this rate only about 5% of the time (5% plant factor). The Jocassee hydroelectric station, with less flow but greater head, will have an installed capacity of 305 megawatts by 1974 and 610 megawatts by 1978, with sufficient water for 14% plant factor at the 305-megawatt rating. The Station will contain three units rated at 886 megawatts each, giving a total generating capacity of more 2658 megawatts at a plant factor of 80 to 90%, or better. Although the capacity of the hydroelectric stations to help meet peak demands is important, it is evident that the total electrical production by the nuclear station overshadows that of the two hydroelectric facilities and that the chief function of the lakes is to furnish an assured supply of cool water for the turbine condensers of the nuclear plants.

B. APPLICATIONS AND APPROVALS

The applications and approvals that have been required in connection with the Keowee-Toxaway Project are given in Table I-1.[1] The tabulation is divided into three parts (Federal, State and local agencies) in each of which the application or approval action is listed in chronological order.

The following additional actions remain. The applicant has applied for certification as required by Section 21(b) of the Federal Water Pollution Control Act and a discharge permit from the Corps of Engineers, Department of the Army. There is no indication in the information submitted by the applicant that the waste water retention pond is covered under the sewage treatment facility permit given by the State of South Carolina Pollution Control Authority.[2]

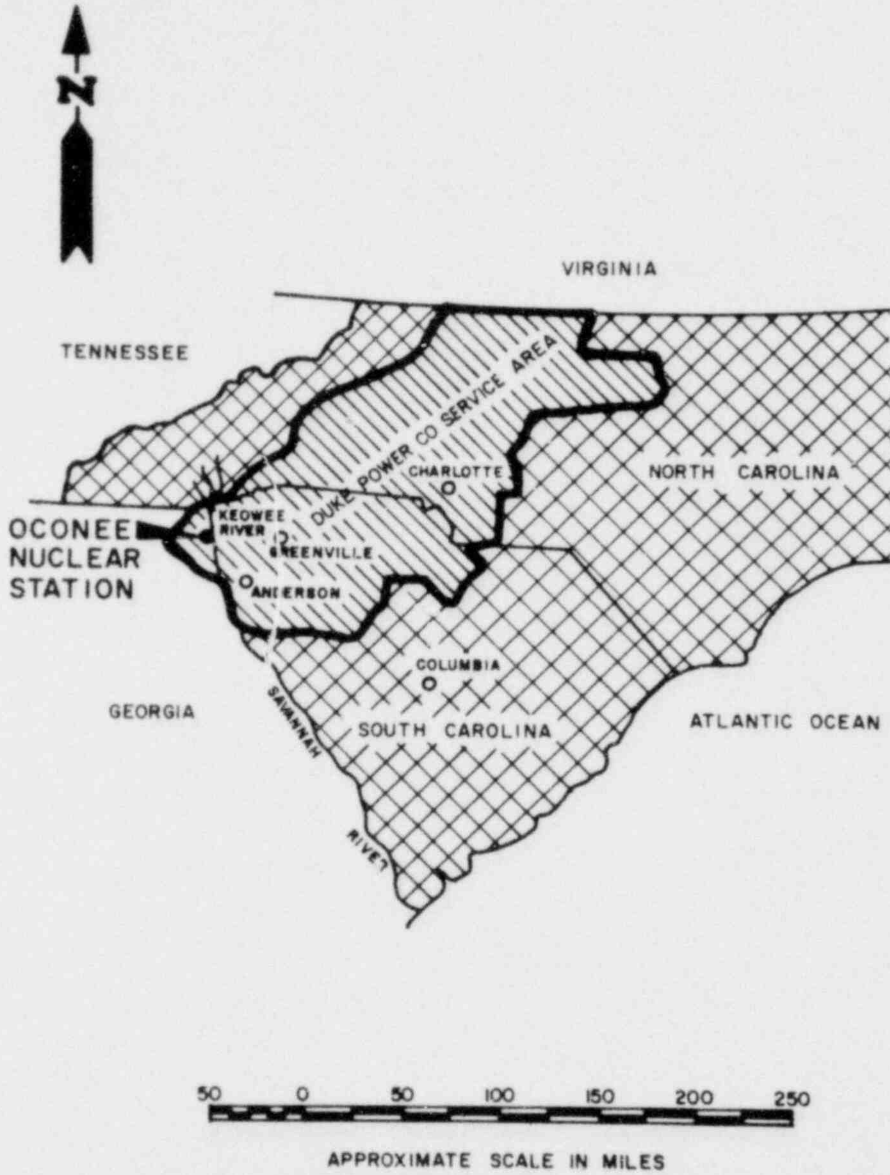


FIG. I-1

DUKE POWER COMPANY SERVICE AREA

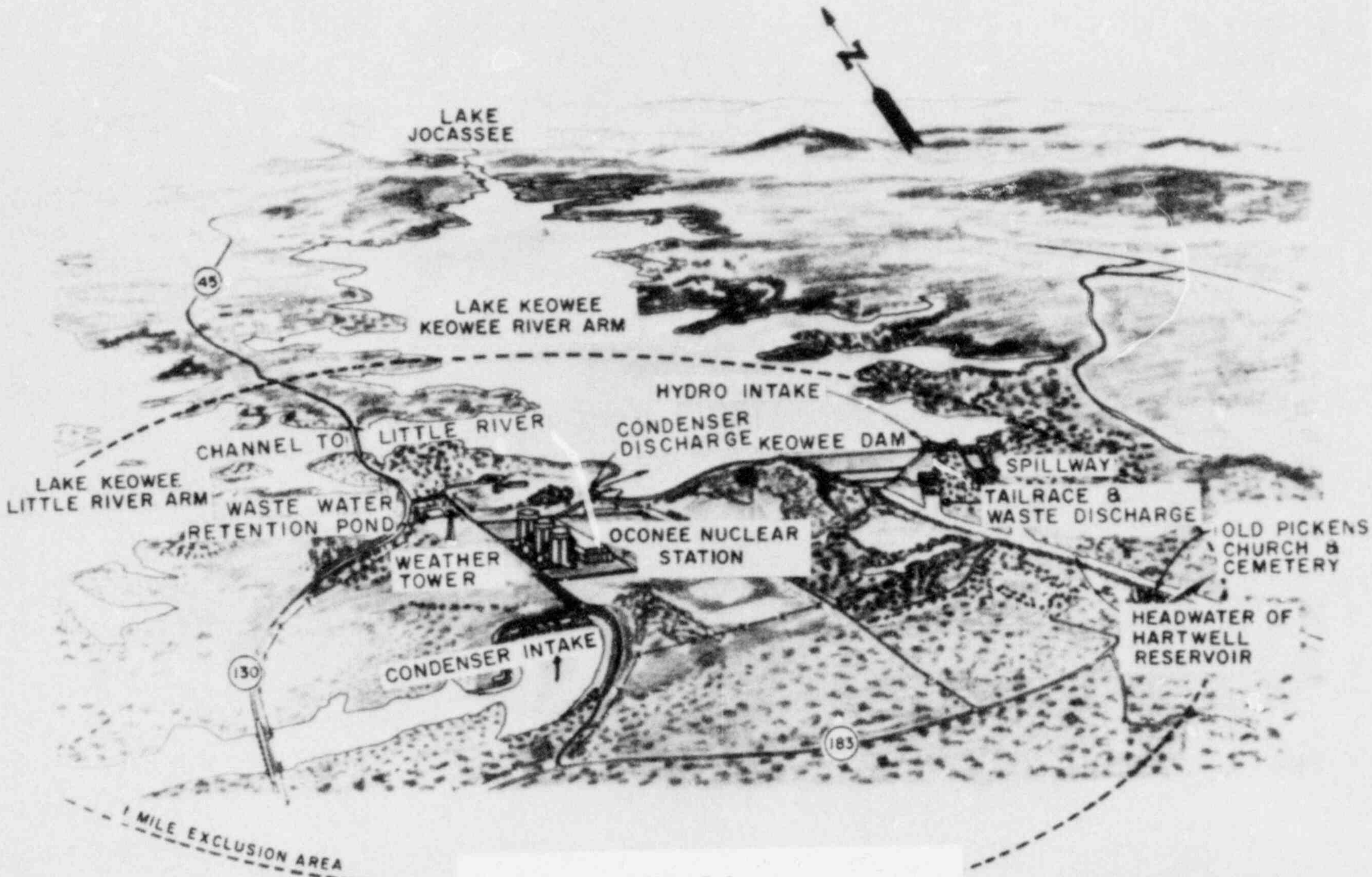


FIG. I-2

LAKE KEOWEE IN THE VICINITY OF

OCONEE NUCLEAR STATION

II. THE SITE

A. GENERAL

The Station is in Oconee County, South Carolina, less than a mile from the Pickens County line and within 25 miles of the boundaries of the states of North Carolina and Georgia (Fig. II-1). Here, at the southern reach of Appalachia, the Piedmont hills join the southern Blue Ridge Mountains to form the Piedmont Crescent of South Carolina. The terrain is mountainous, with elevations differing by almost 2000 feet; the rainfall is abundant (73 to 85 inches per year), and some of the numerous streams are characterized by deep gorges. The Station and its associated lakes and hydroelectric stations, cover several hundred square miles. Fig. II-2 shows the principal cities within a radius of 100 miles from Keowee Dam. Several small towns within 20 miles, are shown in Fig. II-3.

Transportation is good throughout the entire region. Highways S.C. 45 and S.C. 183 (Fig. I-2 and Fig. II-1) are about 1/2 mile from the site; U.S. 76, U.S. 123, and U.S. 178 are readily accessible. Interstate highways I-85 and I-26 cross the region, and a new scenic highway, S.C. 11, is being built along the foothills of the southern Blue Ridge Mountains. The main line of the Southern Railway from Atlanta to Washington passes through the area, and additional rail service is supplied by several smaller lines.

The downstream Hartwell Reservoir (Figs. II-1, II-3) of the Corps of Engineers has a close relationship to the Keowee-Toxaway Project because the minimum daily flow and waste discharge restrictions it imposes on Lake Keowee management. Thus (a) the minimum average daily flow through the Keowee Dam must be equivalent to 152 cubic feet per second, which is somewhat more than the minimum flow rate into Hartwell Reservoir recorded before the formation of Lake Keowee, and (b) the discharge of wastes into the Keowee Dam tailrace is restricted because Hartwell Reservoir water is used by some of the surrounding cities (see Section V.D.2).

B. DETAILS OF LOCATION

The Station is located within an exclusion area of 1 mile radius (Fig. I-2). This area is owned in full except for a small rural church lot, a highway right-of-way, and approximately 9.8 acres included in the Hartwell Project. Lakes Keowee and Jocassee (Fig. II-3), associated with the Station, were created on land owned by the applicant. These lakes cover a total area of about 26,000 acres -- 18,500 acres and 300 miles of shore for Keowee, 7,500 acres and 75

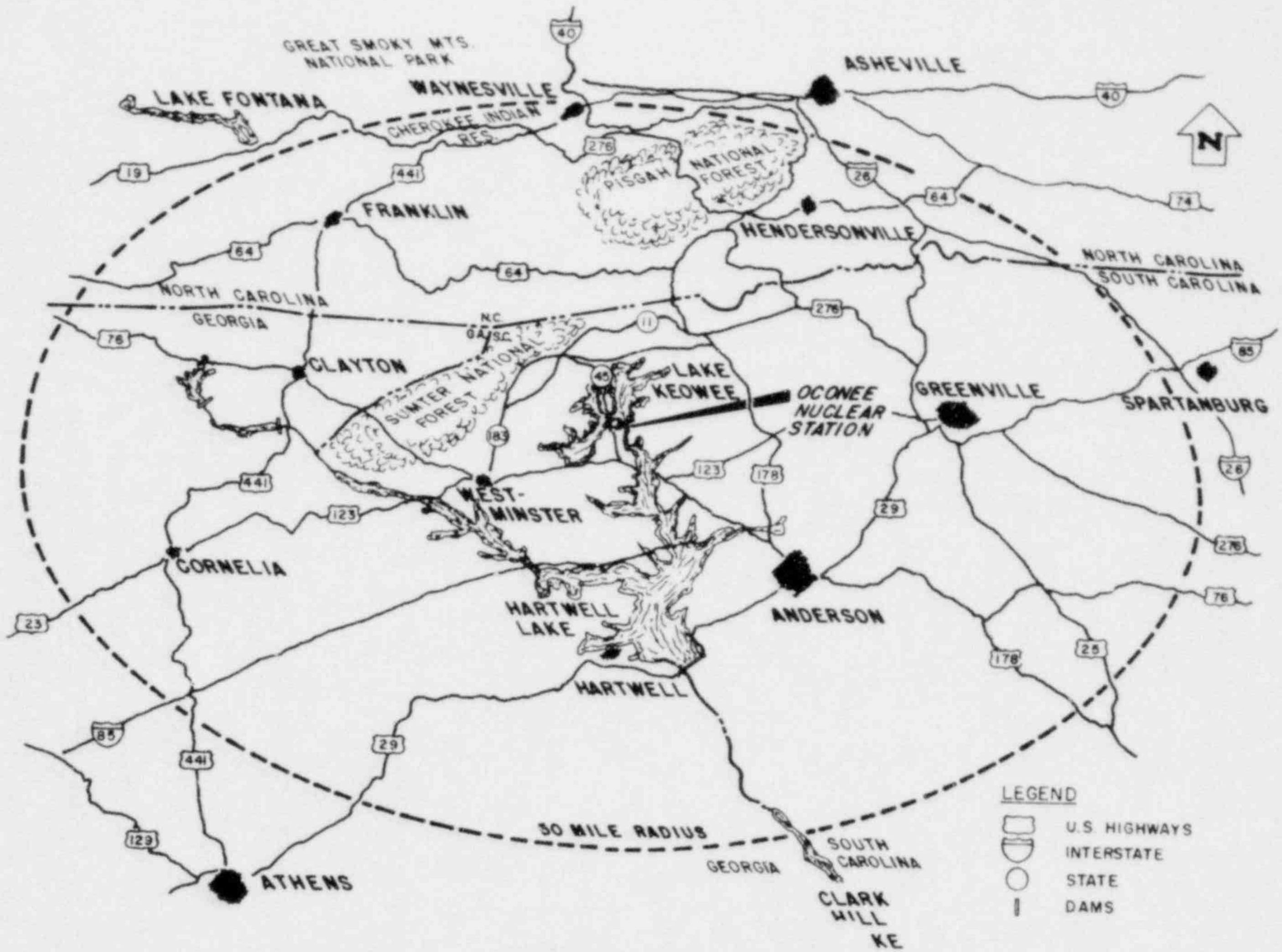


FIG. II-1

OCONEE NUCLEAR STATION

AND ENVIRONS TO 50 MILES

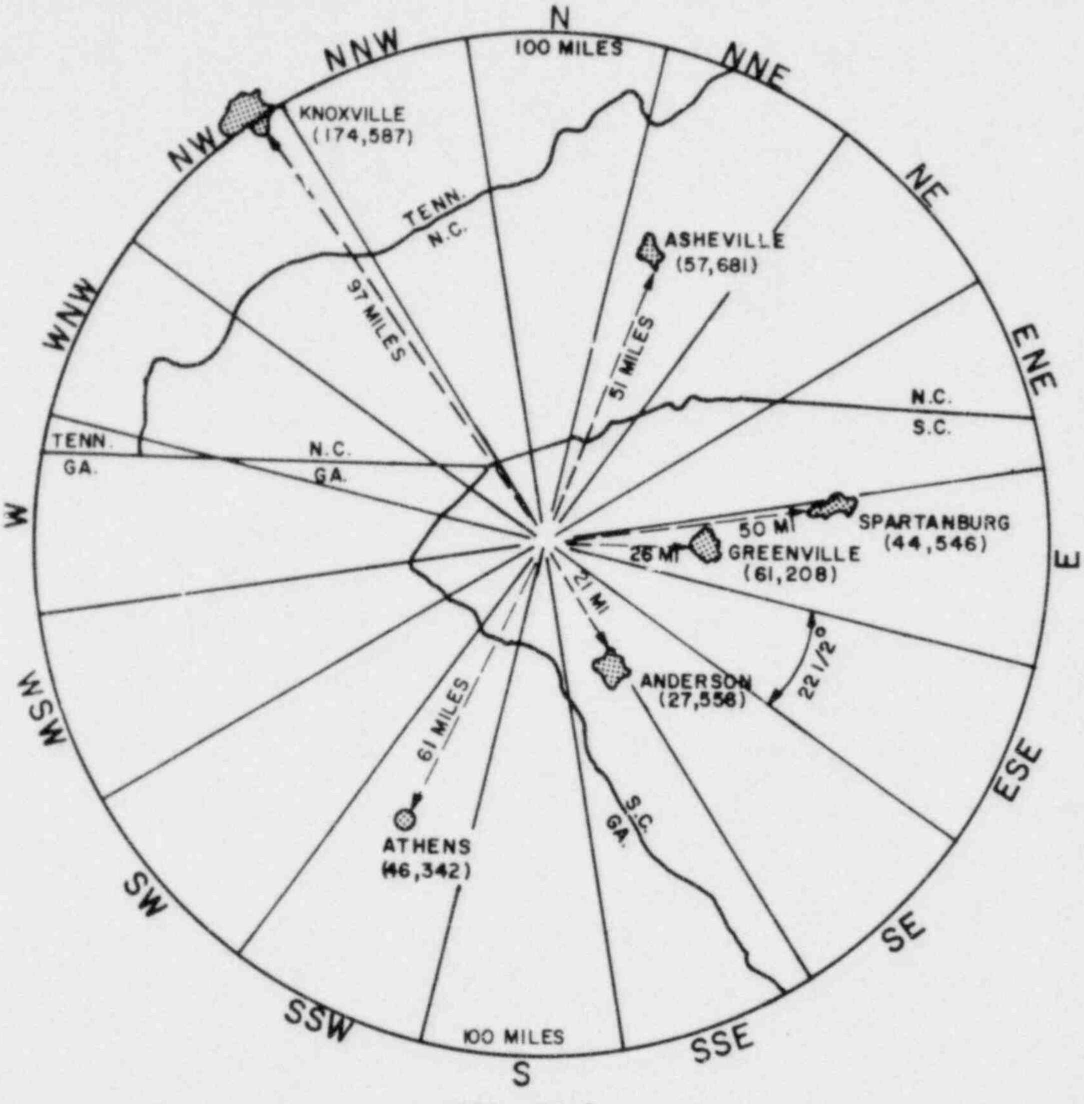


FIG. II-2

DISTANCES OF POPULATION CENTERS
WITHIN A 100-MILE RADIUS FROM
OCONEE NUCLEAR STATION

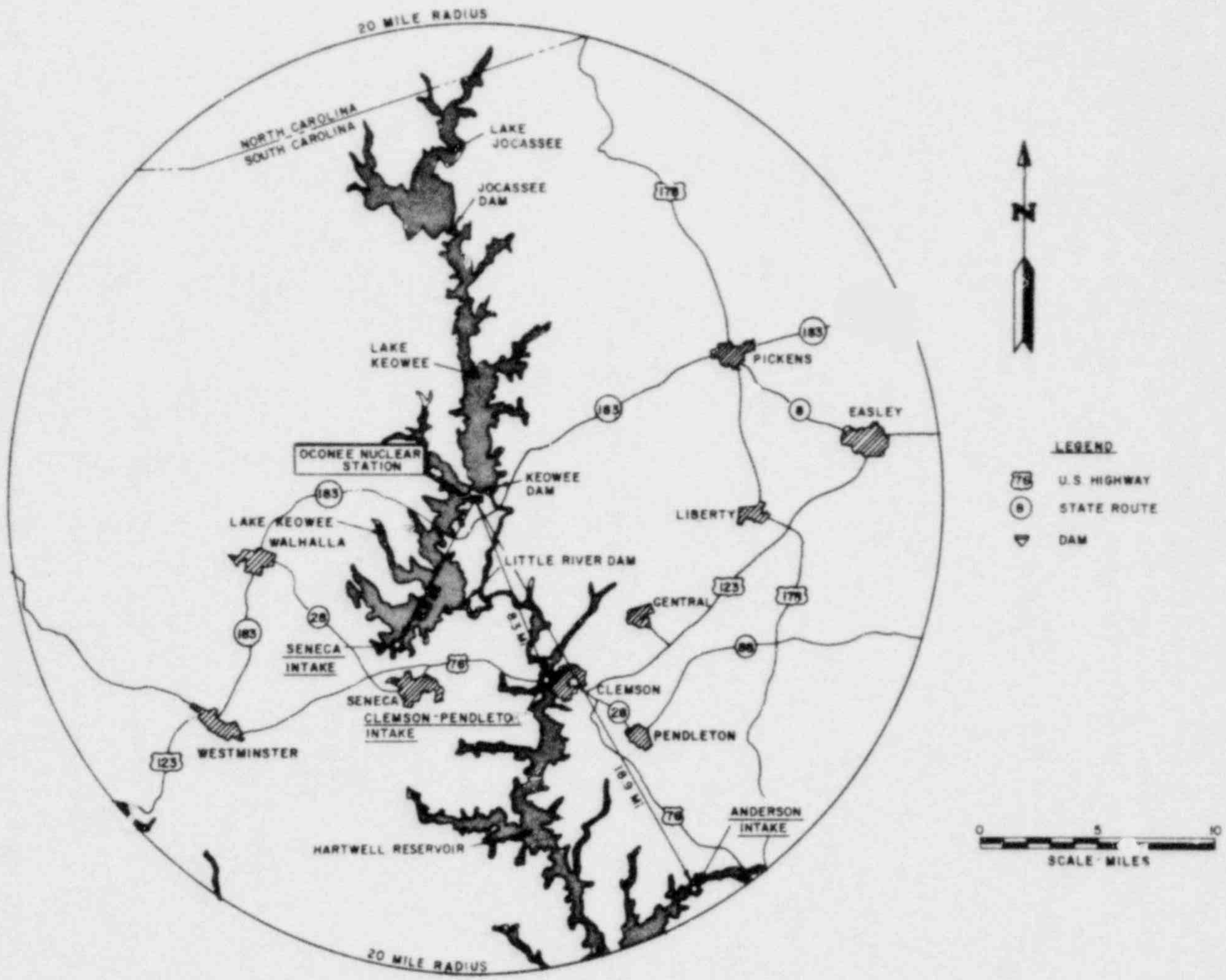


FIG. II-3

GENERAL AREA OF OCONEE NUCLEAR STATION

miles of shore for Jocassee. In addition to the acreage just listed, the applicant owns surrounding land to a total of 157,000 acres, most of which lies north by northeast and north by northwest of Keowee Dam.

C. REGIONAL DEMOGRAPHY AND LAND USE

1. Population

The principal population centers within a radius of 100 miles are shown in Fig. II-2. The largest city within 100 miles is Knoxville, Tennessee, 97 miles northwest, with a population (1970) of about 175,000. (Knoxville, though nearer to Oconee than Charlotte, North Carolina, is by comparison totally unrelated to the Station's service area and its impacts.) The nearest urban center is Anderson, South Carolina, 21 miles southeast, with a population (1970) of about 28,000.[1] The estimated distribution of the 1970 population at distances from 1 mile to 50 miles from the Oconee Station is shown in Table II-1.

The accumulative populations within 5 and 20 miles radius from the site shown in Fig. II-4 are for the year 1965 with projections for the year 2010. From the projected figures it can be shown that the population is expected to increase by more than 50% by the turn of the century, and the greatest percent increase will occur in the near vicinity of Keowee Dam, largely because of residential developments surrounding the lakes (Lake Keowee in particular). The population at and near the project site has changed little in many years, so the picture before site construction was essentially as shown in Fig. II-5. Note especially (i) the farm residence 1.2 miles east of the central Oconee Nuclear site, (ii) Keowee School (356 pupils) 3.8 miles west, (iii) Oconee Memorial Hospital (127 beds) at Seneca 8 miles south-southwest, (iv) Courtney Mills (250 employees) at Newry 5 miles south, and American Enka at Central 8 miles southeast.

In the exclusion area itself (Fig. II-2), the Visitors Center, the lakeside recreational areas, and the Bachelor Quarters for construction employees (to be removed after construction) constitute activity centers that stem directly from the project. Old Pickens Church (not used for regular services), a highway right-of-way, and 9.8 acres of the Hartwell Project are areas that are not owned by the applicant but come under the regulations of the exclusion area. Rights have been obtained to restrict the use of all the public areas.

2. Land Use

The Keowee-Toxaway Project is located in the western portion of the applicant's service area (See Fig. I-1). Since World War II, there

Table II-1. Estimated population distribution about the Oconee Nuclear Station based on the 1970 census

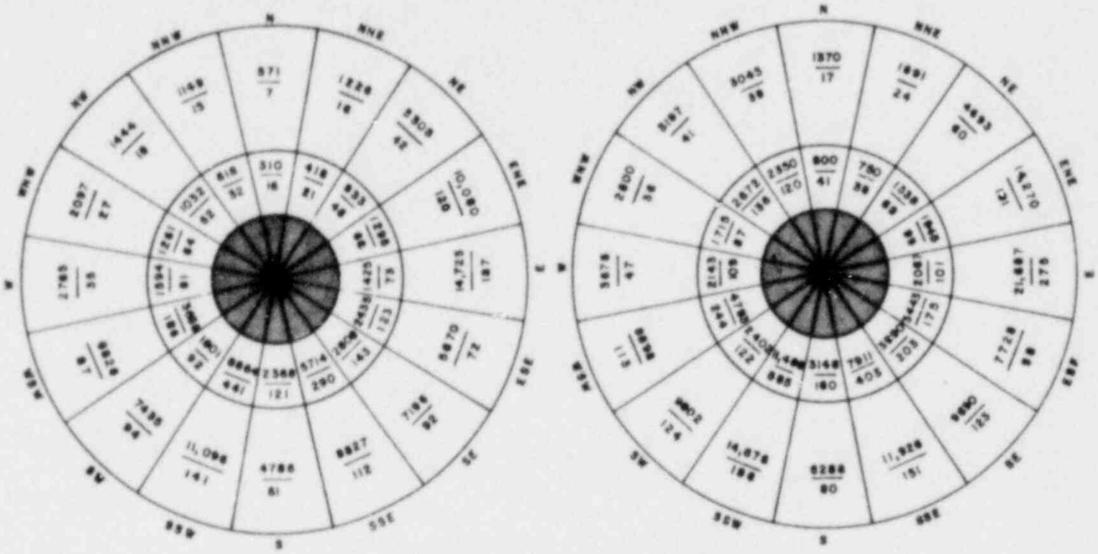
Sector	Population at a radial distance of –								
	1–2 miles	2–3 miles	3–4 miles	4–5 miles	5–10 miles	10–20 miles	20–30 miles	30–40 miles	40–50 miles
SSW	9	13	38	98	8,491	2,428	5,894	8,679	5,615
SW	9	15	50	54	1,427	4,865	6,101	3,886	5,563
WSW	12	33	67	69	3,899	3,533	11,904	11,102	13,946
W	11	39	52	54	1,235	1,022	2,648	1,514	1,723
WNW	11	36	59	68	1,733	1,264	3,786	2,981	3,467
NW	2	5	10	17	635	267	1,203	8,552	4,223
NNW	3	12	20	27	760	706	1,796	6,619	10,434
N	3	11	16	14	249	247	2,204	496	3,596
NNE	7	18	36	44	364	906	3,223	13,243	18,639
NE	12	19	64	75	934	2,805	5,553	2,970	26,716
ENE	13	28	59	104	1,139	9,112	41,716	42,414	35,288
E	16	31	49	221	1,128	13,487	98,134	49,061	19,682
ESE	15	27	11	78	2,649	3,694	13,850	5,294	8,250
SE	8	24	20	59	3,406	5,496	52,736	11,734	10,409
SSE	8	12	18	90	5,323	2,969	14,568	6,105	2,305
S	7	9	21	134	2,185	2,406	5,189	8,046	14,196
Incremental population	146	332	590	1206	35,557	55,207	270,505	182,696	184,052
Cumulative population	146	478	1068	2274	37,831	93,038	3[illegible]3,543	546,239	730,291

2010
5 - 20 Miles

Radius (Miles)	Total - 360° 1966	Total - 360° Rev. 1969
0 - 20	121,845	125,839
0 - 10	49,326	52,973

1965 5-20 MILES

2010 5-20 MILES



NOTES:
TOTAL POPULATION IS CUMULATIVE FROM THE CENTER

NUMBERS ARE $\frac{\text{TOTAL POPULATION}}{\text{PERSONS / Sq. Mile}}$

FIG. II-4

POPULATION DISTRIBUTION IN 1965 AND PROJECTED DISTRIBUTION IN 2010 WITHIN 20-MILE RADIUS OF THE OCONEE NUCLEAR STATION

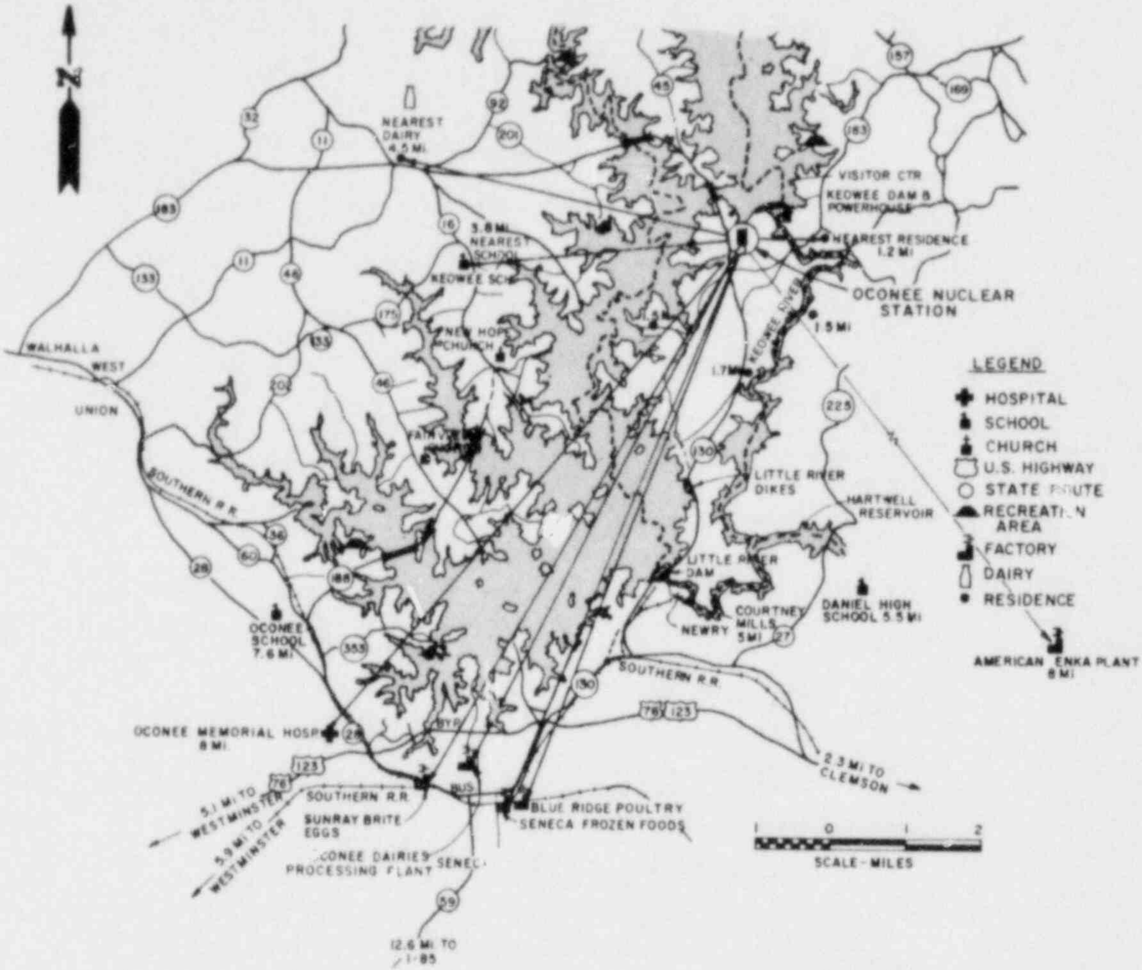


FIG. II-5

POINTS OF INTEREST IN ENVIRONS OF
OCONEE NUCLEAR STATION
FOR DOSE-RATE CALCULATIONS

has been a change in this region away from a cotton economy to one of general manufacturing and industry. The result has been an increase in diverse manufacturing operations and a reorientation in the farming industry, with cotton being replaced by fruit, poultry, and dairy production. Viewed as a whole, the region is one consisting of small farms whose owners are also industrial workers, interspersed with industrial-sized farms that provide food for market. Some of the industries within 8 miles or so of Keowee Dam are shown in Fig. II-5.

D. HISTORICAL SIGNIFICANCE

The 1-mile exclusion area includes the site of Old Pickens township, the structures of which, except for Old Pickens Church and one residence, were destroyed in 1868. The Director of the Pendleton District of the South Carolina State Historical and Recreational Commission supplied this information.

Lake Keowee floods an area that includes the site of Old Fort Prince George (an early British outpost) and the site of old Keoweetown (headquarters of the lower Cherokee Nation). Before the flooding, extensive diggings were made for archeological salvage at these two historical sites. The artifacts that were found are in the possession of state and local museums. This work was conducted by the University of South Carolina using a grant made by the applicant. An old covered bridge that crossed the Keowee River was moved and restored at Keowee-Toxaway State Park. In addition, all graves and cemeteries in the areas that were to be inundated were moved to new locations.

Mr. Charles Lee, State Liason Officer for Historic Preservation was asked to comment on the draft environmental statement. He advised that he had no comment on this project. The National Register of Historic Places was consulted and no historic properties other than those noted above were listed.

E. ENVIRONMENTAL FEATURES

1. Surface Water[2,3]

The area is drained by the Keowee and Little Rivers, which join some 7 miles below the site to form the Seneca River. The Seneca River is a major tributary of the Savannah River.

When the Seneca River was dammed to form the Hartwell Reservoir, water backed up into the lower Keowee and Little Rivers. The Keowee and Little Rivers, now separately dammed (Fig. II-3), form a single lake, Lake Keowee. These dams are about 160 feet high, and the impounded waters (Keowee Lake) furnish the energy to drive the Keowee hydroelectric power station. Lake Keowee is about 20 miles long and has a volume, when full, of about one million acre-feet. Upstream from Lake Keowee on the Keowee River will be the Jocassee Reservoir, with a 360-foot-high dam under construction, and a storage capacity of a little over one million acre-feet. The Jocassee Reservoir will be used for pumped storage, producing electricity during the day from water that is pumped back again into the reservoir at night.

Because of these various dams, lakes, and reservoirs, the natural flow of the rivers is greatly altered. Before the dams were built, the average flow of the Keowee River near what is now the upper end of Keowee Lake was 465 cubic feet per second. The minimum flow was 57 cubic feet per second, and the maximum was 21,000. The combined flow of the Keowee and Little Rivers 1 mile below their confluence, in what is now the upper part of the Hartwell Reservoir, was 1140 cubic feet per second; the minimum flow was 120, and the maximum 25,200. With the creation of Lake Keowee, the maximum discharge into upper Hartwell Reservoir through the Keowee hydroelectric plant is 19,800 cubic feet per second; the minimum discharge attainable is 30 cubic feet per second. (Flow through Little River Dam is negligible.) The average discharge of Hartwell Reservoir is 4,400 cubic feet per second.

The Station is near the ridgeline between the Keowee and Little River valleys and is more than 100 feet above the maximum known flood in either valley. The dams on the lakes further reduce the possibility of a Station flood. The design discharge rate of the spillway for Lake Keowee is 105,000 cubic feet per second and for Lake Jocassee, 46,000 cubic feet per second.

In June 1965 a sample of water from the Keowee River near what is now the upper end of Lake Keowee was analyzed by the U. S. Geological Survey, Water Resources Division. The results are given in Table II-2.

Analyses of the lower Keowee River were made in 1953-1955 under varying conditions and are given in Table II-3. The water of Lake Keowee is essentially soft water; its average temperature varies from 50°F in January (the lake does not freeze) to 85.2°F in August.

2. <u>Groundwater</u>[2]

The Station is in the drainage basins of the Little and Keowee Rivers, which receive the runoff of surface water and groundwater from the site.

Table II-2. Results of chemical analysis of Keowee River water, June 1965

Constituent	Ppm	Constituent	Ppm
Silica (SiO_2)	7.8	Carbonate (CO_3)	0.0
Iron (Fe)	0.01	Bicarbonate (HCO_3)	7.0
Calcium (Ca)	1.0	Sulfate (SO_4)	1.0
Magnesium (Mg)	0.1	Chloride (Cl)	0.6
Sodium (Na)	1.2	Fluoride (F)	0.1
Potassium (K)	0.4	Nitrate (NO_3)	0.1
Dissolved Solids	15.0	Phosphate (PO_4)	0.0
Hardness as $CaCO_3$	3.0		

From Duke Power Company, PSAR, Oconee Nuclear Station, Units 1, 2 and 3, Appendix 2C, p. 2C-3, August 1967. Other properties: pH, 6.6; specific conductance, 13.0 micromhos at 25°C.

TABLE II-3

CHEMICAL ANALYSIS OF THE KEOWEE RIVER
1953-1955
Savannah River Basin
Keowee River near Newry, S.C.

LOCATION--At gaging station 0.4 mile upstream from Sixmile Creek, 1 mile downstream from Little River, and 1.5 miles east of Newry, Oconee County.
DRAINAGE AREA--455 square miles.
RECORDS AVAILABLE--Chemical analysis: October 1953 to September 1954.
Water temperatures: October 1953 to September 1954.
EXTREMES, 1953-54.--Dissolved solids: Maximum, 31 ppm Nov. 16; minimum, 19 ppm Jan. 16.
Hardness: Maximum, 8 ppm Oct. 14, Nov. 16, May 16, June 16, Sept. 17; minimum, 5 ppm, Dec. 15, Jan. 16, Feb. 15, Mar. 15.
Water temperatures: Maximum, 82°F. Aug. 15; minimum, 45°F. Dec. 15.

9-268h — Chemical analyses, in parts per million, water year October 1953 to September 1954

Date of collection	Mean discharge (cfs)	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color	Oxygen consumed: Unfiltered	Oxygen consumed: Filtered
Oct. 14, 1953	500	61	13	0.05	2.2	0.7	2.8	1.1	14	1.5	1.2	0.1	0.1	30	8	0	43.0	6.3	9	2.5	1.6
Nov. 16	402	48	15	.07	2.4	.6	3.2		15	1.1	1.2	.0	.3	31	8	0	48.7	6.4	11	1.6	1.2
Dec. 15	2,700	45	8.9	.08	1.4	.4	1.4		6	1.9	.8	.0	.2	20	5	0	37.2	6.3	21	3.0	2.6
Jan. 16, 1954	11,100	46	5.7	.03	1.4	.4	1.4	.6	5	2.0	1.2	.0	.4	19	5	1	20.6	5.6	6	--	1.8
Feb. 15	978	48	10	.01	1.1	.5	2.6		9	.9	1.2	.1	.2	22	5	0	20.2	6.4	3	2.1	2.0
Mar. 15	1,590	52	8.0	.02	1.4	.4	1.8		7	1.2	1.0	.1	.5	20	5	0	21.1	5.7	18	4.5	2.4
Apr. 14	1,210	59	9.9	.01	1.8	.5	2.1	.7	9	.9	1.2	.2	.5	23	7	0	22.4	6.6	8	2.5	1.4
May 16	1,290	64	7.9	.00	1.4	1.1	1.2	.7	10	2.5	.8	.0	.4	25	8	0	23.6	6.1	3	2.8	1.8
June 16	740	76	11	.00	1.8	.8	1.5	.8	10	1.5	1.2	.1	.7	26	8	0	25.8	6.2	4	2.8	1.6
July 16	376	79	12	.05	2.0	.5	2.4	.7	14	1.2	1.2	.0	.4	29	7	0	29.5	6.3	8	--	1.6
Aug. 15	238	82	11	.04	1.8	.7	2.4	.8	14	.8	1.2	.0	.4	29	7	0	28.2	6.6	7	--	1.6
Sept. 17	203	80	10	.06	1.9	.9	2.5	1.1	15	.7	1.5	.0	.6	30	8	0	31.7	6.6	15	--	1.8

Chemical analyses, in parts per million, of spot samples

Date of collection	Mean discharge (cfs)	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color	Oxygen consumed: Unfiltered	Oxygen consumed: Filtered
Aug. 14, 1946	630	--	12	0.09	1.9	0.8	2.5		13	1.2	1.0	0.0	0.2	28	8	0	--	--	13		
June 15, 1949	1,840	69	8.6	.03	1.5	.6	3.3		11	2.2	1.0	.1	.6	22	6	0	19.4	6.0	7		
Mar. 17, 1955	444	57	12	.00	2.0	1.0	2.0	0.7	15	1.8	1.5	.0	.0	30	9	0	31.0	6.8	3		

Taken from: "Chemical Character of Surface Waters of South Carolina, 1945-1955" by G. A. Billingsley, Bulletin No. 16B, South Carolina State Development Board, prepared cooperatively by the Geological Survey of the U.S. Department of the Interior, Columbia, 1956.

The residual soil in the area is comparatively impermeable, particularly in late winter and early spring when the soil is saturated, and much of the precipitation goes into direct surface runoff. The residual soils do accept some water and the area is underlain by a water table which is a subdued replica of the topography. Groundwater is not an important source of water supply in the area; all neighboring towns obtain their municipal supplies from streams. There are some 30 domestic and farm wells in the general area of the plant. Most are hand dug and are equipped with a bucket or jet pump. They are, for the most part, from 40 to 60 feet deep and yield less than 5 gallons per minute. A few drilled wells in the area obtain a little water from fractured bedrock but the most important source of groundwater is in the residual soil, which locally is as deep as 100 feet. The largest groundwater installation in the area is at the Keowee High School, 4 miles west of the site, which is supplied with water from a battery of eight wells.

The temperature of the well water varies from 46° to 59°F, although most of the readings are between 50° and 53°F. The groundwater is slightly acid, having a pH of from 5 to 6. No chemical analyses of the groundwater are available, but from the nature of the terrain it is reasonable to assume that it is a bicarbonate water with low total dissolved solids and of excellent chemical quality.

From measurements of the permeability of the residual soil, the rate of movement of the groundwater was calculated to be 150 to 250 feet per year. The residual soil has excellent ion exchange properties.

3. Meteorology

Available meteorological records include those from Clemson, South Carolina; the Greenville-Spartanburg Weather Bureau Station; Athens, Georgia; and other nearby stations. In addition, an onsite meteorological survey was conducted from October 1966 to October 1967.

One principal meteorological influence on the site is its location relative to the nearby Appalachian Mountains, which cause a channeling of surface winds. The meteorology of both the site and of the region is therefore rather well known. As a result, the wind rose (Fig. II-6) is bimodal, with maximum frequencies in the sectors north-northeast to east-northeast and southwest to west.[2]

The site is located in a region characterized by a generally high frequency of low wind speeds and calms, i.e., of poor dispersion conditions (Fig. II-7).[4] The duration and frequency of calm and near-calm conditions for three nearby locations are tabulated by season in Table II-4.

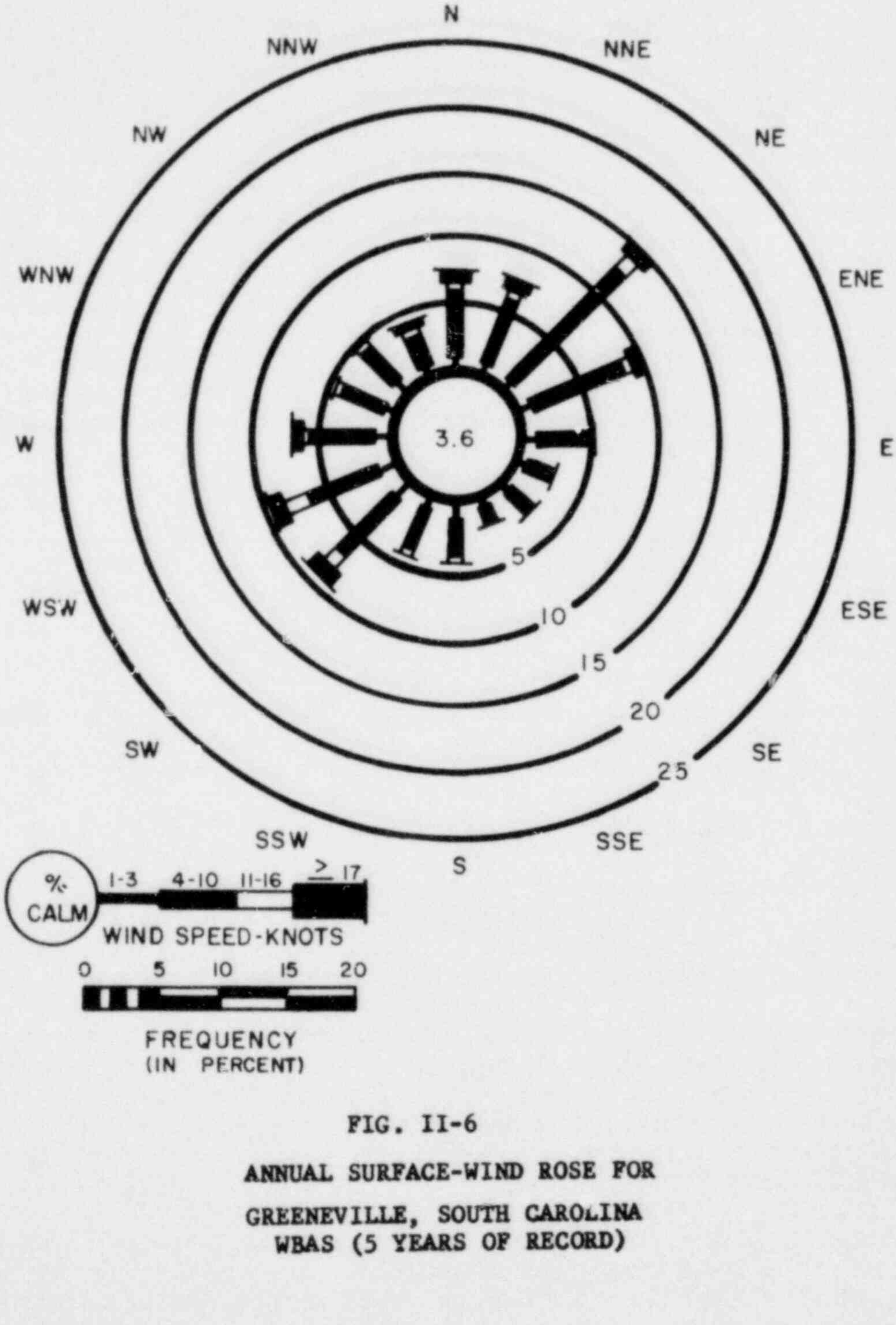


FIG. II-6

ANNUAL SURFACE-WIND ROSE FOR

GREENEVILLE, SOUTH CAROLINA
WBAS (5 YEARS OF RECORD)

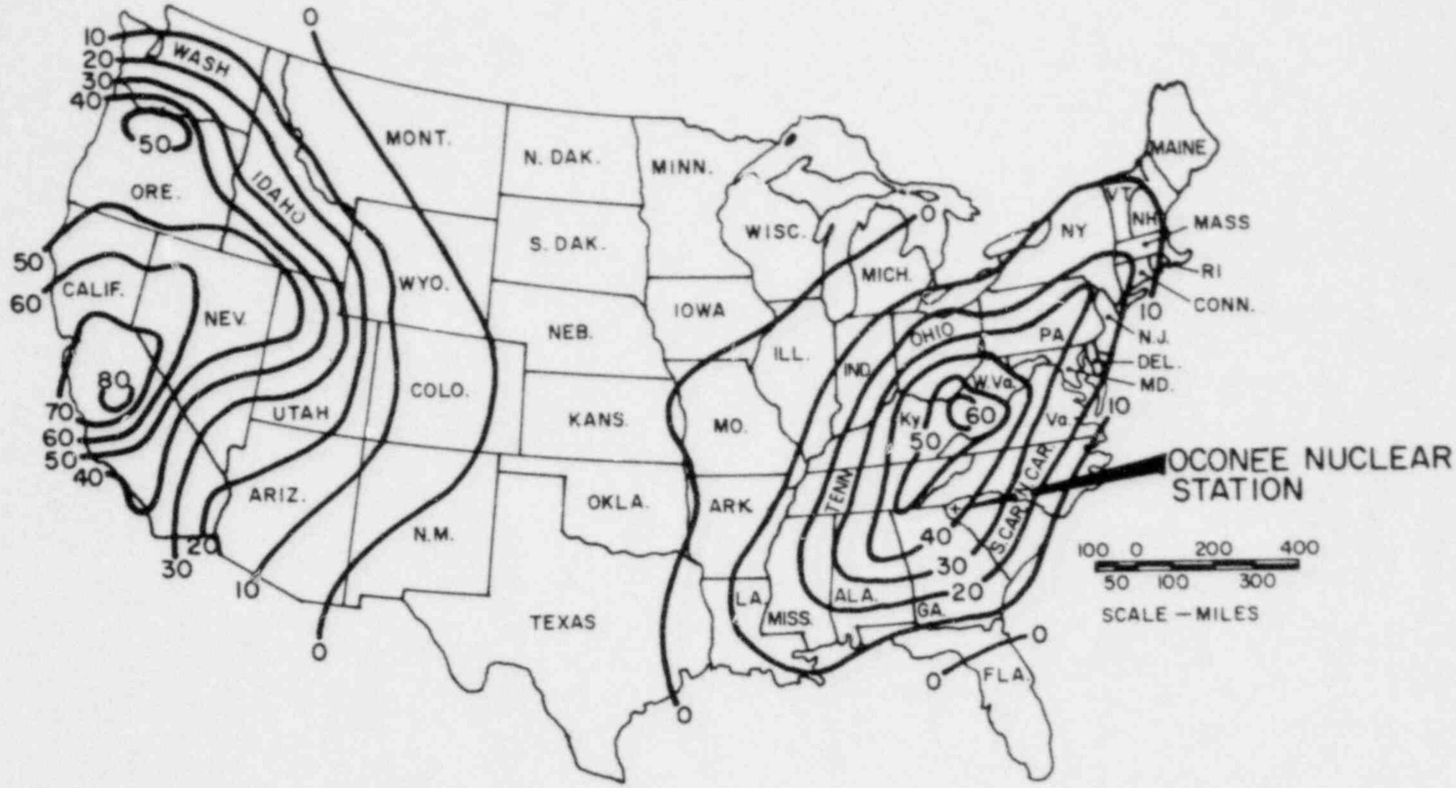


FIG. II-7

FORECAST OF HIGH-POLLUTION-POTENTIAL

DAYS IN THE UNITED STATES

ıble II-4

DURATION AND FREQUENCY (IN HOURS) OF CALM AND NEAR-CALM WINDS

..GE OF THREE LOCATIONS*

(1/59 - 12/63)

A. Calm Conditions: Calm at all locations

Duration (Hours)	Winter	Spring	Summer	Fall	Annual
01-05	74.2**	70.4	94.7	92.5	331.8
06-11	3.9	3.4	5.9	6.9	20.1
12-17	0.3	0.3	0.8	1.3	2.7
18-23	0.0	0.0	0.1	0.3	0.4
24-29	0.0	0.0	0.0	0.0	0.0
30-35	0.0	0.0	0.0	0.0	0.0
36-41	0.1	0.0	0.0	0.0	0.1
Total					355.1

B. Average Wind Speed 1 Knot or Less

Duration (Hours)	Winter	Spring	Summer	Fall	Annual
01-05	76.2	74.5	98.9	95.6	345.2
06-11	4.0	3.5	6.1	7.1	20.7
12-17	0.3	0.3	0.8	1.3	2.7
18-23	0.0	0.0	0.1	0.3	0.4
24-29	0.0	0.0	0.0	0.0	0.0
30-35	0.0	0.0	0.0	0.0	0.0
36-41	0.1	0.0	0.0	0.0	0.1
Total					369.1

*The three locations were Charlotte WBAS, Winston-Salem WBAS, North Carolina; and Greenville WBAS and Greenville-Spartanburg WBAS, South Carolina.

**Hours per season or hou-, per year as appropriate.

To avoid any uncertainty about onsite conditions, the applicant conducted a series of diffusion experiments at the site, in order to verify estimates of the atmospheric dispersion under the worst dispersion conditions. Results from these experiments are given in Table A-II-1 and are the basis for Tables A-II-2 through A-II-7 in Appendix II-1.

The site is subject to severe weather events but is in this respect not unusual for the area. High winds (over 50 miles per hour) can occur in any month of the year, but damaging extremes are rare. The site is sufficiently far inland so that tropical storms, which affect the area several times per year, have winds that are reduced well below hurricane level by passage over land. Associated rainfall amounts, however, may be large. Stations within a 50-mile radius of the site have reported rainfall of up to 20 inches in a 24-hour period.

Tornadoes are comparatively rare in this area but have been observed. The PSAR[2] notes that five tornadoes with tracks long enough to plot occurred in Oconee County in the 50-year period ending in 1965. The mean number of thunderstorm days per year is approximately 60.

In summary, the meteorology is governed mainly by proximity to the Appalachians. This channels the low-level winds and contributes to a generally slow surface air movement. Special meterological studies have verified the atmospheric dispersion for these conditions at the site. Severe weather events occur with the expected frequency for the general area.

4. Geology[2]

The bedrock at the site consists of a banded biotite hornblende gneiss and granite gneiss. The surface of the gneiss has weathered unevenly, and the residual soils found at the surface grade down irregularly. Partly weathered but sound rock is found at depths of from 5 to 40 feet. Enough of this weathered material was excavated so that the foundations of the plant are on firm rock.

The site is in the southeastern Piedmont physiographic province. This northeastward-trending belt of ancient metamorphic rocks extends northward from Alabama east of the Appalachians, and in South Carolina it crosses the state from the fall line on the east to the Blue Ridge and Appalachian Mountains on the west. These rocks are generally recognized as being divided into four parallel northeast-southwest-trending belts in the Carolinas. From southeast to northwest these are the Carolina slate belt, the Charlotte belt, the Kings Mountain belt, and the Inner Piedmont belt. The site is in the northwestern (Inner Piedmont) belt.

The rocks of the site are geologically ancient and complex. Forces that folded and metamorphosed these rocks were associated with the formation of the Appalachian Mountains during the Appalachian Revolution, some 270 million years ago. These forces long since have died away and are no longer possible sources of earthquakes in this area. Faults and other lines of weakness dating from this Revolution may serve to locate present-day minor crustal movements which produce small earthquakes, and their location is of some importance. The most important is the Brevard fault zone that passes 11 miles northwest of the site. The design criteria for the Station, based upon earth shock considerations, took into account the nearest fault zone. Small earthquakes have been detected along this zone with intensities of IV to VI. On this scale of intensities, V and VI represent disturbances that can dislodge loose plaster, etc.; X, XI, and XII represent disturbances that are severely damaging. Epicenters for quakes (positions on the earth's surface directly above the maximum disturbance) are generally in fault zone areas. Besides the Brevard fault there are fault zones 30 to 200 miles southeast where quake intensities of VII or VIII have been recorded; because of their distance, these zones are of slight importance for the Station. By far the largest quake in this general area was the Charleston, South Carolina, earthquake of 1886, that had an intensity at the epicenter of X. This quake was felt over a wide area but was destructive only in the vicinity of the epicenter, 200 miles from the plant. No faulting was observed in connection with this shock; although the bedrock at Charleston is covered with a thick deposit of coastal plain sediment, and faulting might not show.

F. ECOLOGY OF THE SITE AND ENVIRONS

The biota of the Keowee-Toxaway area are tabulated in Appendix II-2. In the part of the Keowee-Toxaway project that was inundated by Lake Keowee the biota was similar to the biota that at present dominates the area surrounding the lake, except that previously more streams and stream-side communities were present.

The Southern bald eagle is the only endangered species that may inhabit the project area.[5,6] A salamander, Plethodon jordani clemsonae, has been found only in the Jocassee area at elevations of 1200 to 1500 feet. A filmy fern, Hymenophyllum tunbridgensa, is found only on Estatoe Creek in Pickens County, in the upper reaches of Jocassee Reservoir along the creek banks.[7]

Forestry production of the region affected by the Keowee-Toxaway Project is summarized in the text and tables of Appendix II-3. Two forest types extending into the Jocassee headwaters region from North Carolina are the intermediate deciduous forest which occupies the upland and mountain slopes and the intermediate hemlock-hardwood forest found principally along the upper river banks and sheltered coves. Pines are more common than other softwwods (red cedar and hemlock) in the relatively high counties (Oconee and Pickens) straddling the Keowee-Toxaway Project (Table A-II-15 and A-II-16). Pine types exceed hardwoods in the South Carolina Piedmont region (Table A-II-17).[8]

Oak-pine and oak-hickory forest types form a mosaic with cleared land and pines throughout the applicant's service area. Major commercial forest species typical of this area are summarized in Table A-II-19. Yellow (loblooly, shortleaf, virginia) pines are predominantly of small diameter and occur in plantations and naturally invading off-field stands. Hardwood stands include many large trees of special interest for both lumer production and nature conservation. (For further discussion see Appendix II-3). A relatively detailed listing of trees and understory plants of the Keowee-Toxaway area is available.[9] Some other unusual plants known to occur locally include (1) a pennywort (Hydrocotyle americana); (2) a sundew (Drosera rotundifolia); (3) mountain camellia (Stewartia ovate); (4) a milkwort (Polygala incarnate), which is rare outside the coastal plain. Oconee bells (Shortia galacifolia) are found principally in many coves in the upper reaches of the project. A stand of virgin timber, which includes 18 species of trees indigenous to the Appalachian area, has been set aside, along with 15 acres, as the Coon Branch Natural Area.

A list of bird species associated with the intermediate deciduous forest and the intermediate hemlock-hardwood forest has been compiled[10,11] (Table A-II-8). Most of these birds are found also in the Keowee-Toxaway area. Additional populations of migrant species of birds are present in the region in spring and autumn.

Populations of diving and swimming birds (ducks, geese, grebes, etc.) on Lake Keowee apparently are not yet large judging from our site observations and information from applicant personnel, and the populations of these birds may continue to be small unless plankton production increases or considerable emergent vegetation appears. A few shorebirds and wading birds were seen around Lake Keowee, and at least small populations of these birds can be expected to utilize the margins of the lake.

We compiled a list of probably mammalian species[12,13,14] present in the area (Table A-II-9), but since no mamalian inventories have been carried out by the Duke Power Company or its consultants we cannot confirm that all of these species are present. Similarly, we are not aware of inventories for local species of amphibians, reptiles, invertebrates, or other fauna. We prepared lists of possible species in families of these animals, but since specialized habitats are required for some species, many that are listed may not be found in the Keowee-Toxaway (Tables A-II-10 and A-II-11).[15,16]

Keowee and Jocassee Lakes were impounded only recently, and it is perhaps too early to expect comprehensive listings of typical lake biota or population data to be available as base lines for documenting later changes. It is common for newly created reservoirs to be relatively more productive in their early years and to reach a level of less productivity as aging occurs. Natural successional changes in the abundance of organisms are probably due to morphological changes, such as increased bottom area, as well as to increases in available nutrient supply.[17] Adequate sampling is necessary to delineate between natural changes through time and those induced by the addition of heat or chemicals to the systems in question.

A list of fish species and population data from studies during 1968-1969 was compiled (Tables A-11-12 and A-II-13), but no information was available to us on phytoplankton, emergent or floating macrophytes (macroscopic vegetation), zooplankton, aquatic invertebrates, etc. A systematic inventory of aquatic biota should be under way or should be started immediately so that possible effects of the hydroelectric-nuclear power complex can be studies for these aquatic ecosystems, which will be going through a rapid ecological succession. For a discussion of the life history of the fishes of Lakes Keowee and Hartwell and of general lake biology, see Appendix II-4.

A predictive model of the fish crop in Lakes Keowee, Jocassee, and Hartwell has been developed which utilizes chemical and physical parameters compiled from data taken on United States reservoirs.[18] The possible effects of reactor operation or water level fluctuation resulting from pumped storage operation are not taken into account in the model. Twenty years after impoundment, the total standing crop is predicted to be about 90 pounds per acre for Lake Keowee (Fig. II-8). Although shad are predicted to be about 30 pounds per acre, members of the Clupeidae family have thus far been absent from samples taken by the South Carolina Wildlife Resources Department.[19] The game fish (centrarchids, catfish, walleye, etc.) are expected to total 40 pounds per acre, while the remaining 20 pounds per acre will be primarily carp and suckers. The Clupeidae serve as an important forage item in the food chain, and it is assumed, since they have been stocked in Lake Hartwell and other South Carolina lakes, that they will also be introduced into Lakes Keowee and Jocassee. Lake Jocassee is expected to support a total standing crop of about 55 pounds per acre after 20 years. Of this crop, shad are predicted to make up about 16 pounds per acre, and game fish about 19 pounds per acre, and other fishes (carp, etc.) 20 pounds per acre.

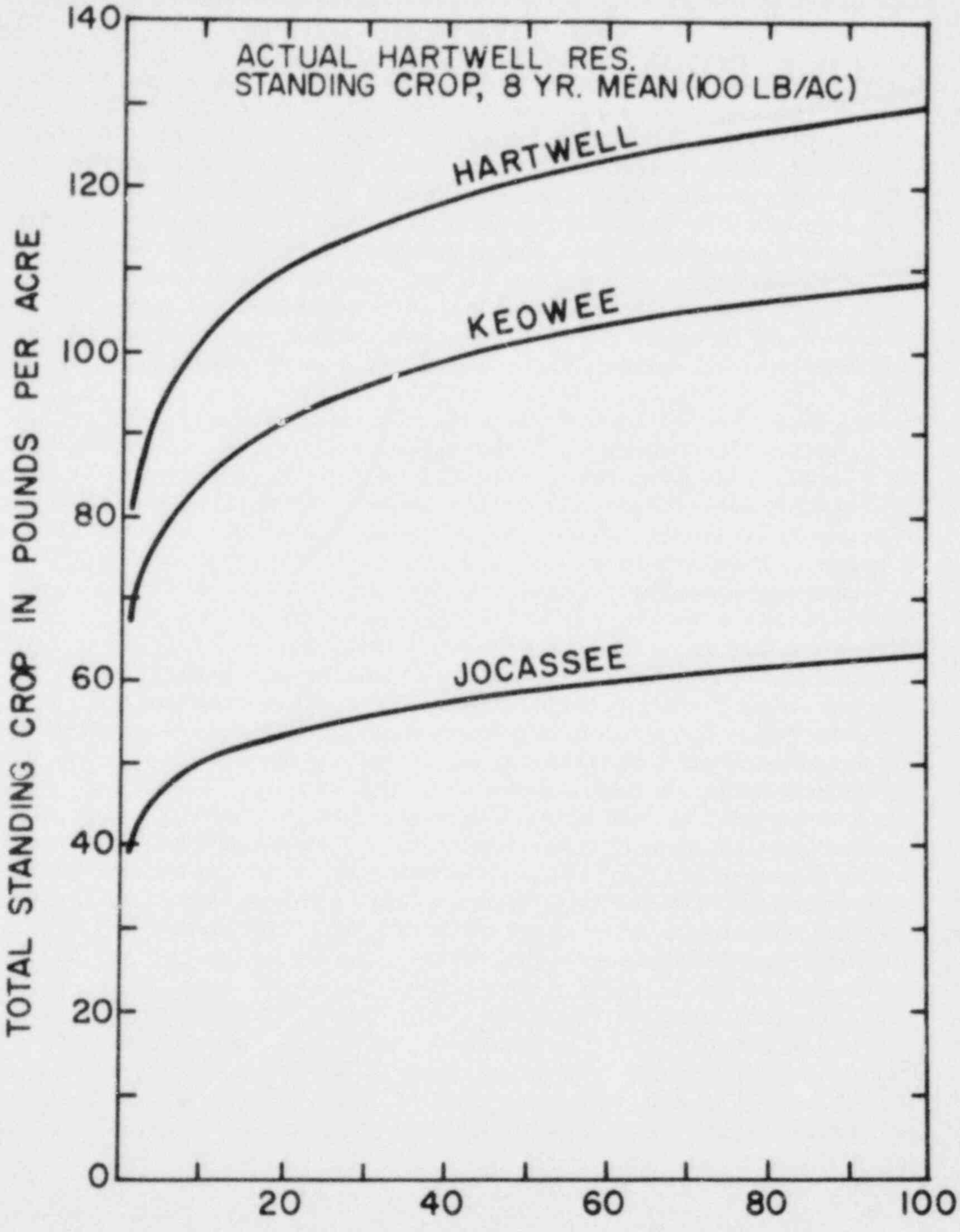


Fig. II-8. Predictions of total standing crop of fish in Lakes Keowee, Jocassee, and Hartwell through 100 years of impoundment. From Robert M. Jenkins, "Estimation of Fish Standing Crop, Sport Fish Harvest and Angler Use for Keowee and Jocassee Reservoirs, in Duke Power Company's Keowee-Toxaway Project, Oconee and Pickens Counties, South Carolina," U.S. Department of the Interior, Division of Fishery Research, National Reservoir Research Program, February 4, 1972.

Predictions of the total sport fish harvest are shown in Fig. II-9. Fishing for game fish is usually excellent during the first few years after impoundment of a reservoir, because the high organic matter in the flooded basin results in a high total reservoir productivity. The game fish harvest usually declines as natural succession causes a shift from game species to predominancy by rough fish. Reservoir angler harvest usually peaks in the third of fourth year. A decline in harvest follows, with secondary harvest peaks irregularly spaced in subsequent years.[18] When combined with ample field data, these predictions should serve as an adequate base line upon which natural and artificial effects can be analyzed.

Hartwell Reservoir will receive the chemical and radionuclide discharges from Oconee Nuclear Station and will be affected by the thermal release. Biological information presently available for this reservoir is limited to fish population studies by the South Carolina Wildlife Resources Department (Table A-II-14). No information on phyto- and zooplankton is available; benthic organisms have not been inventoried.

In the Department of the Interior comments (February 18, 1972), concerning the draft statement on the Oconee Nuclear Plant, referemce was made to the Bureau of Sport Fisheries and Wildlife supplying biota lists for terrestrial and aquatic species. Data received from the Interior personnel consisted of an inventory of fish species in Lake Keowee that had been compiled by a member of the South Carolina Wildlife Resources Department. Subsequently, it became apparent that the type of data required was not available so we compiled biota lists. Copies of these lists were sent to members of the Zoology Department at Clemson University, and their comments are reflected in the listings found in the Appendix II-2 tables.

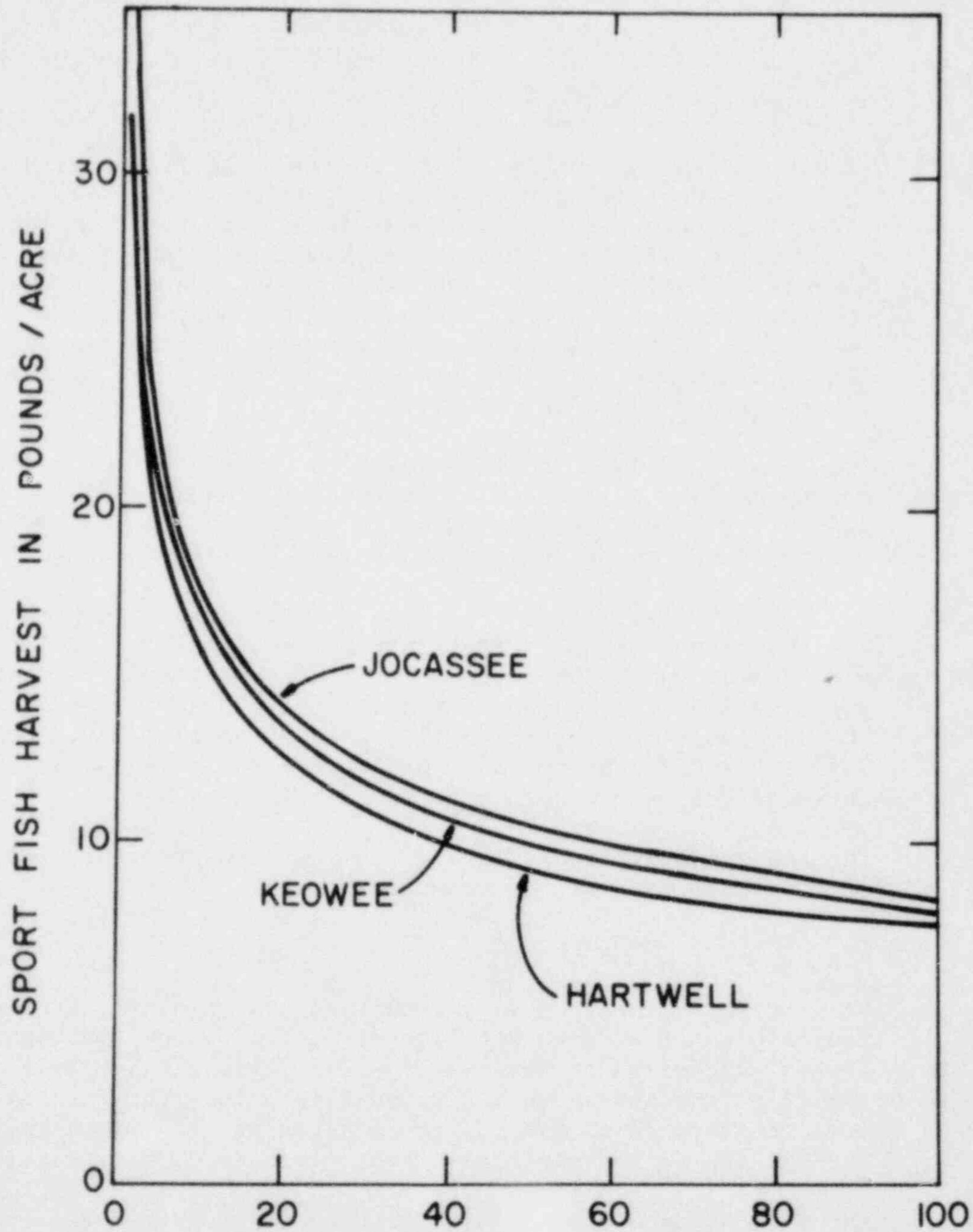


Fig. II-9. Predicted sport fish harvest in Lakes Keowee, Jocassee, and Hartwell through 100 years of impoundment. From Robert M. Jenkins, "Estimation of Fish Standing Crop, Sport Fish Harvest and Angler Use for Keowee and Jocassee Reservoirs, in Duke Power Company's Keowee-Toxaway Project, Oconee and Pickens Counties, South Carolina," U.S. Department of the Interior, Division of Fishery Research, National Reservoir Research Program, February 4, 1972.

III. THE PLANT

A. EXTERNAL APPEARANCE

Because of the surrounding hilly terrain and its particular situation, the Oconee Nuclear Station is not readily visible for any great distance along main roads or from any population center. From the approach along highway S.C. 130, the location of a nuclear plant is advertised by an elevated spherical water tower with decorative rings representing a nucleus and electron orbits. On the hill nearby is a microwave relay tower with weather instruments. The buildings housing the reactors and turbines are partially hidden from the highway by the intervening higher ground (see Fig. III-1).

The paved road into the site leads to a Visitors' Center building of modern design, surrounded by appropriate landscaping as shown in Fig. III-2. The Visitors' Center is situated on a hill, with wide views of the lake and the buildings and switchyards of the nuclear station.

As shown in Fig. III-1, the three reactor buildings are cylindrical concrete structures 125 feet in diameter, and about 200 feet high with domed tops. There are no tall stacks; gases are vented from pipes adjacent to and about the same height as the reactor buildings. The 900-foot-long turbine building and a smaller administration building adjoin the reactor buildings. The switchyards are located on relatively low ground near the turbine building.

The transmission lines leaving the plant on the east side are the most obvious sign of the power network.

B. TRANSMISSION LINES

Power from the Station is transmitted via standard latticework transmission towers (about five per mile) to the applicant's network. A minor exception is the use of steel poles with upswept arms for two miles in suburban North Greenville. The transmission lines that are attributable to the nuclear station are listed in Table III-1. The routing in the vicinity of the plant is shown in Fig. III-3.

About 7800 acres of land will be used for right-of-way by the transmission lines required for the power plant. Of the land in Oconee and Pickens Counties, about 27% is farmland; the rest is woodland.

FIG. III-1

VIEW OF SITE OF OCONEE NUCLEAR STATION

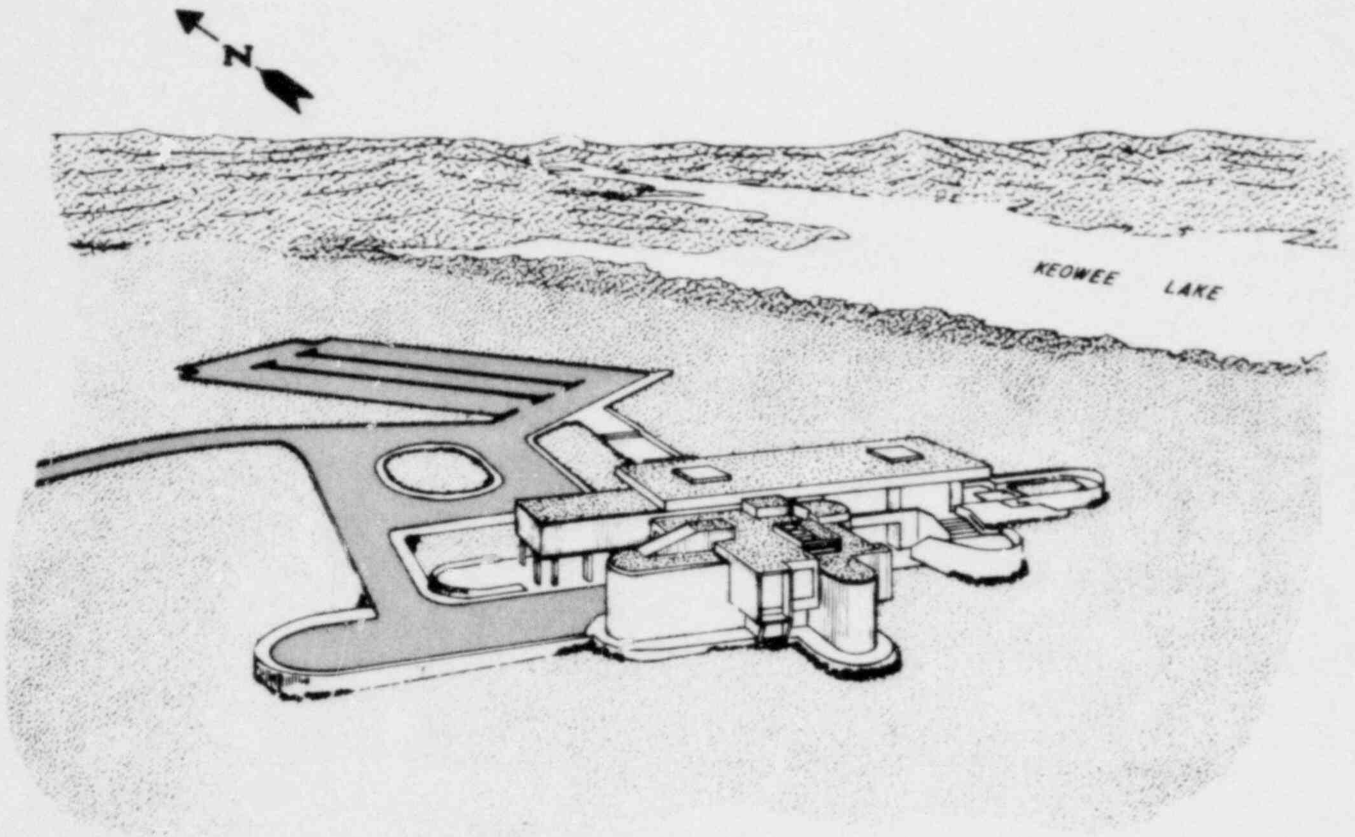


FIG. III-2

VISITOR CENTER AT OCONEE NUCLEAR STATION

Table III-1

Transmission Lines from Oconee Nuclear Station

Destination	Double or Single	kV	Distance (mi)	Width of Right of Way (ft)
Tiger	d	230	53	150
Central (2)	d	230	9	270
Site H*	s	500	130	200
Newport*	s	500	110	200
N. Greenville	d	230	28	200

* These lines are expected to be completed in 1973 or 1974. The entire distance of the lines to Site H and Newport is charged to the Oconee Plant.

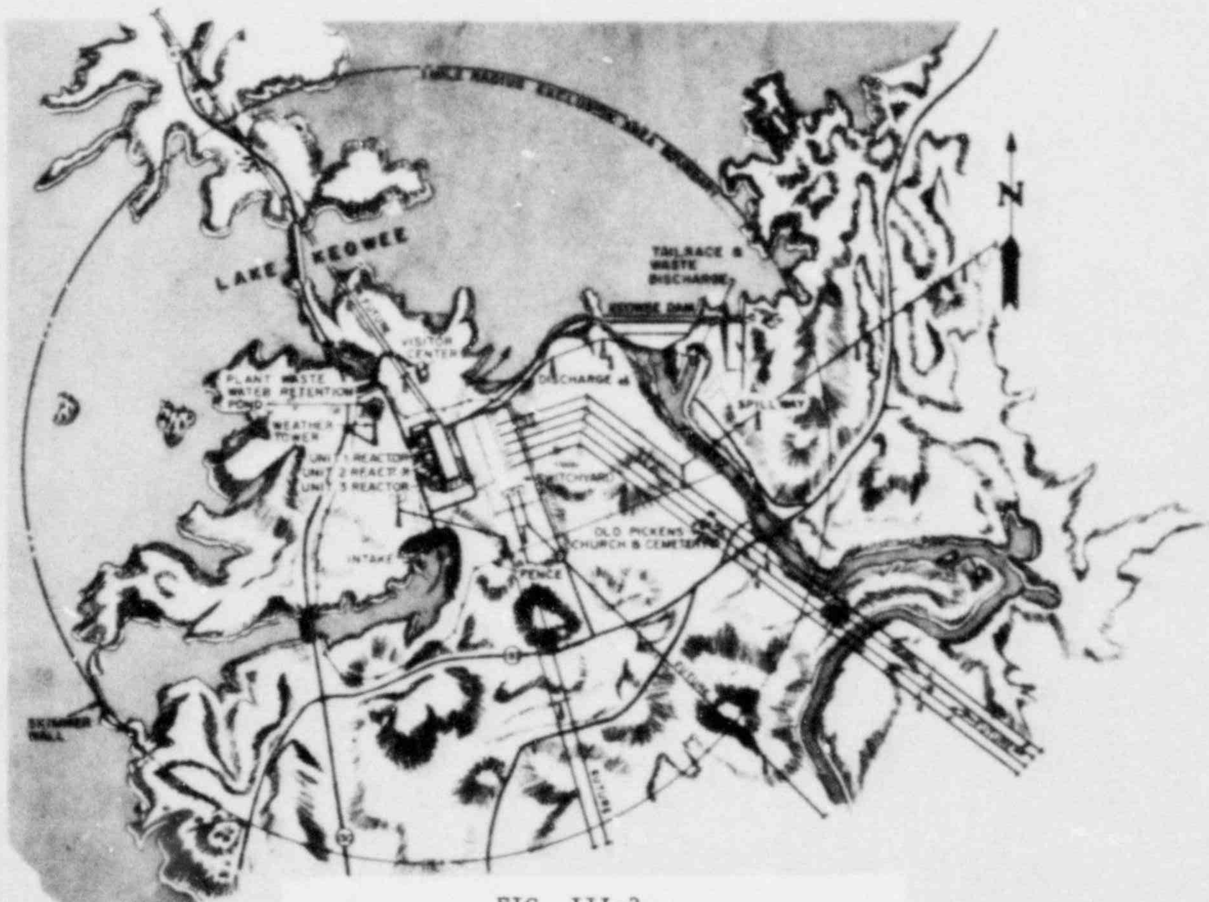


FIG. III-3

POWER TRANSMISSION LINES AT

OCONEE NUCLEAR STATION SITE

C. REACTOR AND STEAM-ELECTRIC SYSTEM

1. Nuclear System

The three units of the Oconee Nuclear Station will be essentially identical. Each will consist of a pressurized water reactor producing steam to drive a turbine-generator. Figure III-4 is a simplified diagram of one unit. A fairly detailed description of the nuclear steam system has been published. [1] One of the reactor units is described below.

The uranium fission chain reaction will occur only in the reactor core, a 12-foot-high close-packed array of fuel assemblies inside the reactor vessel. Each of the 177 assemblies will contain 208 fuel rods, consisting of cylindrical pellets of uranium oxide sealed within zirconium alloy tubes. The rate of the chain reaction will be controlled by neutron-absorbing metal rods that can be moved into or out of the core. Heat produced within the fuel rods will be transferred into water (actually a dilute boric acid solution) that will circulate up through the core. The boron concentration in this primary coolant will be changed as necessary to adjust ("shim") the reactivity of the core. (Boron readily absorbs neutrons.)

When the reactor is operating at full power, heat will be produced at a rate of 2568 megawatts. Primary coolant water will leave the reactor vessel at 604°F and 2200 pounds per square inch; this pressure is high enough to prevent boiling on the fuel rods. The pressure is maintained by electrically heating a sidestream of water to the boiling point in a vessel called the pressurizer. A small amount of hydrogen gas is added to the pressurizer to aid in the recombination of any water decomposed by radiation in the fuel region. The hot primary coolant will pass through tubes in a steam generator, where it will transfer heat to water (secondary coolant) on the outside of the tubes. The pressure will be lower in the secondary system, and the water there will be converted to superheated steam at 570°F and 900 pounds per square inch. This steam will pass through a turbine, driving a shaft connected to a generator which will produce electricity at a rate of 922 megawatts. (About 36 megawatts will be used within the plant, leaving a net electrical output from each unit of 886 megawatts.)

In its passage through the turbine, the steam will expand and cool until it leaves as vapor at 80° to 100°F and at subatmospheric pressure. This vapor will be very pure water, which must be recycled. Recycling will require that the vapor be condensed to liquid water so that it can be pumped efficiently. Condensation will take place on the outside of tubes cooled by lake water being pumped through them. For each

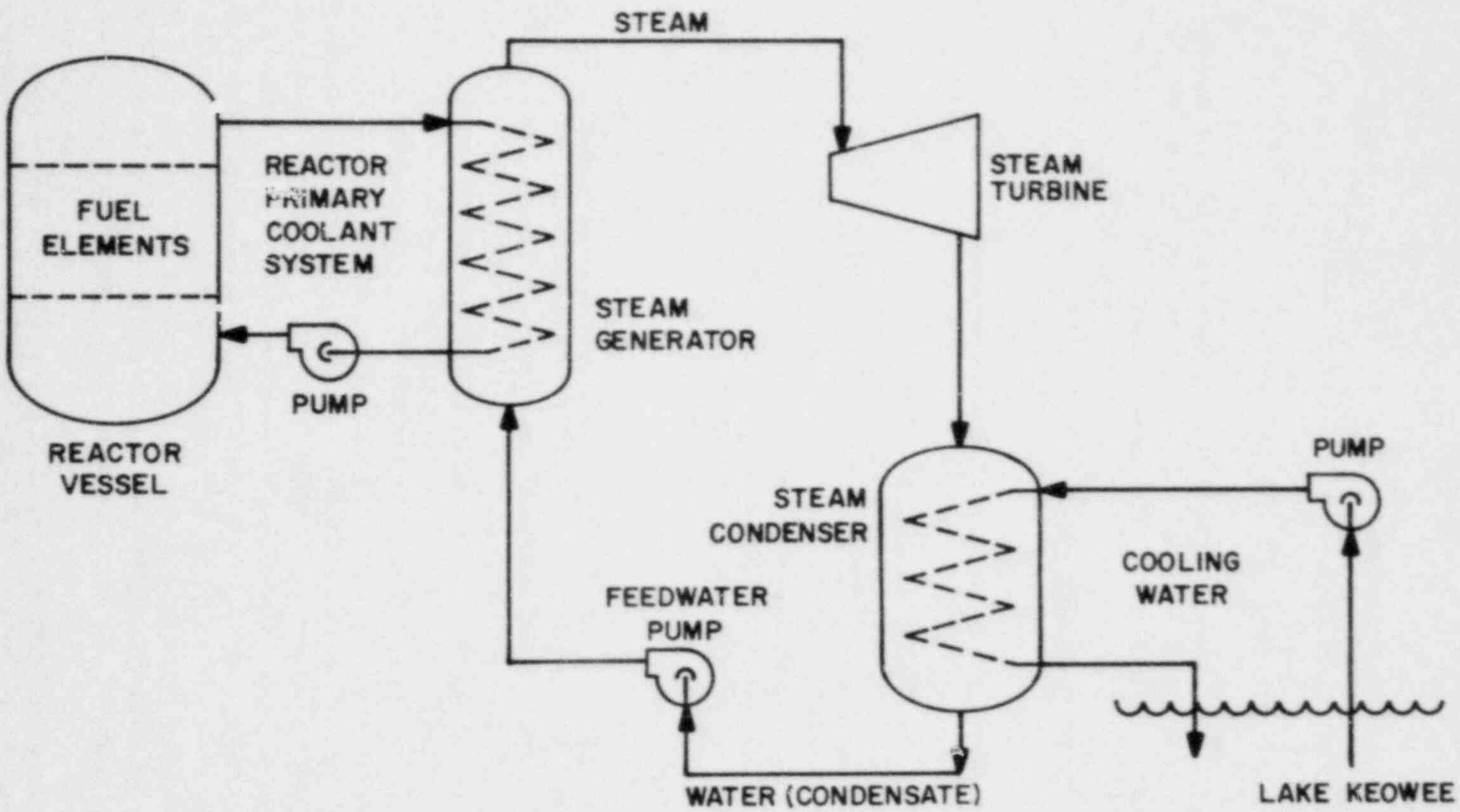


FIG. III-4

SCHEMATIC FLOW DIAGRAM OF HEAT-REMOVAL

SYSTEM AT OCONEE NUCLEAR STATION

reactor unit, heat will be transferred from the condensing vapor to the cooling water at a rate of about 1650 megawatts.

Radiation emitted directly from the fission process will be absorbed in the reactor vessel and in the thick concrete shielding surrounding the vessel. The radioactive products of uranium fission will be almost entirely confined within the sealed fuel rods, but some may appear in the primary coolant because of leaks in a very small fraction of the 36,816 fuel rods. Part of the tritium generated in the fuel will diffuse through the cladding into the primary coolant, but more tritium will be produced directly in the coolant by reactions of neutrons with the dissolved boron. The primary coolant will also contain some corrosion products that have become radioactive by exposure to neutrons in the core. The secondary coolant (steam) will not become radioactive unless there is some inleakage of primary coolant to the secondary system in the steam generators. The reactor and primary coolant system for each unit will be housed in a cylindrical containment building, of reinforced concrete, designed to minimize the escape to the environment of any leakage from the primary system. Treatment of the primary coolant to remove corrosion and fission products and the handling of leakage are described later in the section on the radioactive waste system.

Each unit will be shut down periodically, and the reactor vessel will be opened for replacement of fuel assemblies in which the uranium has been depleted.[2] Spent fuel assemblies will be transferred under water to a storage pool in a building adjoining the reactor containment building. After the radioactivity has diminished, the spent assemblies will be sealed in casks and transported offsite.

The units are generally similar to other pressurized water reactors currently under construction or already in operation. The Babcock and Wilcox Company is responsible for the design, manufacture, and delivery of the nuclear steam supply systems, the nuclear fuel, and the auxiliary and engineered safeguard systems. Babcock and Wilcox also provides technical direction of the erection of this equipment, assistance in operator training, and consultation for initial fuel loading, testing, and initial startup of each of the three units. The applicant is responsible for all other aspects of construction and startup and is also responsible for the coordination, scheduling, administrative direction, and operation of the power station once it becomes operational. The Bechtel Corporation is serving as a general consultant to the applicant to provide such engineering assistance as is needed during the design and construction of the Station.

2. Hydroelectric System

The hydroelectric plant at Keowee Dam has an inlet at 735 feet above mean sea level. A weir, upstream from the dam, restricts the flow of water from the main body of the lake to that above 765 feet. The connection to the two turbines is a 33.5-foot diameter tunnel. At full flow of 19,800 cubic feet per second, the velocity of water in the tunnel will be about 22.5 feet per second. The total rated capacity of the two equal units is 140 megawatts.

The hydroelectric plant at Jocassee Dam has an inlet at 1043 feet above mean sea level. The connections to the four turbines consist of two 33.5-foot-diameter tunnels. At full total flow of about 29,000 cubic feet per second the velocity of water in the tunnels will be about 16.5 feet per second. The total rated capacity of the four equal turbines is 610 megawatts. These four turbines at Jocassee are reversible and can be used to pump water back into Lake Jocassee at times of low power demand. Under this latter condition the total flow will be 26,000 cubic feet per second and the velocity in the tunnels will be 14.7 feet per second.

The Keowee Dam hydroelectric plant will be operated with a plant factor of about 5% (normally one or two hours each weekday). The stream bed of Hartwell Reservoir just below Keowee Dam is at 655 feet above mean sea level, i.e., 5 feet deep at the Keowee Dam, but during operation of the Keowee Dam hydroelectric station, the levels in the receiving stream will rise substantially. These levels are (for normal lake levels).

Distance from Keowee Dam (feet)	2400	9800	23000
Hartwell Headwater Level at Full Discharge (feet above mean sea level)	671.6	667.0	661.4

The Jocassee Dam hydroelectric station will be operated with a plant factor of about 14%. The lake bed level of Keowee at the Jocassee Dam is about 735 feet above mean sea level. This gives a normal depth of 65 feet at this point. As a result, the effects of operating the Jocassee hydrostation and the water level in the discharge area will be less noticeable than at Keowee dam.

The lake levels will fluctuate due to operation of the hydroelectric stations. Limits on this fluctuation are set at 3 feet for Keowee and 6 feet for Jocassee. These limits apply to a weekly cycle of generation-pumping operation during extended drought. The maximum daily fluctuation that is expected is 1.8 ft for Keowee and 3.6 ft for Jocassee.[3]

D. EFFLUENT SYSTEMS

1. Heat

a. General

Any steam-electric generating plant must discharge into the environment a large fraction of the heat that is produced by burning or fissioning fuel. Each unit of the Station when at full power must dissipate about 1650 of the 2568 megawatts of heat being produced. This discharge of heat cannot be avoided or, for present-day power reactors, significantly reduced. The waste heat at the Station is transferred into the waters of Lake Keowee. (In fact, the potential for doing this was the primary reason for the choice of the site and the creation of the lake.)

b. Water Flow

The relationship of the lake and the condenser cooling water intake and discharge is shown in Fig. III-5, which also shows typical lake surface temperatures expected, with the addition of thermal discharges from the station.[4] Water is taken from the Little River arm of the lake and discharged just above the dam on the Keowee River arm. It is nearly 2 miles by lake from the point of discharge to the mouth of the intake canal. More details of the intake are shown in Fig. III-6. A natural cove was deepened and extended to within a few hundred feet of the power plant. Across the mouth of the cove a skimmer wall was constructed extending from above the surface of the lake (normally 800 feet above mean sea level) down to an elevation of 735 feet. This wall insures that cooler water from near the bottom of the lake, enters the intake canal. The water velocity under the skimmer wall will be about 0.6 feet per second at full flow. Further into the intake cove is a submerged dam, or weir, with its crest at 770 feet above mean sea level. This will retain enough water in the intake canal to provide ample condenser cooling for an orderly shutdown of the plant in the event that one of the Lake Keowee dams or dikes fails and the lake drains. (From the weir to the intake structure is nearly 3/4 mile.) The excavated portion of the intake canal is 100 feet at its bottom (elevation 760 feet). When the lake is full (surface elevation 800 feet) the maximum flow through the three condensers (see Fig. III-7) will produce a water velocity in the canal of less than 1 foot per second. At the most extreme drawdown that will be allowed (to 775 feet), the velocity

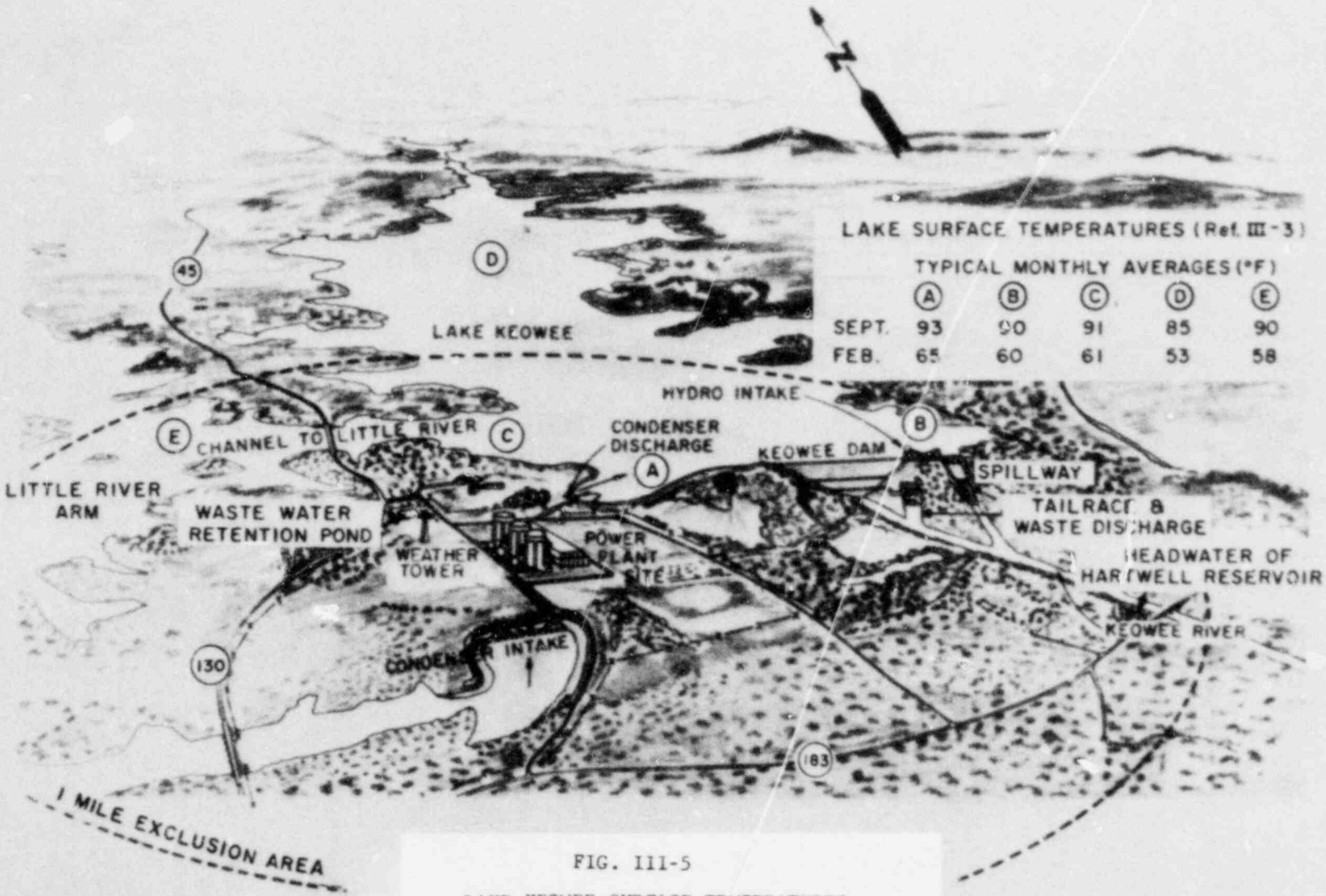


FIG. III-5

LAKE KEOWEE SURFACE TEMPERATURES

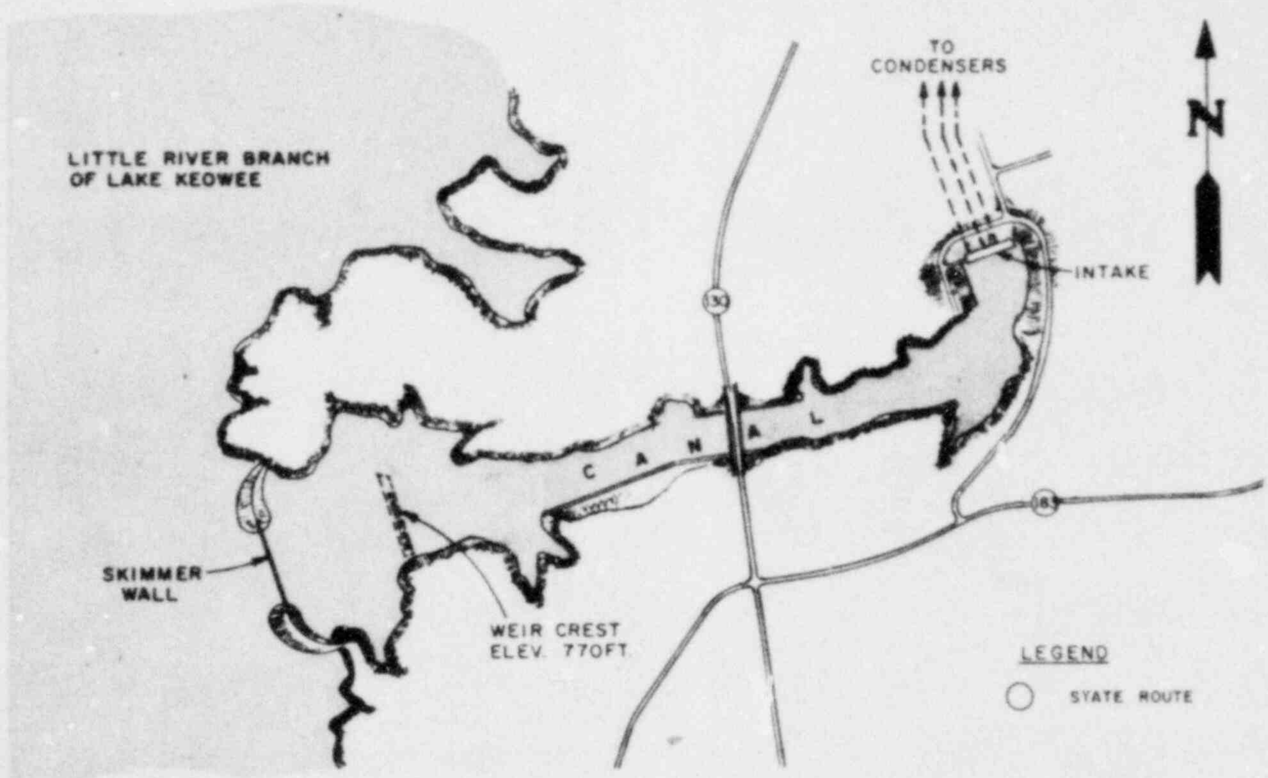


FIG. III-6

CONDENSER INTAKE CANAL AT

OCONEE NUCLEAR STATION

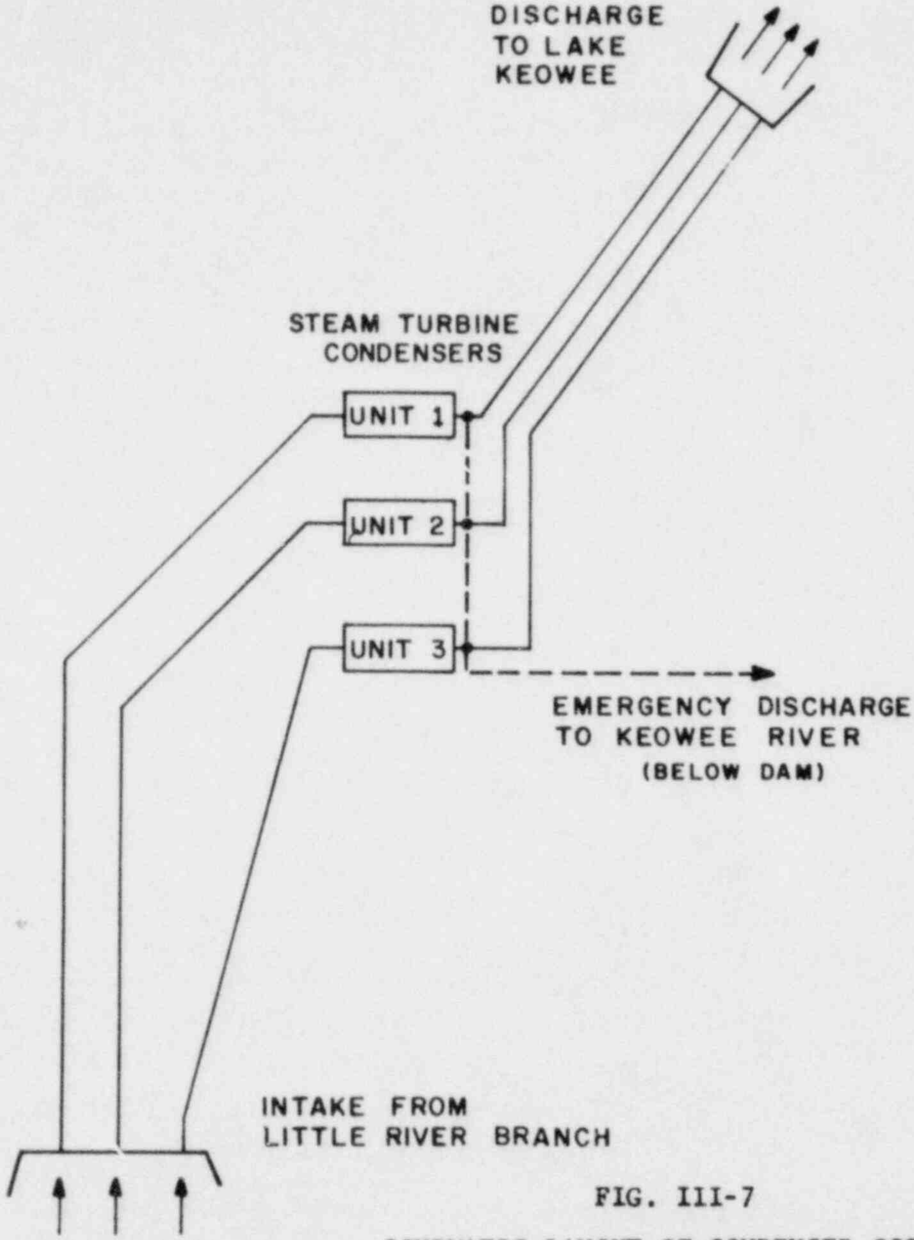


FIG. III-7

SCHEMATIC LAYOUT OF CONDENSER COOLING

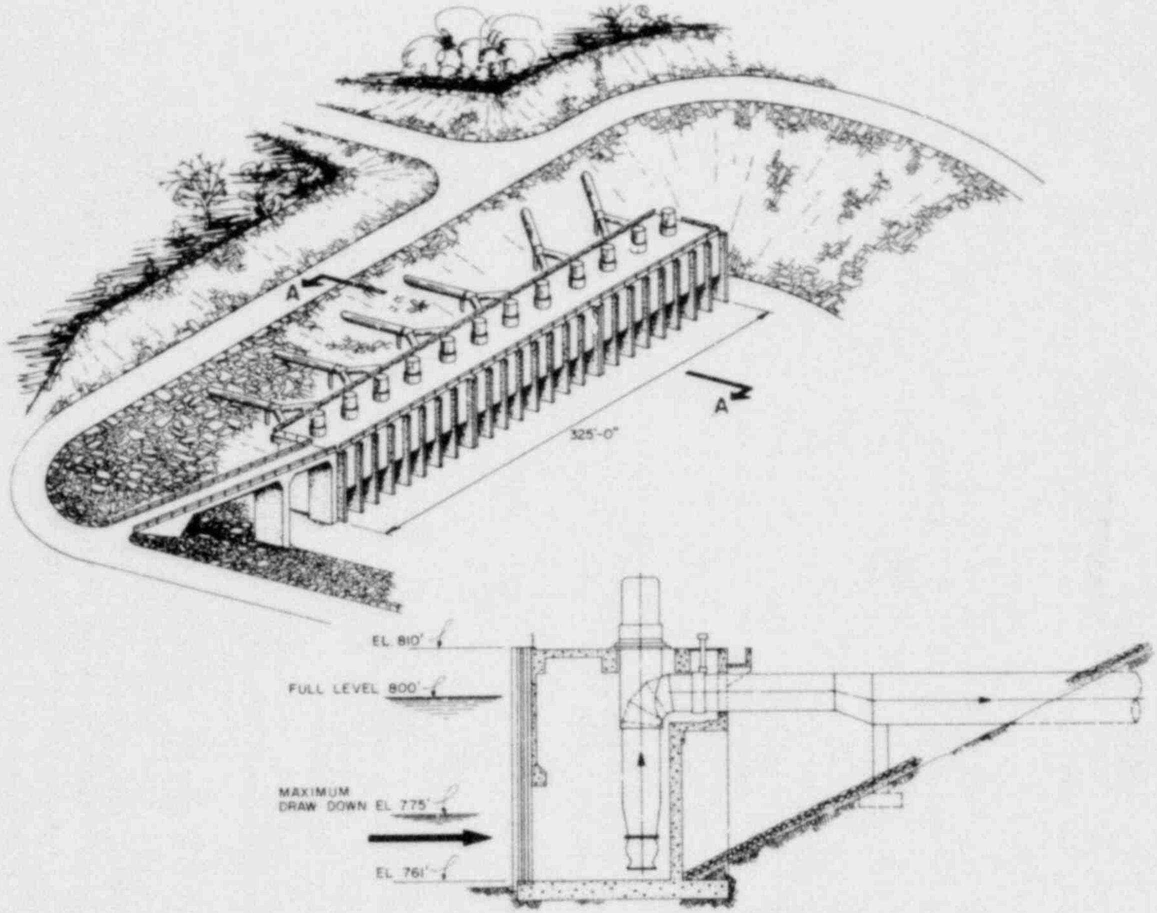
WATER LINES AT OCONEE NUCLEAR STATION

in the intake canal would reach about 3.5 feet per second, but at the screens, the velocity would still be less than 1 foot per second. The intake screens are stationary, of galvanized iron mesh with 3/8-inch openings. The intake structure is shown in Fig. III-8.

Each unit has its own condenser, supplied with water by means of four pumps, each delivering 177,000 gallons per minute (about 394 cubic feet per second). This gives a maximum possible flow from 12 pumps of 4500 cubic feet per second (1500 cubic feet per second per condenser). In addition, there is a 233 cfs service water flow. The temperature of the cooling water is expected to rise approximately 17.6°F through the condenser. Each condenser has about 50,000 tubes made of type 304 stainless steel, 0.875 inch in diameter and 44 feet long. Each of the three condensers will discharge cooling water through two pipes 11 feet in diameter. At the outlet to the lake, the discharge pipes exit through a discharge structure (see Fig. III-9). The six discharge pipes return water to the lake through individual rectangular openings that combine to form a common channel 15 ft by 80 feet. At maximum flow the water velocity at the exit channel would be about 4 feet per second.

It is approximately 2 miles, via the lake, from the condenser outlet to the skimmer wall at the inlet. Heated water from the condenser discharge will be lower in density and "float" at the surface. Since the skimmer wall restricts the intake to a maximum elevation of 735 feet, warmed water will not be "short circuited" through the condenser (see Fig. III-5).

In the event of a power failure, the reactors will be shut down, and cooling water from the condensers will automatically discharge through a 48-inch emergency line to the tailrace of Keowee Dam. The flow will be maintained by siphon action to cool the reactors on shutdown. Figure III-7 is a schematic layout of the condenser cooling water piping.

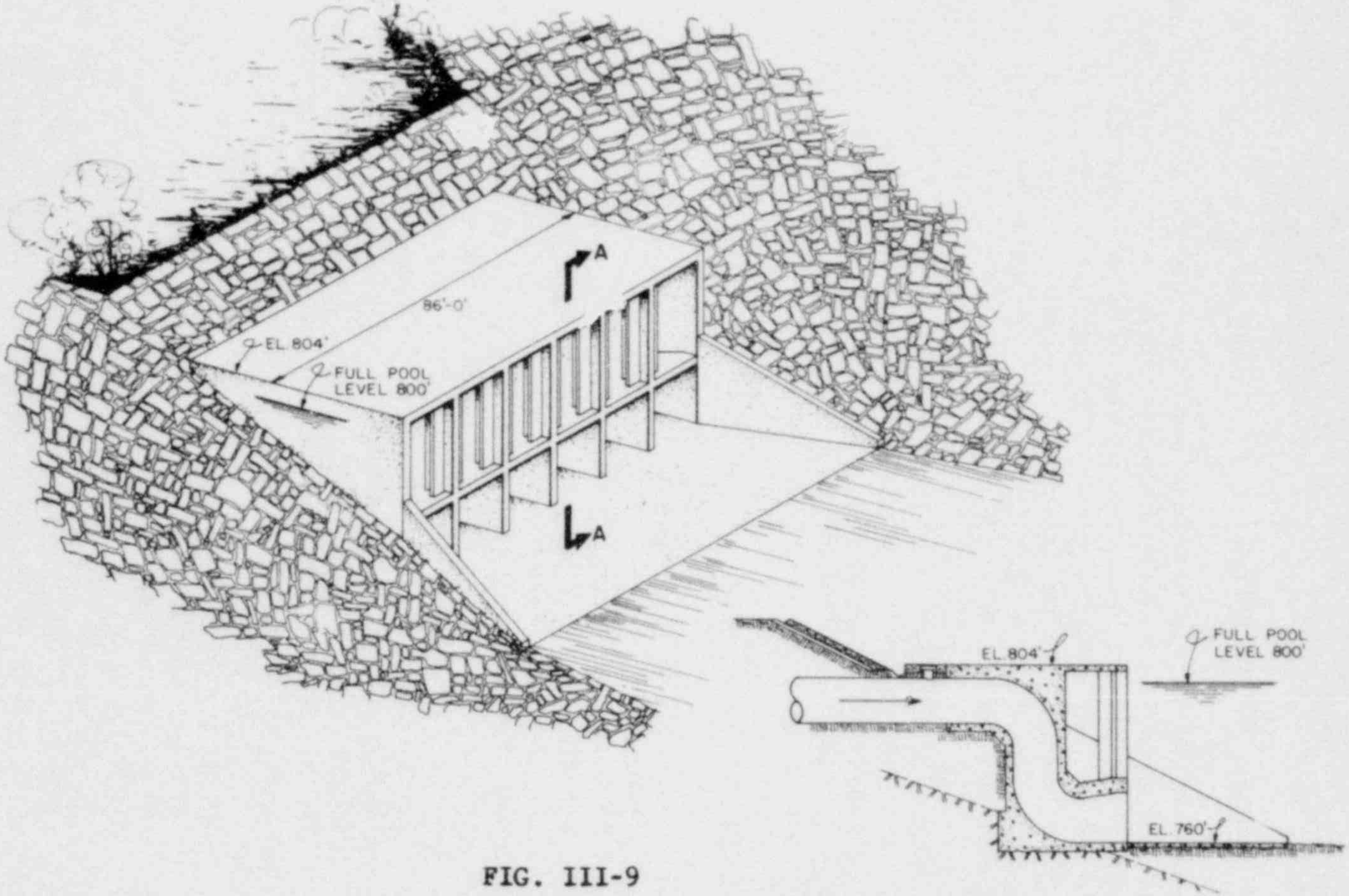


SECTION "A-A"

FIG. III-8

COOLING WATER INTAKE STRUCTURE AT

OCONEE NUCLEAR STATION



SECTION "A-A"

FIG. III-9

COOLING WATER DISCHARGE STRUCTURE AT

OCONEE NUCLEAR STATION

c. Temperature Effects

Three analyses have been conducted to determine the thermal discharge effects from the operation of the Oconee Nuclear Station. In each of these analyses, the effect predicted was based on the operation of all three units planned for the site. Therefore, the operation of less than three units would be expected to produce a smaller plume, affect less area, and have a smaller impact both on Keowee Reservoir and on Hartwell Reservoir.

Studies conducted to predict the effect of discharging heated water were performed by Velz[5] for the Department of the Interior, by the Duke Power Company, and by Oak Ridge National Laboratory for the Atomic Energy Commission. Each of these studies is discussed below, and the results are compared.

(1) The Velz Study

During winter, the heated water discharge plume will rise to the surface of the lake and dissipate its heat to the atmosphere (the ultimate sink for all the waste heat). In summer, the lake surface becomes warm, and the water tends to stratify into a warm dynamic surface (epilimnetic) layer and a cold static submerged (hypolimnetic) layer. The depth of each layer can only be estimated. In 1966, prior to impoundment of the lake, in a study prepared for the U.S. Department of the Interior[5] (hereinafter referred to as the Velz report), such estimates were made for Lake Keowee. The layers will vary depending on the time of year. From late spring to late summer, a temperature gradient of about 20°F should exist between the upper and lower waters in Lake Keowee. Table III-2 gives the condenser inlet temperatures, which are with the expected hypolimnetic temperatures.

The deep water intake allows the station to take advantage of the cooler hypolimnetic waters and discharge the heated water back to the lake. Much of the year, this means there will be little difference between the condenser water discharge temperature and the temperature of the receiving body of water (e.g., in June of a typical year, both the lake surface and condenser discharge temperatures will be about 80°F).

As the temperature of the water rises, the upper limit of dissolved oxygen (the saturation concentration of oxygen) will decrease, as shown in Table III-3. However, since the intake (hypolimnetic) water is generally below this limit, the expected rise in water temperature on passage through the condensers will not usually result in the liberation of oxygen from the lake water.

Table III-2. Condenser Temperatures--

Monthly Averages According to the Velz Report

Month	Inlet (°F)	Discharge (°F)
January	53.1	72.1
February	51.0	70.0
March	50.8	69.8
April	50.8	69.8
May	51.9	70.9
June	60.2	79.2
July	69.0	88.0
August	76.2	95.2
September	81.2	100.2
October	75.4	94.4
November	67.6	86.6
December	60.7	79.7

Source: C. J. Velz et al., "Waste Heat Dissipation in Stream, Ponds, and Reservoirs with Application to the Duke Power Company, Proposed Keowee-Jocassee Developments," prepared for U.S. Department of the Interior (1966), p. 80.

Table III-3. Solubility of Oxygen from an Atmosphere of 20.94% O_2 And 100% Relative Humidity in Water at Several Temperatures[a]

Temperature, °F	O_2, ppm
35	14.0
40	12.9
45	12.0
50	11.25
55	10.6
60	10.0
65	9.4
70	8.9
75	8.4
80	8.0
85	7.6
90	7.3
95	6.95
100	6.7[b]
105	6.4[b]
110	6.2[b]
115	5.9[b]
120	5.7[b]

[a]Interpolated from values of J. H. Carpenter, Limnol. and Oceanog. 11, 265-77 (1966).

[b]Extrapolated from Carpenter's values.

Details of the plume temperature profile would be highly variable, depending on the lake level, effects of reservoir geometry, and climatological factors. One extreme, proposed in the Velz report, should represent the most severe circumstance possible to encounter in normal operation of the system. This circumstance is the occasion of two consecutive years of low rainfall resulting in a severe drawdown of the lake to the lowest allowed level, 775 ft above mean sea level. In practice, it is unlikely that the lake would be drawn down close to 775 ft more often than once in 20 years. (See quotation from Velz report given later in this section.)

Usually the hypolimnetic layer is of sufficient volume to be able to supply cool water to the condensers well into the summer. During warm weather the condenser discharge water may be cooler than the surface layer of the lake and therefore may sink, and heat loss to the atmosphere will be minimized until the lake becomes thermally homogeneous again.

Without a heat load, the thermal stratification of the lake would persist into the late fall, until the surface water cooled enough to "turn the lake over." However, with the full-power thermal load (all three units at full load), the homogeneous condition may occur in August. This is the period for maximum temperatures.

Because there will be periods of reduced load during normal operations, the lake will not be required to absorb the full thermal load from the condensers on a continuous basis. Under full pumping load, the lake volume, at full pond, will be circulated through the condensers every four months; therefore the effects of a reduced load will be felt for several months, and using an averaged load (i.e., plant factor) for studying thermal effects is justified. The Velz study, made before the exact output of the plant was established, assumed a plant having a capacity of 3000 MW(e) and operating at 80% plant factor, with a waste heat rate typical of pressurized water reactors. The average heat loading to the lake was then calculated to be 16.2×10^9 Btu/hr.

The Velz[5] report assumed that the condenser intake would be in the Keowee branch, with the discharge to the Little River branch. The plant was built with the condenser flow in the reverse direction, i.e., intake is from the Little River branch and discharge to the Keowee branch. The estimates given in the Velz report should not be affected significantly by this reversal of condenser flow, since the basis for the study was the total volume and surface of the lake and was independent of the point of discharge of warm water. This construction places the condenser discharge sufficiently close to the inlet to the hydroelectric plant (about 1800 ft) for potentially all the condenser discharge to pass through the Keowee Dam during simultaneous operation of the hydroelectric plant and the nuclear plant. This will reduce the impact of the warm water on Lake Keowee, while raising the temperature of the tailrace water about 3°F under normal operating conditions.

Because of the possible discharge of the heated condenser water to the Hartwell Reservoir, the temperature should be monitored in the tailrace water during all operations of the hydroelectric station. For normal operation, the dilution factor is so high that the discharge temperature of the water should be well within the South Carolina allowable limit of temperature rise of 5°F. If Lake Keowee is at low level and the hydroelectric station is operated below capacity, the potential exists for the water discharged to Hartwell Reservoir to exceed this limit. In this case, the applicant would have to take the necessary steps to come within the State limit.

In the Velz study it was assumed that the rate of flow of cooling water through the three condensers would be 3800 cfs, which would result in a temperature rise of 19°F. The study concluded that under expected full heat load and normal climatology the peak water temperatures at the condensers would occur toward the end of August, as follows:

Condenser inlet	81.8°F
Condenser outlet	100.8°F

(The above temperatures are calculated; predictions are not this precise.) The calculated monthly averages for a normal year are shown in Table III-2.

The Velz report further assesses the effect of a once-in-20-years adverse climatological combination, resulting in a severe drawdown and heating of the lake.

> "The surface water temperature is expected to decline from 103.2°F to 94°F within an area from the source of approximately 1800 acres. At the critical drawdown stage of Lake Keowee the total reservoir area is 14,600 acres, and hence the affected area of temperature superelevation above 94°F constitutes 12.3% of the total reservoir."

In the condenser discharge lines, the water would remain at maximum temperature for 2 to 5 min. The time of residence is inversely proportional to the pumping rate of cooling water; with only one out of two pumps per unit operating, the residence time could be about 12 min.

With a full pond, the surface temperature of the lake would probably seldom exceed 94°F at any point. At extreme drawdown, to a surface elevation of 775 ft, surface temperatures could exceed 94°F, as noted in the Velz report. Under the extreme conditions, if we assume a layer of warm water averaging 10 ft thick at maximum drawdown, there would be a two-day lag after discharge from the condenser before enough heat was dissipated to drop the temperature from 103°F to 94°F for any given unit volume of water. According to the Velz report, the warm area would cover about 1800 acres (about 12% of the effective surface area of the lake at 775 ft). It is assumed that warm water would spread more or less uniformly across the surface of the lake from the condenser discharge point.

The approach to heat dissipation taken by Velz et al.[5] in estimating the thermal effects on Lake Keowee is based on energy budget relationships. All possible factors were considered, including convection, radiation, and evaporation. Natural lake temperatures were estimated, and then estimates were made of elevated temperatures and affected areas due to the heat load imposed by the plant.

Assumptions concerning the physical relationship of the plant and lake were necessary, as mentioned above. Further basic assumptions made in Velz' report were:

1. The discharge of waste heat is into a deep reservoir.
2. The complete interconnected reservoir is effective in heat dissipation.
3. There is no lateral or vertical short-circuiting of flow.
4. Natural-eddy conductivity is ignored.
5. Heated condenser waters are discharged upon the surface.
6. An average mixing depth of 10 ft is assumed throughout the year.
7. Water is drawn to the condensers from the hypolimnetic layer.

These assumptions are reasonable and are such that the direction of flow through the plant is probably immaterial, barring abnormal conditions. (The direction of flow assumed in the Velz report is the reverse of that actually constructed.)

The calculations are in agreement with general approximations that can be made for the surface area needed for heat dissipation.

(2) Duke Power Company Analysis

In response to the comments on the Draft Detailed Environmental Statement, the applicant performed an analysis of the heat dissipation in Lake Keowee for the full year.[6] Table III-4 lists acreages encompassed within isotherms of the temperatures tabulated for Lake Keowee for heat dissipation from the three units of the Oconee Nuclear Station. These are given for each of the 12 months of the year. In Appendix III-1, Figures A-III-1 to A-III-8 show approximate positions of isotherms in the lake for largest winter and summer areas.

The values given in Table III-4 were obtained through extrapolation of information from surveys, made by the applicant, of the effluent from the Marshall Steam Plant on Lake Norman.[6] The method followed was that developed by J. G. Asbury and A. A. Frigo[7] and is derived from analysis of thermal plumes from several lakes. Lake Keowee and Lake Norman are similar in many respects, thermally speaking, and many similarities exist between the effluent from the Marshall Steam Plant and that expected from the proposed Oconee plant. For these reasons, the approach taken by the applicant[6] appears reasonable. Comparison of the two systems (i.e., Marshall-Norman steam plant vs Oconee-Keowee steam plant) was made by the U.S. Department of the Interior.[8]

Vertical temperature profiles are given in Appendix III-1, Figs. A-III-9 to A-III-12. These profiles were established through a procedure similar to that used by C. J. Velz et al.[5,6] Expected flows were inserted and withdrawn from the reservoir at the appropriate levels. That is, flows to the lake were assumed to be added at a point equal to the temperature of the inflowing water. Flows from the lake were assumed to be at a temperature equal to that at the level of the discharge structure. A material and energy balance established any unknown temperatures. For each month, the temperature at the first of the month was supplied by the temperature at the end of the previous month.

Table III-4. Isotherm areas to within 3°F of ambient for Lake Keowee

A. Monthly average isotherm areas for average meteorology

Month	Isotherm temperature (°F)	Acres	Percent of total area	Month	Isotherm temperature (°F)	Acres	Percent of total area
January	75	0	0	February	70	0	0
	70	160	1.0		65	190	1.1
	65	370	2.2		60	430	2.6
	60	650	3.9		55	930	5.6
	55	2540	15.2		50	4800	28.8
	52	5100	30.5		47	Ambient	
	49	Ambient					
March	70	160	1.0	April	70	430	2.5
	65	430	2.6		66	2170	12.8
	60	1240	7.4		63	Ambient	
	57	4020	24.2				
	54	Ambient					
May	72	0	0	June	80	0	0
	71	Ambient			79	Ambient	
July	86	0	0	August	86	1410	8.0
	83	Ambient			83	Ambient	
September	90	280	1.6	October	90	0	0
	85	3440	14.1		85	330	2.0
	83	4090	23.6		80	2020	12.0
	80	Ambient			76	4560	27.0
					73	Ambient	
November	80	160	1.0	December	70	160	1.0
	75	530	3.2		65	610	3.7
	70	1230	7.4		60	2050	12.3
	66	5520	33.0		57	5520	33.0
	63	Ambient			54	Ambient	

Table III-4 (continued)

B. Maximum daily average isotherm areas for average meteorology

Month	Isotherm temperature (°F)	Acres	Percent of total area	Month	Isotherm temperature (°F)	Acres	Percent of total area
January	75	90	0.5	February	70	90	0.5
	70	280	1.7		65	280	1.7
	65	530	3.2		60	530	3.2
	60	1390	8.3		55	1390	8.3
	55	5100	30.5		50	5100	30.5
	52	Ambient			47	Ambient	
March	75	60	0.4	April	75	60	0.4
	70	280	1.7		70	930	5.5
	65	560	3.4		66	2720	16.1
	60	2170	13.0		63	Ambient	
	57	4790	28.7				
	54	Ambient					
May	75	0	0	June	82	160	0.9
	74	160	0.9		79	Ambient	
	71	Ambient					
July	90	0	0	August	90	190	1.1
	86	1640	9.0		86	2680	15.2
	83	Ambient			83	Ambient	
September	95	50	0.3	October	95	0	0
	90	700	4.1		90	160	0.9
	85	2870	16.6		85	940	5.6
	83	4420	25.5		80	2460	14.5
	80	Ambient			76	4700	27.8
					73	Ambient	
November	85	200	1.2	December	80	120	0.7
	80	610	3.7		75	310	1.9
	75	2050	12.3		70	620	3.7
	72	5520	33.0		65	1920	11.5
	69	Ambient			61	5100	30.5
					58	Ambient	

Table III-4 (continued)

C. Monthly average isotherm areas for extreme meteorology

Month	Isotherm temperature (°F)	Acres	Percent of total area	Month	Isotherm temperature (°F)	Acres	Percent of total area
January	70	80	0.5	February	70	160	1.1
	65	410	2.8		65	530	3.5
	60	940	6.4		60	1230	8.3
	55	5520	37.5		56	5520	37.0
	52	Ambient			53	Ambient	
March	70	210	1.4	April	70	620	4.0
	65	740	4.9		68	1930	12.5
	61	4100	26.9		65	Ambient	
	58	Ambient					
May	78	0	0	June	83	0	0
	76	Ambient			83	Ambient	
July	90	380	2.4	August	95	190	1.2
	86	3000	19.2		90	2680	17.3
	83	Ambient			89	3530	22.7
					86	Ambient	
September	90	330	2.2	October	85	190	0.9
	85	2440	16.3		80	1030	6.9
	83	4070	27.2		75	3670	24.6
	80	Ambient			74	4560	30.6
					71	Ambient	
November	80	160	1.1	December	70	160	1.2
	75	530	3.7		65	530	3.8
	70	1230	8.7		60	1230	8.9
	66	5520	38.9		56	5520	40.0
	63	Ambient			53	Ambient	

Table III-4 (continued)

D. Maximum daily isotherm areas for extreme meteorology

Month	Isotherm temperature (°F)	Acres	Percent of total area	Month	Isotherm temperature (°F)	Acres	Percent of total area
January	75	0	0	February	75	80	0.5
	70	250	1.7		70	370	2.5
	65	700	4.8		65	820	5.5
	60	2950	20.0		60	4100	27.5
	58	5520	37.5		59	5520	37.0
	55	Ambient			56	Ambient	
March	75	120	0.8	April	75	40	0.3
	70	490	3.2		70	1470	9.5
	65	1020	6.7		68	2870	18.5
	61	5310	34.9		65	Ambient	
	58	Ambient					
May	80	160	1.0	June	86	0	0
	79	700	4.5		83	Ambient	
	76	Ambient					
July	95	90	0.6	August	100	50	0.3
	90	1410	9.1		95	840	5.4
	86	4090	26.2		90	3290	21.2
	83	Ambient			89	4230	27.2
					86	Ambient	
September	95	50	0.3	October	90	120	0.8
	90	700	4.7		85	740	5.0
	85	2910	19.4		80	2170	14.5
	83	4470	29.8		76	4500	30.1
	80	Ambient			73	Ambient	
November	85	210	1.5	December	75	120	0.9
	80	610	4.3		70	410	3.0
	75	2050	14.5		65	940	6.8
	72	5520	38.9		60	5520	40.0
	69	Ambient			57	Ambient	

Table III-5 indicates the discharge temperature and the temperature rise through the condenser as expected by the applicant, and the expected ambient lake surface temperatures. It is assumed that the temperatures here presented are the "best" known at the time of this writing. The early work done by Velz et al. was based on an assumption of 19°F temperature rise across the condenser. In Appendix III-1, Figs. A-III-1 to A-III-16 represent the latest information supplied by the applicant. It should be recognized that operating conditions will vary and that the temperature rise across the condenser will not be constant. However, because plume area is directly proportional to both temperature rise and flow rate, plume areas will be approximately constant, since as the temperature rise increases, the flow rate decreases. Temperature deviations of a second order should be expected in normal operation, but such deviations should not have a measurable effect on the environment.

The full rated power of each of the three units of the nuclear plant is 2568 MW(t), of which 886 MW is the net electrical output for transmission. This leaves 1682 MW per unit to be dissipated to the environment. (About 30 to 35 of the 1682 MW(t) is used within the plant for auxiliary cooling but must somehow be dissipated; therefore, it is assumed in the analysis that eventually all the heat finds its way to the condenser coolant.) The total heat load to the environment from all three units operating at 100% load is equivalent to 17.22×10^9 Btu/hr. (About 0.32×10^9 Btu/hr is attributed to auxiliary heat dissipation, while 16.9 Btu/hr is from direct condensation of the turbine discharge vapor.)

To estimate the temperature of the tailrace water during simultaneous operation of the Keowee hydroelectric plant and the Oconee nuclear plant, the following assumptions were made:

1. No heat is lost to the atmosphere between the condenser discharge and the penstock.

2. Water is drawn into the penstock equally from all levels from the sill to the lake surface.

Both of these assumptions are of a conservative nature.

Table III-5. Temperatures in Lake Keowee with Oconee Units 1, 2, and 3 operating at 100% load

These values are derived from the calculations of the vertical profiles; i.e., surface temperatures are directly drawn from the calculations, and discharge temperatures are derived from the temperature at the skimmer wall opening plus the condenser temperature rise.

Month	Monthly average discharge temperature (°F)	Monthly average temperature rise across condenser (°F)	Maximum daily average discharge temperature (°F)	Maximum instantaneous discharge temperature (°F)	Ambient surface temperature (°F)	Maximum daily average ambient surface temperature (°F)
			Average[a]			
January	75	25	78	80	49	52
February	70	25	73	76	47	49
March	73	25	77	79	54	58
April	74	25	77	81	63	73
May	72	18	75	78	71	83
June	80	18	83	88	79	86
July	86	18	90	93	83	87
August	89	16	92	94	83	88
September	94	16	96	98	80	83
October	90	18	95	97	73	80
November	83	20	89	91	63	69
December	74	20	84	86	54	59
			Extreme[b]			
January	72	20	75	78	52	55
February	73	20	76	79	53	56
March	73	20	77	79	58	62
April	73	20	76	80	65	75
May	78	20	81	84	76	88
June	83	18	86	91	83	90
July	93	18	97	100	83	87
August	98	18	101	103	86	91
September	94	18	96	98	80	83
October	88	18	93	95	71	78
November	83	20	89	91	63	69
December	73	20	77	79	53	58

[a] Average monthly meteorology, streamflow, and drawdown conditions.

[b] Extreme 20-year meteorology, streamflow, and drawdown conditions.

With these assumptions, a maximum temperature of about 5°F above ambient could occur some months during the year. These calculations were performed by the applicant,[6] and results are given in Table III-6. Figures A-III-13 to A-III-16 of Appendix III-1 show the isotherms in Hartwell due to the Keowee warm water discharge.

In the unlikely event of a reactor shutdown following a temporary loss of all electrical power, cooling water can be discharged directly to the tailrace of the hydro plant by siphon action. About 94 cfs would be discharged at a temperature rise of about 64°F. This flow would be diluted by the normal leakage of 30 cfs from the Keowee dam but would still require about 300 acres to cool to 3°F above ambient.

(3) AEC Staff Analysis

In the study of the thermal behavior of the plume from Oconee, independent calculations were made by Oak Ridge National Laboratory (for the Atomic Energy Commission) using a model which assumed zero mixing. That is, all temperature decline was assumed to be the result of heat transfer to the atmosphere. As was anticipated, such areas tend to be larger than those inferred by extrapolation of data from the Marshall steam plant by the applicant. This approach is excessively conservative but does provide a hypothetical upper limit to the area required for dissipating the necessary quantities of heat. These latter values are shown in Table III-7 Table III-8 lists the assumed temperature rise and resultant flow rates through the condensers for a monthly average with a 90% load factor.

The method used by ORNL was an adaptation of a procedure outlined in Report No. 5 of Research Project RP-49.[9] A series of uniformly mixed cooling ponds was hypothesized, with the influx to each "pond" being the efflux from the preceding "pond".

Meteorological data needed for this analysis were obtained from the U.S. Weather Bureau in Asheville, North Carolina. Calculations indicated that wind speed is the factor of greatest importance in determining the area needed for cooling. Little difference in results was noted at wind speeds less than 3 mph. From this, one can infer that dead calm conditions would not result in excessively larger plume areas than those calculated at low wind speeds.

Table III-6. Isotherm areas for Lake Hartwell

Month	Keowee discharge temperature (°F)	Hartwell ambient (°F)	3° isotherm temperature (°F)	Acres	Percent of total area
A. Monthly average 3° isotherm areas for average meteorology					
January	54	49	52	360	0.6
February	52	47	50	920	1.5
March	59	54	57	870	1.4
April	66	63		0	0.0
May	72	71		0	0.0
June	80	79		0	0.0
July	84	83		0	0.0
August	84	83		0	0.0
September	82	80		0	0.0
October	76	73		0	0.0
November	68	63	66	160	0.3
December	59	54	57	170	0.3
B. Maximum daily average 3° isotherm areas for average meteorology					
January	54	49	52	360	0.6
February	52	47	50	920	1.5
March	59	54	57	870	1.4
April	66	63		0	0.0
May	72	71		0	0.0
June	80	79		0	0.0
July	84	83		0	0.0
August	84	83		0	0.0
September	82	80		0	0.0
October	76	73		0	0.0
November	68	63	66	160	0.3
December	59	54	57	170	0.3
C. Monthly average 3° isotherm areas for extreme meteorology[a]					
January	59	53	56	380	0.6
February	58	52	55	370	0.6
March	63	58	61	310	0.5
April	69	65	68	200	0.3
May	77	76		0	0.0
June	84	83		0	0.0
July	85	83		0	0.0
August	89	86		0	0.0
September	83	80		0	0.0
October	75	71	74	110	0.2
November	69	63	66	220	0.4
December	59	53	56	300	0.5
D. Maximum daily average 3° isotherm areas for extreme meteorology[a]					
January	59	53	56	380	0.6
February	58	52	55	370	0.6
March	63	58	61	310	0.5
April	69	65	68	200	0.3
May	77	76		0	0.0
June	84	83		0	0.0
July	85	83		0	0.0
August	87	86		0	0.0
September	83	80		0	0.0
October	75	71	74	110	0.2
November	69	63	66	220	0.4
December	59	53	56	300	0.5

[a]Extreme meteorology is defined as the circumstance of the combination of the warmest year in 20 years of observation and lowest drawdown and its attendant hydrology.

Table III-7. Isotherm areas within 3°F of ambient for Lake Keowee, assuming zero mixing

100% plant load

Month	Isotherm area (acres)			
	Average year[a]		Extreme year[d]	
	Normal[b]	Low wind[c]	Normal[b]	Low wind[c]
January	6705	7845	6637	7973
February	6038	7264	6123	7295
March	5471	6481	5557	6477
April	650	*e*	3773	*e*
May	*e*	*e*	*e*	*e*
June	*e*	*e*	*e*	*e*
July	*e*	*e*	3614	3500
August	600	*e*	3840	3956
September	4069	4588	4187	4602
October	5171	5574	5175	5838
November	6347	6936	6260	6891
December	6966	7954	6950	7951

[a]An average year is one in which climatology and hydrology are close to the overall average condition.

[b]Normal refers to overall average meteorological conditions.

[c]Low wind – wind speed is changed to 3 mph, instead of the overall average for the period in question; all other factors remain as for "normal."

[d]An extreme year is one in which climatology and hydrology combines to bring about low levels and high temperatures in the lake on a once in 20 probability.

[e]Plume area negligible; in some cases the warm water from the condensers will be cooler than the ambient and therefore will actually submerge.

Table III-8. Condenser flow, temperature rise, and residence time for a normal year

Monthly averages

Month	Condenser flow (cfs)	Condenser outlet temperature (°F)	Temperature rise (°F)	Residence time in condenser (sec)	Residence time in pipe (sec)
January	3033	65.7	23	8.6	208
February	3033	67.0	23	8.6	208
March	3036	70.0	23	8.6	208
April	3037	71.0	23	8.6	208
May	3881	70.0	18	6.7	162
June	3890	78.0	18	6.7	162
July	3897	84.0	18	6.7	162
August	4389	88.0	16	5.9	144
September	4393	91.4	16	5.9	144
October	4380	80.3	16	5.9	144
November	3882	70.4	18	6.7	162
December	3872	61.3	18	6.7	162

The one-in-20 extreme condition in climatological factors was examined, and in general there was little effect on areas or temperatures in the plume, there being more effect from wind speed than low lake levels. Because of the early exhaustion of the hypolimnion in an extreme year, the late summer temperatures can rise to potentially high levels. Table III-9 lists the time-temperature plume relationship for a normal year plus the July and August values for an extreme year, under the highly conservative assumption of zero mixing.

The residence time in the condensers and condenser discharge lines is relatively short. The condenser flows, calculated from predicted temperature rises, along with residence times are listed in Table III-8. These figures are for a normal year and a 90% load factor.

The maximum drawdown of Lake Keowee is stipulated to be 775 ft above mean sea level, which is equivalent to a residual volume of 563,907 acre-ft in Table III-10. Assuming normal advection of 1000 cfs (a conservative figure during the summer), under the maximum drawdown conditions a volume equal to the lake volume would be pumped through the condensers in about 80 days. At full pond the recirculation time would be greater than four months.

During the normal operation of the hydroelectric plant, as defined by the applicant, the 20-year maximum drawdown would occur in the cold months of the year, when the lake is isothermal. The maximum drawdown for summer operation was projected as a lake level of 786 ft.[5] (This would have occurred in 1957 had the lake been in existence.) At this level, the lake volume is 704,158 acre-ft. Allowing for advection, about 100 days would be required to pump a volume equal to the lake volume through the condensers. It is assumed that such recirculation will totally destroy the thermal stratification in the lake by late summer.

The Environmental Protection Agency has suggested in its comments that the cyclic nature of the operation of the pumped storage into the Jocassee reservoir will contribute to mixing of the warm water plume of the power plant. Examination of the lake volumes shows that if the full volume within weekly pumping limits were pumped (or discharged) in a single operation (about 47,000 acre-ft), then about one-fourth of the volume in the Keowee arm of the lake between elevations of 760 and 790 ft would be involved. The Keowee arm of the lake is long and narrow and the cyclic flow from Jocassee would therefore have a small added mixing effect on the thermal plume from

Table III-9. Plume temperature as a function of time after discharge to Lake Keowee

Monthly averages, 90% plant factor

Hours after discharge	Plume temperature (°F)																			
	January		February		March		July[a]		August[a]		August		September		October		November		December	
	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind	Average wind	Low wind
1	65.7	68.0	67.0	67.0	70.0	70.0	93.0	93.0	98.0	98.0	88.0	88.0	91.4	91.4	80.3	82.6	70.4	72.0	61.3	62.9
2	65.6	67.9	66.9	66.9	69.9	70.0	92.9	93.0	97.9	97.9	88.0	88.0	91.3	91.3	80.2	82.5	70.3	71.9	61.3	62.9
3	65.5	67.8	66.8	66.9	69.8	69.9	92.9	92.9	97.8	97.8	88.0	88.0	91.2	91.2	80.1	82.4	70.2	71.8	61.2	62.8
4	65.3	67.7	66.7	66.8	69.6	69.8	92.8	92.9	97.7	97.7	87.9	88.0	91.1	91.1	80.0	82.3	70.1	71.7	61.1	62.7
5	65.1	67.7	66.5	66.7	69.6	69.8	92.7	92.8	97.5	97.6	87.9	87.9	90.9	91.0	79.8	82.2	70.0	71.6	60.9	62.6
6	64.9	67.4	66.3	66.5	69.4	69.6	92.6	92.7	97.2	97.3	87.8	87.9	90.6	90.8	79.6	81.9	69.8	71.4	60.8	62.4
7	64.5	67.0	66.0	66.3	69.1	69.5	92.4	92.5	96.9	97.0	87.7	87.8	90.3	90.5	79.3	81.7	69.5	71.1	60.5	62.2
8	64.0	66.6	65.6	66.0	68.7	69.3	92.1	92.4	96.4	96.6	87.6	87.8	89.8	90.1	78.9	81.3	69.1	70.8	60.2	61.9
9	63.4	66.0	65.0	65.6	68.2	69.0	91.7	92.1	95.8	96.1	87.4	87.7	88.7	89.6	78.4	80.7	68.6	70.3	59.7	61.5
10	62.1	62.3	64.3	65.1	67.5	68.6	91.2	91.7	93.1	94.8	87.3	87.5	85.6	87.9	75.4	77.9	67.1	69.6	59.0	60.9
11	57.0	61.4	61.7	64.4	66.3	68.0	90.6	91.3	90.8	92.2	87.0	87.4	83.2	85.4	72.6	74.8	63.2	65.7	55.3	58.4
12	53.3	57.1	58.3	62.9	63.2	67.3	89.7	90.7	89.0	90.4	86.6	87.1	81.4	83.5	70.6	72.6	60.6	62.7	52.3	54.9
13	50.6	54.1	55.9	60.0	61.1	66.4	88.4	89.9	87.7	89.0	86.2	86.9	80.2	82.1	69.1	71.0	58.5	60.6	50.0	52.3
14	48.6	51.7	54.1	57.9	59.5	64.6	87.4	89.1	86.7	87.9	85.7	86.6	79.3	81.2	67.9	69.8	57.0	59.0	48.3	50.5
15	47.2	50.1	52.8	56.3	58.3	63.2	86.5	88.3	85.7	87.0	85.3	86.2	78.5	80.4	67.1	68.9	56.0	57.8	47.2	49.2
16	46.0	48.9	51.6	55.2	57.1	62.1	85.8	87.6	85.1	86.3	84.8	85.9	77.7	79.6	66.3	68.1	55.0	56.9	46.3	48.2
17	44.9	47.7	50.6	54.1	56.2	61.0	85.5	87.1	84.7	85.7		85.7	77.3	79.0	65.7	67.4	54.2	56.0	45.4	47.3
18	44.1	46.7	50.0	53.1	55.6	60.2									65.4	66.9	53.6	55.4	44.7	46.5
Ambient	43.7	46.0	49.6	52.6	55.4	59.9	85.4	87.1	84.5	85.7	84.6	85.6	77.2	78.8	65.3	66.9	53.4	55.0	44.3	46.0

[a]These areas are based on a 1 in 20 extreme climatological year. The normal year would result little or no plume area for July.

Note: During monthly April, May, and June, no significant plume areas are expected, since the condenser discharge temperature will be very close for less than the ambient surface temperature.

Table III-10. Volume and area data for Lake Keowee

Water surface elevation (ft)	Surface area (acres)	Storage volume (acre-ft)
810	20,570	1,150,300
805	19,471	1,050,191
800	18,372	955,586
795	17,305	866,388
790	16,239	782,528
785	15,109	704,158
780	13,979	631,438
778	13,601	604,517
775	13,032	563,907
770	12,085	501,117
760	10,240	389,489
750	8,709	294,741
740	6,861	216,897
730	5,554	154,832
720	4,394	105,097
710	3,265	66,802
700	2,360	38,672
690	1,410	19,821
680	776	8,891
670	327	3,375
660	141	1,034
650	65	0

the Oconee Nuclear Station, because this plant is about 10 miles from Jocassee. The increase in temperature in the water at the Jocassee dam resulting from Station operation is expected to be less than 1°F. If the total lake were assumed to be a "mixing pond" and uniformly heated by this effluent from the nuclear station, the surface temperature of the lake would then be about 3°F above ambient.

The withdrawal from Keowee at Jocassee of water 1°F above ambient on pumping mode would not have a measurable effect on Lake Jocassee because of mixing that would occur in the epilimnion of Jocassee on pumping. Tables III-10 and III-11 are lists of the volume-area-level data for lakes Keowee and Jocassee.

(4) Comparison of Analytical Studies

The above-noted three analyses of thermal effects were based on separate approaches. The Velz report was published before details of the Nuclear Station were completed and before the lake was impounded. In addition, water quality criteria have undergone revision since then, and information needed for full evaluation of the ecological impact of the nuclear station was not supplied in the study.

The study by the applicant was extensive and based on the measurements of a situation similar in many respects to that expected with the Oconee plant. This represents probably the most realistic appraisal of expected conditions in the lake. Additionally, this analysis considers 100% plant load factor.

The separate study made for the AEC is based on hypothetical limiting factors and should represent an outer limit on expected thermal effects, thus circumscribing the applicant's analysis. Examination of the results, shown in Tables III-4 and III-7, reveals that plume areas are generally within 30% of the applicants estimates, which is considered reasonable agreement.

The difference in the results is readily attributable to the zero mixing assumption in the estimates of plume area made by ORNL. Study of the results reveals that, for the cases where ORNL estimates showed large areas, e.g., during the cold months, the densimetric Froude

Table III-11. Volume and area data for Lake Jocassee

Water surface elevation (ft)	Surface area (acres)	Storage volume (acre-ft)
1120	7818	1,237,250
1115	7690	1,198,433
1110	7565	1,160,298
1105	7440	1,122,788
1100	7315	1,085,898
1095	7190	1,049,633
1090	7065	1,013,998
1086	6965	985,941
1085	6940	978,988
1080	6815	944,600
1060	6278	813,683
1040	5741	693,503
1020	5261	583,503
1000	4780	483,103
980	4322	392,086
960	3863	310,246
940	3376	237,851
920	2890	175,192
900	2332	122,972
880	1774	83,815
860	1263	53,446
840	930	31,514
820	615	16,061
800	346	6,454
780	135	1,650
760	30	0

number* reached unity at an area of about 1000 acres. If mixing effects are considered, the maximum areas would be materially reduced, because mixing becomes an important additional factor in reducing temperature after a Froude number of 1.0 or more is reached.

The studies by the applicant and Oak Ridge National Laboratory were primarily directed toward satisfying the requests of other Federal agencies for further information in order to be better able to assess the impact of the Oconee Nuclear Station on Lakes Keowee, Jocassee, and Hartwell.

The following field studies should be made during plant operation to demonstrate the adequacy of the above predictions:

1. Determine monthly lake isotherms at least under conditions of high and low flow.

2. Establish whether there are conditions when recirculation occurs.

3. Measure temperature as a function of depth in the area within 3000 ft of the condenser discharge, and in the vicinity of the skimmer wall, on a monthly basis.

d. Oxygen Effects

It is well known that the hypolimnion of reservoirs often becomes devoid of oxygen during the summer months. When deep intake structures are used to withdraw cool water for cooling, as is the case with the Oconee Nuclear Station, the oxygen-deficient water may be withdrawn by the plant and discharged to the surface of the reservoir.

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* The densimetric Froude number is a dimensionless number that is calculated as the ratio of mechanical forces to buoyant forces. In general, if the Froude number is less than unity, buoyant forces dominate. The number is:

$$F = \frac{V}{\sqrt{\frac{\Delta\rho}{\rho} g_c d}}$$

where

V = velocity
ρ = density
g_c = gravitational conversion constant
d = typical linear dimension (plume depth in this case).

The applicant has analyzed the potential effects of discharging water low in dissolved oxygen from his Oconee Nuclear Station.[10] His approach was to analyze dissolved oxygen concentration versus area based on surveys at the Marshall Steam Station on Lake Norman. Lake Norman data were then extrapolated to Lake Keowee by scaling up the areas according to the ratio of cooling water flow rates. The applicant believes that the predictions are conservative because:

1. Oconee discharges into a more open lake than Marshall and mixing will be greater, resulting in dilution of the low dissolved oxygen water;

2. All predictions are based on plume center-line measurements and dissolved oxygen values would be higher in other parts of the plume.

Based on his analysis, the applicant predicts the following areas of the lake will be affected:

Average conditions

Dissolved oxygen concentration	Acres affected
Less than 5 mg/liter	3000 acres
Less than 4 mg/liter	2100 acres to a depth of 7 ft
Less than 3 mg/liter	1200 acres to a depth of 4 ft
Less than 2 mg/liter	700 acres to a depth of 2 ft*
Less than 1 mg/liter	100 acres to a depth of 4 ft*

Extreme conditions

Dissolved oxygen concentration	Acres affected
Less than 5 mg/liter	5100 acres
Less than 4 mg/liter	3000 acres
Less than 3 mg/liter	1200 acres to a depth of 2 ft*
Less than 2 mg/liter	700 acres to a depth of 1 ft*
Less than 1 mg/liter	100 acres to a depth of 4 ft*

Approximate surface areas of deficient oxygen are shown in Figs. III-10 and III-11.

Oxygen solubility, temperature, reaeration rates, biological and chemical oxygen demand, and photosynthetic reaeration interact to make the

*Average depth.

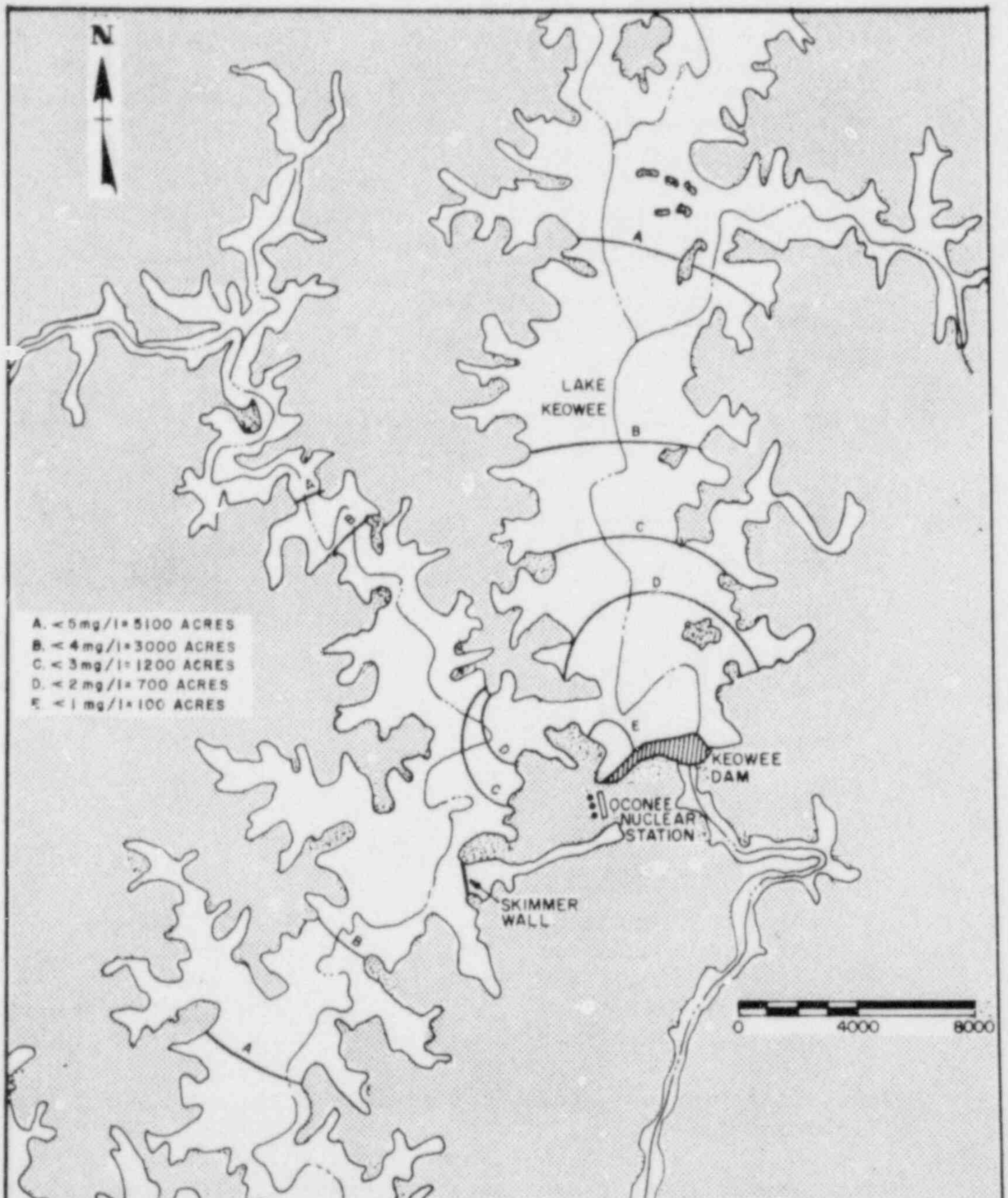

Fig. III-10. Expected normal areas of dissolved oxygen of less than 5 mg/l in Lake Keowee -- extreme conditions.

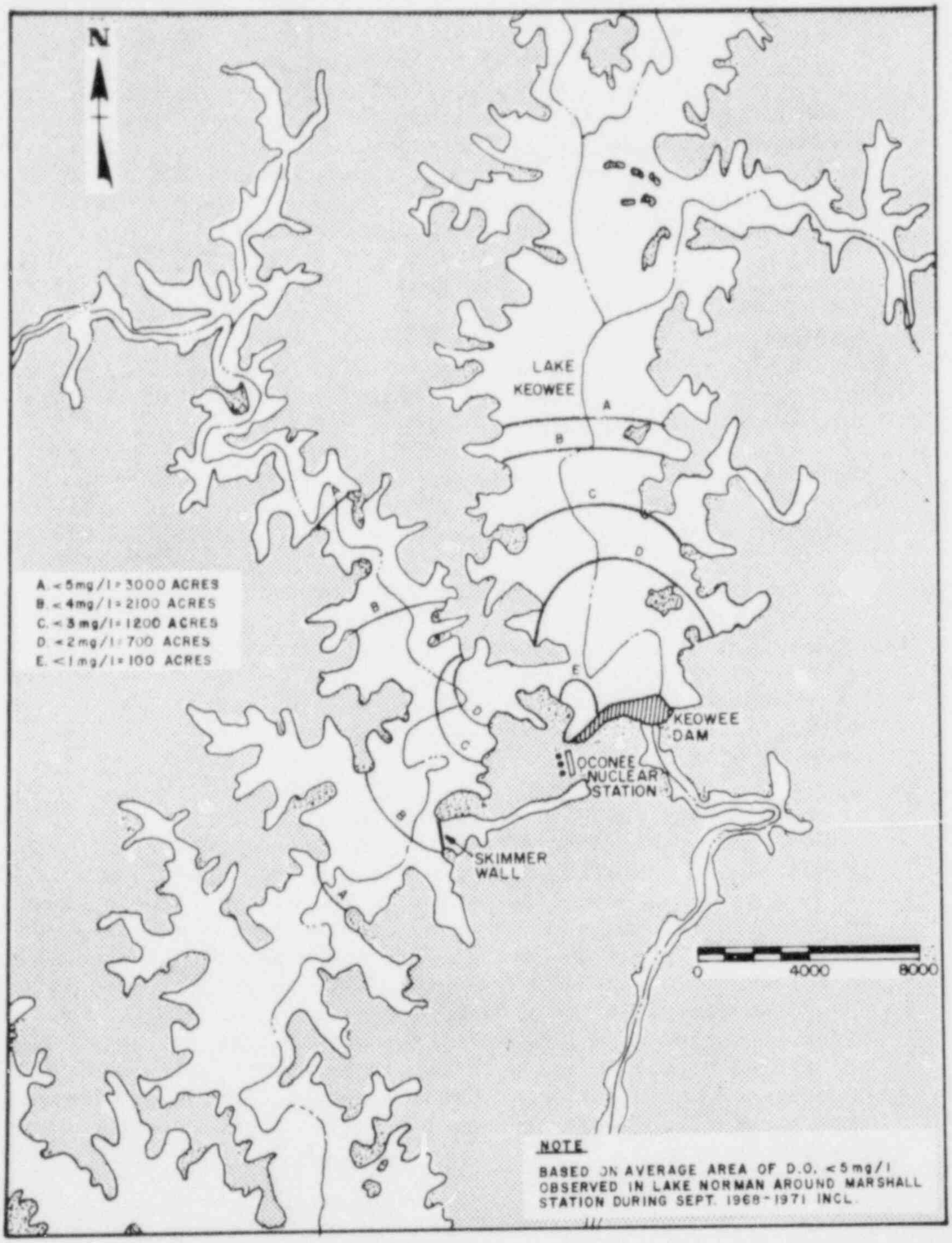

Fig. III-11. Expected normal areas of dissolved oxygen of less than 5 mg/l in Lake Keowee — normal conditions.

prediction of oxygen concentrations difficult. Because each of these parameters may vary with time and because sufficient information is seldom available, prediction of dissolved oxygen from these factors is risky. The applicant's approach appears to be reasonable, considering the current state of the art. His evaluation is based on empirical data from a situation similar to that at the Oconee plant and therefore should represent a better evaluation than would be possible from an analytical model.

An examination of the thermal study was made to find the areas of the plume within which buoyant forces exceed mechanical forces (i.e., densimetric Froude number of 1 or less). This would be the area within which the dissolved oxygen content would be altered only by surface reaeration and would probably be very nearly the same as that on entering the condensers.

The areas so defined ranged from 900 to 1200 acres for the critical months of August, September, and October. This is in substantial agreement with the estimates made by the applicant, as noted above.

From November to March, the lake is expected to be isothermal and essentially uniform in dissolved oxygen, which condition would result in no problem from the dissolved oxygen standpoint. During the rest of the year, the condenser discharge is expected to be very close in temperature to the surface ambient, plus or minus a few degrees F. In this case, early mixing will occur, and oxygen-deficient areas would be minimal.

In studying the question of dissolved oxygen in the tailrace of Keowee, the problem of determining the dissolved oxygen in the upper layers (above the sill but below the plume) of the reservoir above the dam appeared beyond the state of the art. At the present time, no specific statement can be made concerning the dissolved oxygen in water discharged to Hartwell, except that it will probably be deficient during the summer months. If one can assume that the water under the plumes in the region of the dam is unaffected by a surface layer of oxygen-deficient water, then the dissolved oxygen concentration of the tailrace is expected to be 0.75 to 0.85 times the oxygen concentration (depending on lake levels and hydroplant flow rates) that would be expected in the absence of the Oconee Nuclear Station.

2. Radioactive Waste Systems

The operation of a nuclear reactor results in the production of radioactive fission products, the bulk of which remain within the cladding of the fuel rods. During operation of the reactor, small amounts of fission products may escape from the fuel cladding into the primary coolant; also, some radioactive materials are produced as a result of neutron activation of corrosion products in the coolant. Some of these materials in low concentrations may be released into the atmosphere as gases or released in liquids to the tailrace of the Keowee Hydroelectric Station which ultimately discharges to the Keowee River and Hartwell Reservoir by controlled processes after appropriate monitoring, treatment and sampling.

The radioactive waste treatment systems presently incorporated in the Oconee Nuclear Power Station are described in the applicant's Final Safety Analysis Report and the Environmental Report dated July 1970 including the Supplemental Report dated October 18, 1971 and Revision 1 to the Supplement dated November 2, 1971. The radioactive waste handling and treatment systems of the Oconee Nuclear Station are designed to collect and process the liquid, gaseous and solid wastes that are by-products of Station operation and that might contain radioactive materials. The liquid waste treatment system is sized to accommodate the waste produced during simultaneous operation of Units 1, 2 & 3 and is common to all three units. Units 1 and 2 will share a common gaseous waste treatment system. Unit 3 will have a separate treatment system which can be interconnected to the system for Units 1 and 2; however these systems will normally be operated independently. The radioactivity that may be released during operation of Units 1, 2 and 3 at full power will be as low as practicable in accordance with Commission regulations, as set forth in 10 CFR Part 20 and 10 CFR Part 50. In this regard the liquid waste release will be coordinated with the operation of the Keowee Dam Hydroelectric Plant to assure maximum dilution.

Operating experience with pressurized water nuclear power plants licensed by the AEC has shown that releases of radioactivity from these plants have generally been small percentages of the limits imposed under 10 CFR Part 20 (see Tables A III-1, -2, -3, and -4, Appendix III-2).

a. Liquid Waste

The liquid radioactive waste treatment system common to all three units will consist of tanks, piping, pumps, evaporators, process equipment and instrumentation necessary to collect, process, store, analyze, monitor and discharge potentially radioactive wastes from Units 1, 2 and 3. Treated liquid wastes will be handled on a batch basis as required to permit optimum control and reduce the chance for an inadvertent release of radioactive liquid. Prior to release of any treated liquid wastes, samples will be analyzed to determine the type and amount of radioactivity in a batch to assure conformance with release limits. Liquid waste will be released through a single discharge header to the tailrace of the Keowee Hydroelectric Station which ultimately discharges to the Keowee River. Releases will be controlled by radiation monitors which will automatically terminate liquid waste discharges if high radiation levels are detected in the discharge line.

Nearly half the estimated total radioactivity discharged as liquid will originate from system leakages, which will be collected in three different types of storage tanks (miscellaneous waste, high-activity waste and low-activity waste) and processed as shown on the flow diagram in Fig. III-12. Most of the rest of the activity will come from the reactor coolant bleed treatment system. Both types of high-activity liquids (from systems and reactor coolant) will normally be processed through evaporators; additionally, in the reactor coolant bleed treatment system, the liquid will be processed through a demineralizer prior to evaporation.

Liquid wastes expected to have a low level of radioactivity will be collected in the low-activity waste tank. Auxiliary building floor drains and laundry wastes are expected to make up the major fractions of these wastes. After sampling and analysis these wastes will either be discharged directly to the tailrace of the Keowee Hydroelectric Station or transferred to the miscellaneous waste holdup tanks for further processing.

Liquid wastes expected to have an intermediate level of radioactivity will be collected in the high-activity waste tank. After sampling and analysis, the contents of this tank will be transferred either to the low-activity waste tank for release to the tailrace or to the miscellaneous waste holdup tank for further radioactive decay or to the waste evaporator feed tank for processing. Our evaluation assumed that most of this waste will be processed through the waste evaporator, which will concentrate the impurities for disposal through the solid waste drumming facility. The distillate from the evaporator will be returned to the condensate test tanks, where it may be used as reactor coolant makeup or released to the tailrace. Before being released to the tailrace it is possible to purify the liquid waste, if necessary, through a polishing demineralizer to further reduce any activity present.

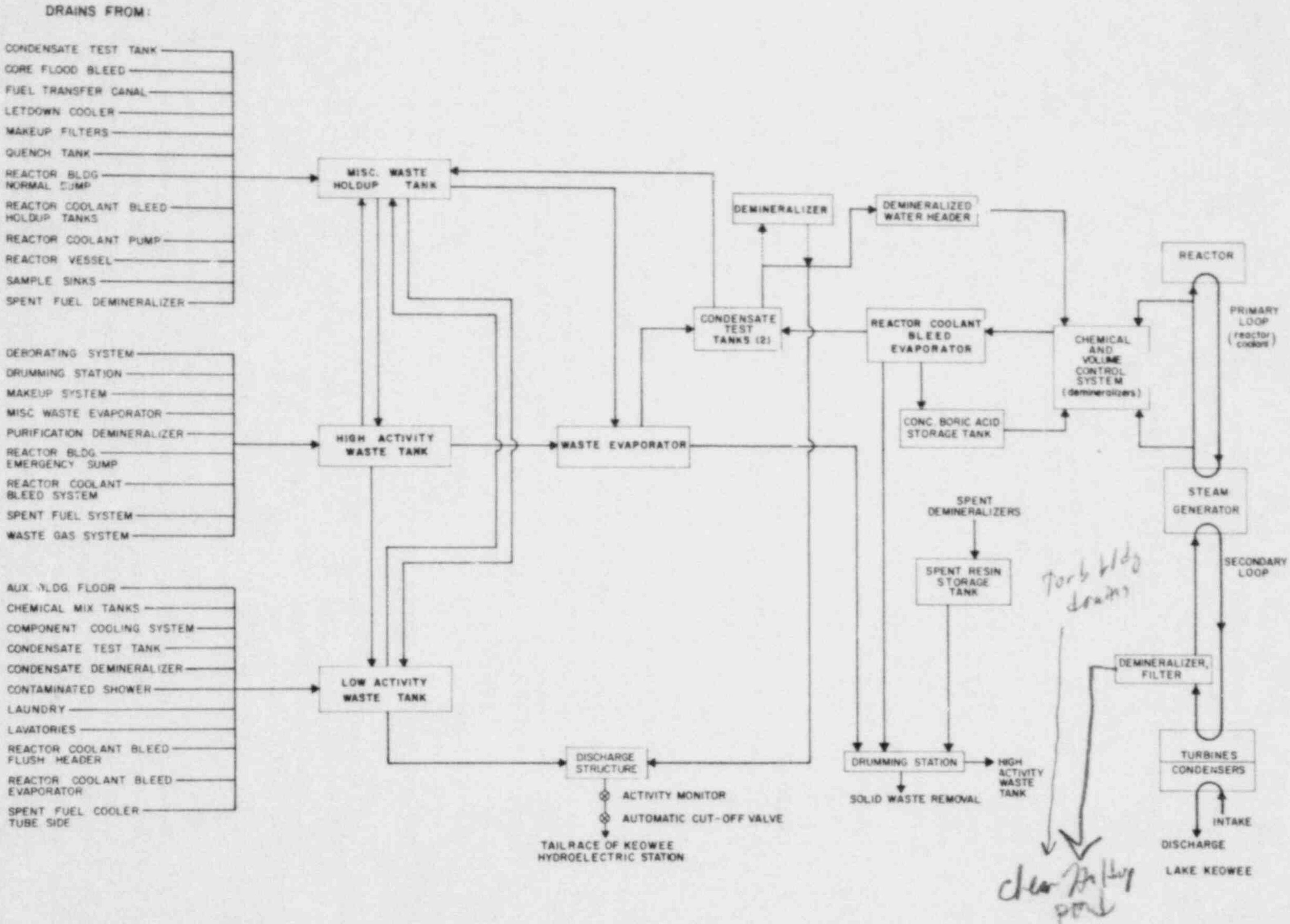

Fig. III-12. Radwaste liquid and solid discharge system at Oconee Nuclear Station.

Liquid wastes expected to have a high level of radioactivity will be collected in the miscellaneous waste holdup tank. From there they will be sent either to the low-activity tank for discharge (approximately 250,000 gal/year) to the tailrace or to the miscellaneous waste evaporator feed tank for processing as described previously.

The reactor coolant treatment system will purify the coolant, which is the liquid of highest activity, in three different ways. Ordinarily, part of the coolant will be circulated through demineralizers, which will remove about 90% of the ionic corrosion products and the fission products which may have leaked from the fuel elements. After this purification, part of the coolant will be bled from the system and fed to the reactor coolant bleed evaporator in order to remove some of the boric acid from the system. Reduction in boron concentration is accomplished primarily in the reactor coolant bleed evaporator; by using this evaporator most of the boric acid can be recovered from the coolant and stored in the concentrated boric acid storage tank (Fig. III-12). It is anticipated that approximately 1,000,000 gal of reactor coolant will be processed annually by this evaporator when all three units are in operation.

The distillate from the evaporator will be collected in the condensate test tanks and either discharged to the tailrace or used as makeup water for the reactor coolant. If necessary, the condensate can be recycled through the evaporator to further reduce its activity. By continuously bleeding some of the reactor coolant as feed to the evaporator and simultaneously adding demineralized makeup water, the concentration of boron in the coolant can be lowered to the required concentration. The reactor coolant storage tanks for all three units are arranged so that they can be utilized to store liquid from the other units if needed. The reactor coolant bleed evaporator is common for all three units.

Small quantities of primary coolant which leak into the steam generator feedwater system should not result in any significant discharge of radioactivity to the environment, since full-flow demineralizers continuously purify the steam generator feedwater and there is no generator blowdown. The applicant has estimated a leak rate of 10-20 gal per minute of steam-generator secondary system feedwater into the turbine room sump. This leakage would normally be discharged into Lake Keowee via the cooling condenser discharge. However, if significant activity occurs in this liquid (as a result of a large leak from the primary coolant also into the secondary system) provisions have been made for routing this liquid into the radioactive waste treatment system for reuse as coolant makeup or for release to the tailrace. As noted above, before being released to the tailrace it is possible to purify the liquid waste, if necessary, through a polishing demineralizer to further reduce any activity present.

The radioactive liquid waste released from the Station will be from either the low-activity waste tank or the condensate test tank. In order to achieve highest dilution ratios, the applicant intends to coordinate the releases with the operation of the Keowee Hydroelectric Station. Table III-12 lists radioactive fission and corrosion products which are expected to be present in the rector coolant system and the liquid waste treatment system. Our estimates of anticipated annual releases are based on the assumption that all of the reactor coolant bleed will be released each year after processing. Other conditions assumed include 0.25 percent leaking fuel, a 30-day holdup in the letdown system, a 10^4 decontamination factor (D.F) for both the waste evaporator and the coolant bleed evaporator and a D.F. of 10 for the demineralizers. Exceptions to the decontamination factors for specific isotopes have been taken; for example, a tritium D.F. of 1 is used for both evaporation and demineralization. No removal by demineralization was considered for yttrium, molybdenum and cesium. A decontamination factor of 10^3 was used for the evaporation of iodines.

Based on the assumptions noted above and summarized in Appendix III-3 the anticipated releases from the primary sources for normal operation were calculated to be a fraction of those shown in Table III-12. To compensate for treatment equipment downtime and expected operational occurrences the values shown in Table III-12 have been normalized to 1 curie per year release from each unit.

b. Gaseous Waste

During power operation of the facilities, radioactive materials released to the atmosphere in gaseous effluents include low concentrations of fission product noble gases (krypton and xenon), halogens (mostly iodines), tritium contained in water vapor and particulate material including both fission products and activated corrosion products.

The primary source of gaseous radioactive wastes is from the degassing of the primary coolant during letdown of the cooling water into the various holding tanks. Additional sources of gaseous waste activity include the auxiliary building exhaust, spent fuel area exhaust, the discharge from the steam jet air ejectors, purging of the reactor containment building and ventilation air exhausted from the turbine building. The gaseous waste handling and treatment systems for the Oconee Nuclear Station are shown schematically in Fig. III-13.

Table III-12. Anticipated annual releases of radioactive materials in liquid effluents from Oconee 1, 2, and 3

Radionuclide[a]	Reactor coolant bleed (Ci/year)	Liquid waste system (Ci/year)	Activity concentration in tailrace[b] (μCi/cm^3)
^{89}Sr	0.002	0.006	8.1×10^{-12}
^{91}Y	0.14	0.034	1.8×10^{-10}
^{90}Y	0.002	0.002	4.1×10^{-12}
^{99}Mo	0.018	0.004	2.2×10^{-11}
^{99m}Tc	0.002	0.004	6.1×10^{-12}
^{129m}Te	0.018	0.042	6.1×10^{-11}
^{129}Te	0.018	0.042	6.1×10^{-11}
^{131}I	0.06	0.14	2.0×10^{-10}
^{134}Cs	0.19	0.44	6.4×10^{-10}
^{136}Cs	0.022	0.042	6.5×10^{-11}
^{137}Cs	0.012	0.032	4.5×10^{-11}
^{137m}Ba	0.012	0.032	4.5×10^{-11}
^{140}La	0.002	0.002	4.1×10^{-12}
^{140}Ba	0.002	0.002	4.1×10^{-12}
^{51}Cr	0.022	0.006	2.9×10^{-11}
^{54}Mn	0.048	0.01	5.9×10^{-11}
^{55}Fe	0.102	0.022	1.3×10^{-10}
^{59}Fe	0.018	0.008	2.6×10^{-11}
^{58}Co	1.1	0.26	1.4×10^{-9}
^{60}Co	0.048	0.008	5.7×10^{-11}
Total (Units 1,2,3)	~1.84	~1.14 ≅ 3.0	3.0×10^{-9}
^{3}H (Units 1,2,3)	~3000		3.0×10^{-6}

[a]Nuclides not listed are considered to be < 0.002 Ci/year.

[b]Concentration when diluted with annual average flow of 1100 cfs.

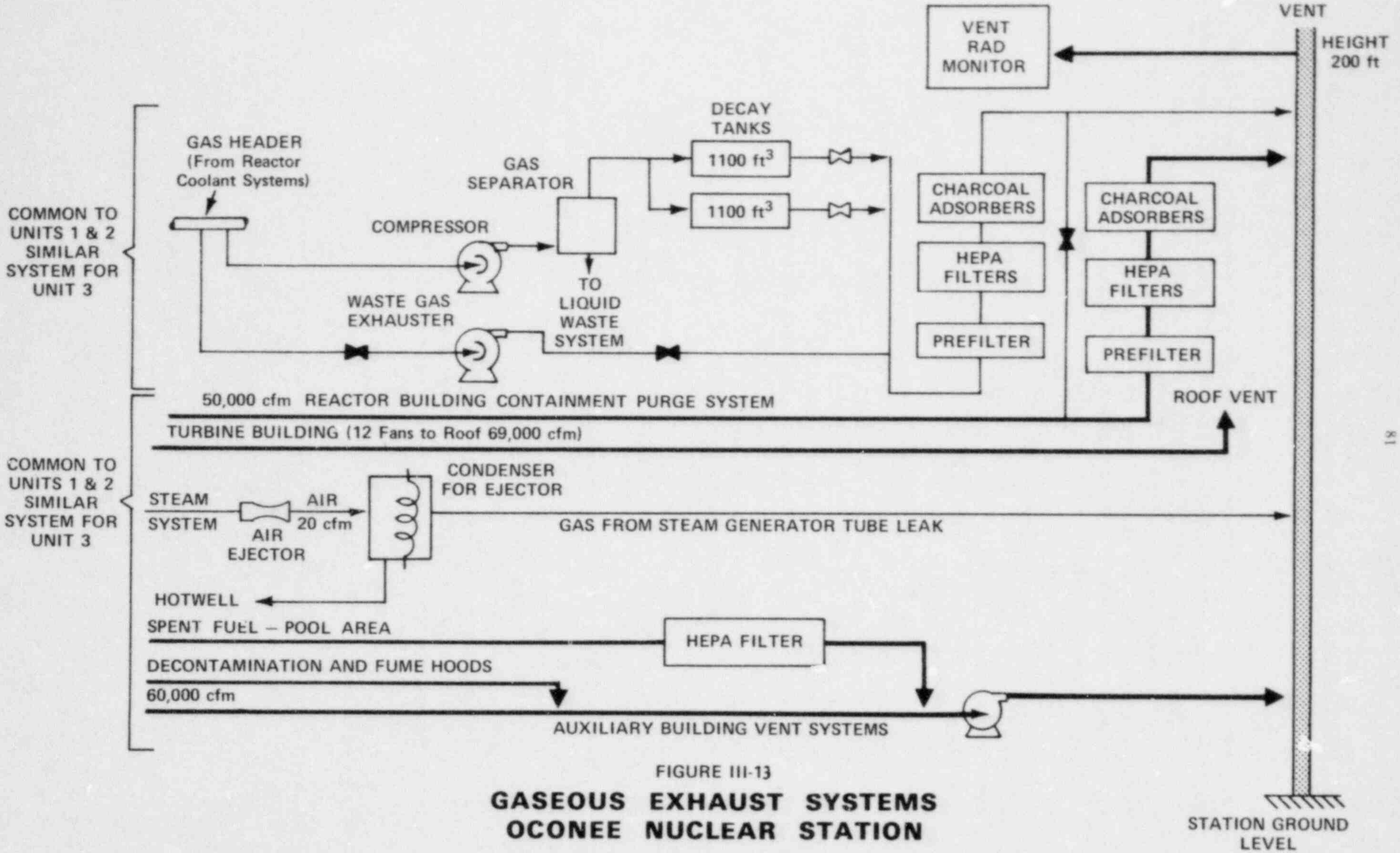

FIGURE III-13

GASEOUS EXHAUST SYSTEMS
OCONEE NUCLEAR STATION

Components that can contain potentially radioactive gases will be collected in a vent header. All liquid waste tanks are vented to the gaseous waste vent header to provide for filling and emptying without overpressurization or creating a vacuum. The vent gases are subsequently drawn from the vent header by one of two compressors or a waste gas exhauster. The gas compressor discharges through a gas separator to one of two waste gas storage tanks (each system has two storage tanks with a unit capacity of 1100 cubic feet at a pressure of 100 psig) where the gases will be held up for radioactive decay. The operation of the waste gas storage tank is such that it can function both as a surge and a storage decay tank. When filled, the storage tanks will be sampled and analyzed to determine the release rate or the need for additional holdup for radioactive decay. Table III-13 is based on a holdup time of 30 days. (The assumptions used in the calculations are summarized in Appendix III-3.) The gas storage tanks and the waste exhauster will discharge to the unit vent after passing through a filter bank consisting of a prefilter, high-efficiency particulate filter and charcoal adsorber. The gas will be further diluted by ventilation air from the various operating areas prior to being released to the atmosphere, with continuous monitoring, through the unit vent 200 feet above ground level. The waste gas exhauster normally will not operate and is intended to be used when large volumes of gases containing little or no radioactivity are available for release to the monitored unit vents.

Radioactive gases may be released inside the reactor containment building when components of the primary system are opened to the building atmosphere for operational reasons or where minor leaks occur in the primary system. Prior to access, the reactor containment atmosphere will be monitored for activity and, when necessary, purged through prefilters, high-efficiency particulate air (HEPA) filters and charcoal adsorbers and released to atmosphere through the unit vent. The purge equipment is sized for a flow rate of 50,000 cfm providing approximately 1.5 air changes per hour in the reactor building. Units 1, 2 & 3 will have a separate vent stack from each reactor building.

Radioactive gases may also be released to the auxiliary building through leaks and open equipment. Units 1 & 2 share a common building while Unit 3 will have a separate auxiliary building.

Table III-13. Anticipated annual releases of radioactive materials in gaseous effluent from Oconee Nuclear Power Station, Units 1, 2, and 3

Based on 30 days holdup

Radionuclide	Containment purge, Units 1, 2, and 3[a] (Ci/year)	Waste gas system, Units 1 and 2 (Ci/year)	Waste gas system, Unit 3 (Ci/year)	Steam air ejectors, Units 1, 2, and 3[b] (Ci/year	Total, Units 1, 2, and 3 (Ci/year)
^{85}Kr	34.2	1478	739	5.73	2,257
^{87}Kr	0.12			8.70	8.8
^{88}Kr	0.93			27.9	28.8
^{131m}Xe	26.6	294	147	9.54	477
^{133}Xe	2844	5342	2671	1929	12,786
^{135}Xe	1.05			9.66	10.7
^{138}Xe	0.02			6.45	6.47
^{131}I	0.78			0.024	0.80
^{133}I	1.14			0.03	1.17

[a]Each unit will have a separate plant vent.

[b]Each steam air ejector discharges to the individual plant vent.

To minimize the release of radioactive materials the buildings will be maintained at negative pressure with respect to the outside pressure. Ventilation air will move from areas of low potential towards areas of higher potential. Gases purged from the auxiliary buildings will also be continually monitored and released to the atmosphere untreated through the unit vents. A common fuel storage area will serve Units 1 and 2 while a separate fuel storage area will be provided for Unit 3. Ventilation air in these areas will be exhausted untreated through the auxiliary building exhaust systems and discharged to the unit vents.

The turbine building will be ventilated by 12 roof-mounted exhaust fans. Ventilation air is pulled through outside air louvers and discharged without treatment through the roof exhaust fans.

Radioactive gases which may enter the secondary coolant loop through a leak in the steam generator tubes will be removed from the steam system by the air ejectors and will be discharged from the monitored systems to the individual unit vents. Small quantities of primary coolant which leak into the steam generator feedwater system should not result in any significant discharge of radioiodine to the environment, since full-flow demineralizers continuously purify the steam generator feedwater and there is no generator blowdown.

Table III-13 shows the anticipated annual release of radioactive materials in gaseous effluent for each unit based on the systems as described in the applicant's Final Safety Analysis Report and considers operation with 0.25 percent leaking fuel and a 20 gal per day primary to secondary system leak rate. The applicant has considered additional modifications which could theoretically further reduce radioactivity in the plant such as filters and a cryogenic system; however the applicant is convinced that such improvements would be of negligible value in view of the already small quantities of activity anticipated to be released from the station.

c. <u>Solid Wastes</u>

The sources of solid radioactive waste will be spent demineralizer resins, filter and strainer elements, evaporator concentrates and miscellaneous items such as contaminated clothing, filters, rags, paper, gloves and shoe covers. The spent resins will be slurried to the drumming facility from the spent resin storage tanks and collected in suitable containers. These containers will be equipped with filters to retain the solids and the liquid portion will be returned to the high-activity liquid waste tank. The evaporator concentrates will be either stored and shipped as liquids or mixed with vermiculite or concrete and shipped as solid waste. The applicant has not yet made a final decision regarding this matter. Miscellaneous solid wastes (clothing, rags, paper, etc.) will be hydraulically compressed in 55-gal steel drums. All solid radioactive waste will be packaged and shipped offsite to a licensed burial ground in accordance with AEC and DOT regulations. The radioactivity to be shipped annually from the station has been estimated by the applicant to be 2×10^5 curies contained in 2,500 cubic feet of spent resins. It has also been estimated that about 100 55-gal drums of low-level contaminated solid waste will be produced annually from each unit. The Staff concurs in the applicant's estimate of the activity to be produced in solid waste.

3. Chemical and Sanitary Waste Systems

The chemicals used in significant quantities at the Oconee Nuclear Station are listed in Table III-14.

a. Condenser Cooling System Output

The condensers will be cooled by a once-through flow of water from Lake Keowee. No chemicals will be added to this condenser cooling water; deposits of aquatic growth and corrosion products will be removed from the condenser tubes by circulating sponge rubber balls which are slightly larger in diameter than the inside diameter of the condenser tubes. The Duke Power Company has successfully used this technique in the Marshall Power Station on Lake Norman, North Carolina, with no apparent adverse environmental effects.

The amount of condenser tube corrosion products discharged annually into Lake Keowee is expected to be small, since the type-304 stainless steel condenser tubes are resistant to corrosion by water at 100°F.

b. Demineralizer Regeneration Solutions

The demineralizers in the steam generator feedwater system, in the primary coolant treatment system, and in the condensate (from the evaporators) treatment system will not be regenerated chemically but will be replaced with fresh resins upon exhaustion. The deborating

Table III-14. Chemical wastes from Oconee Nuclear Station

	Pounds per year (3 units) (from DPC)	Concentration in water released to environment (ppm)	
		Average[a]	Maximum possible[b]
Reactor coolant			
Boric acid	50,000 (startup)	2.4×10^{-5}[c]	8.8×10^{-4}
Lithium hydroxide	180	*d*	*d*
Hydrazine	300	*e*	*e*
Steam generator feedwater			
Hydrazine	1,800–13,000	*e*	*e*
Regeneration of deborating demineralizers			
Sodium hydroxide	4,100	*f*	*f*
Regeneration of water treatment demineralizers			
Sodium hydroxide	440,000	0.12[g]	4.4[g]
Sulfuric acid	150,500	0.068[h]	2.5[h]
Laundry and cleaning detergents			
Floor cleaning (liquid)	1[illegible],000	0.0046[i]	0.17[i]
Laundry (solid)	4,760	0.0022[i]	0.081[i]

[a]Total per year diluted by average trailrace flow of 1100 cfs (9.823×10^{14} cm^3/year).

[b]Total per year diluted by minimum tailrace flow of 30 cfs.

[c]53 lb/year from evaporator overheads

[d]Most will probably be removed by the demineralizers and evaporators.

[e]Normally, hydrazine is reacted chemically and is not discharged.

[f]Most of this material will be sent to the waste drumming facility as evaporator bottoms.

[g]Sodium released; Keowee River normal concentration is 1.2–2.8 ppm (G. A. Billingsley, "Chemical Character of Surface Waters of South Carolina, 1945–1955," Bulletin No. 163, South Carolina Development Board, 1956).

[h]Sulfate released; Keowee River normal conc. is 0.7–2.5 ppm (G. A. Billingsley, "Chemical Character of Surface Waters of South Carolina, 1945–1955," Bulletin No. 163, South Carolina Development Board, 1956).

[i]Processing of these wastes through the sanitary waste system may significantly reduce this value.

demineralizers will be regenerated with sodium hydroxide (4,100 pounds per year for the three units). The neutralized effluent from this regeneration will be collected by the liquid radioactive waste disposal system, processed through the evaporators, and pumped with the concentrates to the waste-drumming station.

The demineralizers used in the treated water system, which supplies deminer lized water to the plant, will be periodically regenerated with sodium hydroxide (146,356 pounds per year per unit) and sulfuric acid (50,156 pounds per year per unit). The effluent from the regenerating treatment will be neutralized and sent to the holding pond and eventually will be discharged to the tailrace of the Keowee Hydroelectric Station. No chemical sludges are expected from Oconee's water purification system.

Small amounts of hydrazine (5 to 35 pounds per day) will be added to the steam generator feedwater to reduce corrosion. The concentration of hydrazine in the discharge will be very small, since most of it will have already reacted chemically with oxygen to produce nitrogen and water.

c. Reactor Coolant Chemicals

Boric acid is the chemical that will be added to the reactor coolant in greatest quantities. The total added to the reactor coolant system will be about 60,000 pounds. However, most of this will be collected in the reactor coolant bleed evaporator concentrate and recycled for use in the reactor coolant, so under normal circumstances only small amounts will be discharged in the overhead from the evaporators. This amount is estimated at 53 pounds of boric acid per year from all three units.

Small amounts of lithium hydroxide (60 pounds per year per unit) will be added to the reactor coolant system for control of acidity. During shutdowns, small amounts of hydrazine (100 pounds per year per unit) will also be added to the reactor coolant system for removal of radiolytic oxygen.

d. Sanitary Waste

The sewage treatment system for the Oconee Nuclear Station employs a "total oxidation" type of aerobic digestion unit. The effluent (approximately 5,100 gal per day) is chlorinated to a residual of 0.2 to 1.0 part per million (ppm) and discharged to the Keowee River downstream from the Keowee Hydroelectric Station. Assuming dilution by the minimum tailrace flow of 30 cubic feet per second, this effluent containing a maximum of 1.0 ppm chlorine would be immediately diluted to 0.00026 ppm chlorine. This is well within safe limits for chlorine concentration. This facility has been approved by the South Carolina Pollution Control Authority. Two separate waste treatment facilities, one of 7,500 gal/day and one of 10,000 gal/day, are provided at the site to serve the construction work force.

4. Other Waste Systems

A holding pond has been constructed primarily to contain the backwashed demineralizer resins from the nonradioactive portions of the system. It also receives the neutralized spent demineralizer regenerating solutions described earlier. These regenerant solutions are estimated to have a BOD of approximately 10-20 ppm before entering the holding pond and the BOD will be reduced essentially to zero before leaving. This settling basin receives very little natural drainage and can accommodate 5,000,000 gal (668,000 cubic feet) of water between the elevations of its two discharge lines. Thus sufficient storage volume exists to allow a large fraction of the solids to settle out before it is necessary to discharge any liquid from this holding basin. Supplies of water treatment chemicals are stored inside the water treatment building where any spillage would be contained and subsequently drained to the waste holding pond. The water will also be sampled, and chemically treated if necessary, before release from the holding pond. The overflow goes into the yard drainage system, which discharges into the tailrace of the Keowee Hydroelectric Station. The holding pond was designed to contain all backwashed demineralizers expected to be used during the life of the Station.

E. TRANSPORT OF FUEL AND RADWASTE

The applicant has indicated that nuclear fuel and solid waste associated with the operation of the three reactors at Oconee will be transported by truck to and from the plant site. The new fuel will come from the Babcock & Wilcox fuel fabrication plant at Lynchburg, Virginia, a distance of about 300 miles. Irradiated fuel will be sent to a licensed fuel recovery plant, probably the plant at Barnwell, South Carolina, a distance of about 150 miles. The applicant indicates the solid wastes will be shipped to a licensed commercial radioactive waste burial ground for disposal; the site will probably be the Kentucky burial ground, a distance of about 300 miles.

1. Transport of Cold Fuel

The nuclear fuel for each of the Oconee reactors consists of 103 tons of U-238 enriched to an average of 3.06% by weight with the isotope U-235. The fuel is in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. A fuel element is made up of 208 fuel rods about 12 feet long and weighs about 1,500 pounds. In regular operation, about one-third of the fuel elements are replaced each year. The applicant will ship cold fuel in a DOT-AEC approved shipping container authorized for use under DOT Special Permit No. 6206. This package, which holds 2 fuel elements, is about 40 inches in diameter, 200 inches long, and weighs about 7,300 pounds when loaded. Twenty packages have been approved for shipment on a single vehicle.

On the average, 9 truckloads of 10 packages each will be shipped to the site for use in the three reactors each year.

2. Transport of Irradiated Fuel

Although a fuel element removed from the reactor will be unchanged in appearance and will contain some of the original U-235 (which is recoverable), it will have been irradiated to about 10,000 megawatt-days per ton on the average. As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of fission products and some plutonium. As the radio-activity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. After discharge from a reactor, the fuel elements are placed under water in a storage pool for radioactive decay and cooling prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the irradiated fuel elements will be shipped in approved casks designed for transport by truck or rail. Each cask will carry 2 or more irradiated fuel elements and weigh from 30 to 100 tons. The weight will be due principally to the radiation shielding--steel, lead, or uranium.

The applicant estimates that the irradiated fuel removed from the three reactors will require up to 89 shipments by truck each year.

3. Transport of Solid Radioactive Wastes

The applicant estimates that the solid wastes generated by the three units will amount to approximately 2,500 cubic feet of evaporator bottoms and about 350 cubic feet of demineralizer resins. That waste will be packaged in approved Type B packages for shipment. In addition, low-level contaminated wastes, such as contaminated clothing, rags, paper, gloves, shoe coverings, etc., will be compacted in 55-gallon drums for shipment and disposal, and approximately 100 drums will be shipped each year.

The waste will be shipped by truck to a licensed disposal site. It is estimated that about 45 truckloads of drums and shielded containers will be required to remove the solid waste each year.

The procedures for transport of radioactive materials to and from nuclear facilities are being developed cooperatively in meetings between the Atomic Energy Commission and other Federal agencies.

IV. ENVIRONMENTAL IMPACTS OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF PLANS AND SCHEDULES

Construction of the dams for impounding the waters which form Lakes Keowee and Jocassee (see Fig. II-3) was started in the spring of 1968. Construction of the Little River and the Keowee River dams of Lake Keowee was completed in the fall of 1970; the first stage of fill was completed in April 1968, and complete fill (to within 2 feet of full pool) was completed in April 1971. The Jocassee River dam of Lake Jocassee is scheduled for completion in the spring of 1972. Its first stage of fill was reached in March 1971, but final filling will not be attained until about December 1974.

The Oconee Nuclear Station will consist of three units designated 1, 2, and 3, scheduled to begin operation in early 1972, 1973, and late 1973, respectively. Unit No. 1 was 95% complete, No. 2 is 60% to 75% complete, and No. 3 is 40% to 50% complete, as of October 18, 1971.

B. IMPACTS OF SITE PREPARATION AND PLANT CONSTRUCTION

In considering the impact of site preparation for the Station, the impacts of creating Lakes Keowee and Jocassee, which are essential features of Oconee, were also be taken into account. These lakes have converted a land resource into a water resource; in so doing, some land was necessarily sacrificed, and almost 1000 people required relocation. Creation of the new lakes required as follows:

Lake Keowee

18,500 acres cleared
14,084 acres woodland
4,416 acres field and pasture
430 acres for dam, access roads, construction yards, etc.

Lake Jocassee

7,500 acres cleared
7,270 acres woodland
230 acres field and pasture
360 acres for dam, access roads, etc.

Oconee Site

510 acres cleared

As the land was cleared, the inhabiting population and a certain few institutions were necessarily relocated.

In summary, the water resources replaced the following in human habitations and resources:

Lakes Keowee and Jocassee

150 houses removed (12 on farms)
57 tenant houses removed
120 summer cabins removed
2,100 acres farmland inundated
23,837 acres nonfarmland inundated
48 farm people relocated
780 nonfarm people removed

The immediate site for the Nuclear Station:

17 houses removed (2 on farms)
1 vacation house removed
8 farm people relocated
56 nonfarm people relocated

In addition,

Jocassee Girls Camp was relocated at Lake Keowee
2 sawmills were removed
Piedmont Nursery was relocated in Oconee County

Not only were 26,000 acres of forested and farming land covered by water, but much trout water was eliminated.[1] Exact numbers of trout are not available, but rainbow, brook, and brown trout are residents of the streams in the mountainous regions above Jocassee Dam. Portions of the streams affected were in North Carolina, and the North Carolina Wildlife Resources Commission has been contacted, but no information is available at this time.

While reduction of habitat does not necessairly mean the extinction of faunal and floral species, the total population of any organisms requiring the specialized habitats may be reduced in that particular geographic area. The Clemson salamander, Oconee bells, and Hymenophyllum (filmy fern) populations were probably reduced by the destruction of the small stream-side habitats. Both species have been found in the wooded regions above Jocassee Lake.[2] The small mammal inhabitants of the impounded area were eliminated, while larger mammals, including deer, were probably able to relocate within the area, since the potential carrying capacity of the Horsepasture area has not been approached.[1]

Prior to the construction of the Keowee and Jocassee Dams, walleye were regularly captured during the spawning season in the Seneca River arm of Hartwell Reservoir. Spawning has ceased in this area, and the South Carolina Wildlife Resources Department has stated that the reduction is spawning is probably a "result of excessive turbidity resulting from the construction of the Keowee-Toxaway complex."[3] After construction is completed, it is hoped that this condition will be alleviated and that a minimum flow through the Keowee Dam can be maintained during the spawning period in order to reestablish suitable areas for spawning in that arm of the reservoir. Unless controlled by the Duke Power Company, the velocity of the water discharged from the Keowee Dam hydroelectric station (19,800 cfs) may be great enough to preclude any spawning in this area.

In Appendix II-3, Table A-II-19 indicated a low proportion of bottomland forest (elm-ash-cottonwood) in Oconee and Pickens Counties as of 1967. Lake clearing operations probably continued to diminish this proportion.

Oconee and Pickens Counties are the only counties in South Carolina with estimated acreage of the white pine-hemlock group. Since this type reaches best development along steam terraces and cool lower slopes, we expect that loss of this evergreen community was increased by clearing for Lake Jocassee.

C. CONTROLS TO LIMIT IMPACT OF PREPARATION AND CONSTRUCTION

Controls to limit impacts of construction such as dust, noise, and excavated material were not necessary because the inhabitants of the areas to be inundated were already relocated when most of the construction occurred.

The intensity of power station construction activities reached a peak in early 1971 and has been decreasing slowly since that time. Flights over the area by helicopter verified that construction impacts were reduced by the practice of prompt landscaping.

V. ENVIRONMENTAL IMPACTS OF PLANT OPERATION

A. LAND USE

The applicant acquired more than 157,000 acres of land in conjunction with the Keowee-Toxaway Project. The alteration of 26,000 acres of this land to form Lake Keowee and Lake Jocassee was the major change in land use. This land was previously mostly wooded with some farms. Conversion of much of the remaining land to forestry and wildlife management programs also are major changes in land use.

Operation of the Oconee Nuclear Station will require restriction of the use of the 2000 acres of land and water within a one-mile radius of the reactors. No permanent residents are in this area; however, there is a visitors' center about 300 yards from the reactor containment buildings.

The access to and the use of the lake have been facilitated by the construction of eight access areas around the perimeter. Each is reached by gravel roads and is furnished with a boat ramp. Proposed facilities include picnic tables and parking areas. In addition, a 155-acre recretional complex is being planned by the applicant.

Plans are under way to develop land around Lake Keowee into residential areas. A few residences have already been built. Access roads to the proposed development areas have been constructed.

Operation of the plant requires the construction of transmission lines involving some 7800 acres of land for right-of-ways. This will not significantly affect agricultural crop production but will limit construction of buildings and timber growth within the right-of-ways.

B. WATER AND AIR USE

1. Water Use

Lake Keowee was created to serve the cooling needs of the Station. However, the water of Lake Keowee will also be used for operation of the hydroelectric turbines at the dam, for fish propagation, and for recreation and sports on Lake Keowee. Protection of this water use is aided by application of water quality standards to Lake Keowee and to Hartwell Reservoir.

Water quality standards applying to the Station have been promulgated under the authority of Act Number 1157, 1970 Acts and Joint Resolutions of the South Carolina General Assembly.[1] These standards require that the applicant obtain permits from the Pollution Control Authority of the State for operation of any waste treatment facilities, including those for industrial wastes or sewage. The holding pond is considered a facility for industrial wastes under the standards. In addition, the following restrictions and requirements pertain:

a. No wastes amenable to treatment or control shall be discharged into any State waters without treatment or control.

b. Tests or analytical determinations to determine compliance or noncompliance with standards shall be made in accordance with methods and procedures approved by the Pollution Control Authority.

c. In making any tests or analytical determinations on classified waters to determine compliance or noncompliance with water quality standards, representative samples shall be collected at locations approved by the Pollution Control Authority.

d. General water quality criteria are established to maintain in the waters of the State a water quality sufficient for the survival and general well-being of fish and other aquatic life during periods of migration and passage.

(1) The water temperature shall not exceed 90°F at any time, after adequate mixing of heated and normal waters as a result of heated liquids, nor shall the water temperature after passing through an adequate zone for mixing be more than 3° above than the monthly average temperature of water unaffected by the heated discharge. The zone for mixing shall be determined by the Pollution Control Authority.

(2) The pH shall range between 6.0 and 8.5.

(3) The dissolved oxygen shall have a daily average of not less than 5 milligrams per liter with a low of 4 milligrams per liter.

At this time, the size of the mixing zone has not been established by the South Carolina Pollution Control Authority.

Groundwater quality in the vicinity of the project is not expected to be affected by the Station operation, because the normal flow of groundwater is toward the lake basin.

Water loss by evaporation due to the heat effluent depends on many factors. In this geographic area, humidity conditions are such that excessive evaporation should not occur. The maximum rate of evaporation for a total of three reactor units operating on a hot, dry day would be about 5% of the average natural flow of water (1,100 cfs) into the lake. Under normal conditions it would be considerably less than this. Use of lake water by municipalities also will cause a relatively small removal of water.

The predicted concentrations of chemicals in water released to Hartwell Reservoir are given in Table III-14. The concentrations of these chemicals should be determined from studies at operating conditions and reported. This program should include at least the following field measurements:

a. Identification and quantities of chemicals discharged. The chemicals measured should include chlorine, boron compounds, and heavy metals, and other chemicals discharged. The concentration should be measured at the point of discharge and at a point downstream in the headwaters of Hartwell Reservoir at water quality monitoring stations K4 and K5. Currently, water quality monitoring stations exist at five points on Hartwell Reservoir and at eight points on Keowee Reservoir. The positions of these stations are shown in Figures 15 and 16 of the applicant's "Supplement to Environmental Quality Features of Keowee-Tr _way .roject," October 1971.

b. The acidity (pH) should be measured at the point of discharge.

2. Air Use

The only use of the air will be for dilution of gases from operation of the nuclear plant and for a small boiler fired with fuel oil. This boiler is for occasional use only. Some localized increase in fog may result from the increased surface temperature of the reservoirs. This should affect areas near the reservoirs, but not affect areas a few miles away.

C. BIOLOGICAL IMPACTS

1. Impact on the Terrestrial Environment

Alteration of 26,000 acres from a terrestrial to an aquatic ecosystem has been the major biological impact in the Keowee-Toxaway area. The main environmental impacts on most of the remaining terrestrial ecosystems can be expected to result from (1) operations of the applicant's subsidiary, Crescent Land and Timber Corporation, (2) game management practices of the South Carolina Wildlife Resources Department, (3) activities of persons who construct permanent residences or who visit the area, and (4) management of transmission line systems.

Typical environmental effects produced by timber management organizations are (1) the favoring of tree species preferred for pulpwood or sawtimber, (2) removal or suppression of species undesirable for their purpose, (3) alteration of species compositions and/or population dynamics of understory vegetation and animals, (4) construction of access roads, (5) development of logging roads, and (6) construction of fire-protection facilities. Land and timber practices of organizations that own an area are better than practices of groups that only buy and remove timber.

Certain wildlife management practices of the South Carolina Wildlife Resources Department can be expected to cause environmental effects in the areas they manage. For example, management of "preferred" species, including deer, bear, boar, and turkey, typically result in increases in the population densities of these species. Management of the white-tailed deer introduced into this area will receive considerable attention. If populations of deer become dense, considerable impact on its preferred, accessible foods will follow, as well as some trampling effects. Wild boar can be particularly damaging to biota, because this omnivorous large mammal, in addition to eating plants (including underground parts) and animals, also roots up large areas. Management of areas by selectively cutting vegetation or by planting food or cover vegetation for wildlife can have local effects on plant and animal populations. Effects of hunters on an area are of academic importance, because such areas are managed to attract hunters. Lead poisoning should not be a problem unless lead shot becomes concentrated in areas used for dove or waterfowl hunting. Stocking deer in the wildlife area as part of a statewide program may have resulted in an increase in incidence of Rocky Mountain spotted fever in the area.[3]

The Coon Branch Natural Area and the understory vegetation of the "virgin forest" may be vulnerable to high populations of large game animals because of browsing, grazing, rooting, trampling, etc. If large populations develop, thought should be given to an exclusion fence if it is desirable to preserve a truly virginal condition of the area.

Housing developments, roads, and similar constructions will essentially subtract from forests and earlier-successional "natural" areas in the region. Vegetation of an area, construction (roads, buildings, picnic tables, restrooms), trampling, and noise. An increase in road kills of animals can be expected under the circumstances due to increased vehicular traffic. Wastes resulting from human activities (sewage, chemicals, garbage, and litter) may create problems that must be handled.

The applicant has attempted to comply with the Department of the Interior and the Department of Agriculture guidelines for transmission line routing and maintenance.[4] We observed that contouring the soil and planting low vegatation (e.g., fescue and lespedeza) on the transmission lines right-of-way in the Keowee-Toxaway area are serving to stabilize the soil and reduce erosion on these recently disturbed areas. The ecological effects of power lines in this project have involved the change of 7800 acres of forest to a habitat type regulated by the applicant or to an acceptable type desired by the landowner. Consequently, some species of plants and animals will benefit from these habitat changes, and others will be eliminated or reduced in numbers. Many mobile species benefit from the presence of ecotones (transmission zone between diverse communities) between power-line areas and surrounding forests and fields (if suitable food and cover are provided under the power lines), because such ecotones contribute to a more varied food base.

The local terrestrial environmental impact of the Oconee Nuclear Station operation will be relatively minor. Some effects, including fog drift and slight temperature rise from heat dissipation in the lake, are expected on land areas in proximity to the discharge of reactor condenser water.

2. Impact on the Aquatic Environment

The position and design of the Station in relation to Keowee Lake indicates that the major effects on aquatic life in Lake Keowee will result from (1) discharge of waste heat from the power plant condensers, (2) entrainment of smaller organisms in cooling water through the plant, (3) impingement of fish on the intake screens, and (4) discharge of water with low levels of dissolved oxygen. Organisms in the headwaters of Hartwell Reservoir will be subjected to increases in temperature and decreases in dissolved oxygen as the hydroelectric plant operates and pulls through the discharge plume from the nuclear plant. The intake structure of the hydroelectric plant is designed to withdraw Lake Keowee water from the surface to the top of the intake structure (approximately 35 ft below the lake surface). This additive thermal discharge probably will favor organisms that can tolerate periodic surges of warmed water, at least at the Keowee headwaters of Hartwell Reservoir.

Radionuclides and chemicals released to the waters just below Keowee Dam are expected to have no discernible effects in Hartwell Reservoir if discharges are limited to the concentrations listed in Tables III-12 and III-14.

a. Chemicals

Normal operation of power plant facilities requires the discharge of certain chemicals. Chemical wastes to be discharged from the station are listed in Table III-14. As described in Sect. III.D.3, chlorine will be used only in the sanitary waste system. The chemical wastes are released to the tailrace of Keowee Dam. Consequently, consideration of chemicals is limited to the headwaters and main body of Hartwell Reservoir.

Chlorine. Studies have shown that an avoidance response was exhibited by rainbow trout at free chlorine levels of 0.001 ppm.[5] Chlorinated sewage effluent was found to be toxic to minnows at concentrations of 0.04 to 0.05 ppm.[6] At a pH of 7.0, 0.08 ppm of residual chlorine killed half of a test population of rainbow trout.[7] Another test population of trout could tolerate 0.23 ppm for only 96 hr.[8] Chlorine concentrations ranging from 0.15 to 0.20 ppm killed 25% of a test population of carp in 12 to 16 days, and golden shiners were killed at 0.08 ppm in 4 hr.[9] The amount of chlorine to be released (5100 gal/day at 0.2 to 1.0 ppm) probably will have no effect on the aquatic organisms in upper Hartwell Reservoir, because instantaneous dilution with the minimum tailrace flow of 30 cfs (extreme case) will reduce the concentration to 0.00026 ppm.

Boron. While boric acid and other boron compounds can kill aquatic life, the concentrations required to elicit such responses are usually very great. Gambusia affinis (mosquito fish) to be stocked by the applicant were found to have TLM's (median tolerance limit) as follows:[9]

Chemical	Temperature (°F)	pH	24-hour TLM (ppm)	48-hour TLM (ppm)	96-hour TLM (ppm)
Boric acid	68-73.4	5.4-7.3	18,000	10,000	5600
Sodium borate	71.6-78.8	8.6-9.1	12,000	8,200	3600

The 24-hour TLM of Lepomis macrochirus was found to be 15,000 ppm at 20°C (68°F).[9]

Hydrazine. Hydrazine is used as an oxygen scavenger and biocide in both the primary and secondary coolant water. Exposure of rainbow trout to 146 ppm of hydrazine hydrate (pH, 8.4; temperature, 13°C or 55.4°F) caused an adverse reaction after 14 to 18 minutes and death in 22 to 35 minutes.

Toxicity tests for the various chemicals are needed for the resident fish species in the headwaters of Hartwell Reservoir, but since the increases in normal river concentration, due to Oconee's discharge (Sect. III), should be less than the concentrations needed to show significance in terms of lethality,[10] little or no effect from these releases might be expected. The effect of temperature elevations on the toxicity level of the discharged chemicals (Sect. III.D.3) also should be investigated.

b. Dissolved Oxygen

The effects of thermal discharge from power stations on the dissolved oxygen (DO) in the receiving waters have been extensively investigated and reviewed by Parker and Krenkel.[11] The general conclusions of the studies reviewed have been that passage of water through the condensers does not alter the dissolved oxygen content to such a degree that detrimental biological effects result. In most cases the decrease in dissolved oxygen is less than 1 ppm.

Measurements of the dissolved oxygen have been made on the Marshall Steam Plant located on Lake Norman, North Carolina.[12] Hypolimnetic waters serve as condenser coolant at this plant. These measurements are the basis for the dissolved oxygen isopleths presented in Sect. III. The Lake Norman studies indicated that during the colder seasons (November through March) the average decrease in dissolved oxygen, from intake to discharge, was less than 1.0 ppm at the immediate site of the discharge. During the warmer months (May through September), the dissolved oxygen concentration of the intake water was lower than that of the average lake area due to the hypolimnetic withdrawal. The discharge concentration decreased to an average (1969-1970) of 5.2 ppm in May, 1.0 ppm in July, and 0.7 ppm in September (measurements at the surface and at 10-ft depth were averaged). Concentrations equal to the ambient lake levels were not reached until 4.8 miles downlake. Analysis indicates that under normal conditions (in September) on Lake Keowee, dissolved oxygen values will be less than 1.0 ppm over 100 acres and that 3000 acres will have less than 5.0 ppm. There is no discharge canal present at this station, and the influence of the discharge configuration and the greater quantity of water available for dilution have not been assessed.

If oxygen levels become critical, detrimental effects on the biota in the affected areas of Lake Keowee will result. The minimal oxygen concentration that the various fish species can tolerate may be influenced by the temperature of the discharged condenser water. A temperature rise from 10° to 20°C (50° to 68°F) resulted in a decreased resistance to lowering of oxygen concentration in perch, and in rainbow trout, resistance to decreased oxygen was lowered when a temperature rise from 10° to 15°C occurred.[13] Avoidance of the discharge area by large fish when oxygen concentrations are low should occur before the lethal oxygen minimum is reached.[14] Nonmobile eggs or less mobile fry may not be able to escape. In such an oxygen-deficient environment, it can be expected there will be no organisms with high oxygen requirements, either because mobile organisms will avoid this area or nonmobile organisms will be killed.

c. Thermal Effects

As described in Sect. III, large amounts of heat will be discharged to Lake Keowee during the operation of the Oconee Nuclear Station. The cooling water, discharged under normal operating conditions at a rate of 3800 cfs, will have a temperature ranging from 22°F above the surface temperature in January to essentially the same as the ambient lake surface temperature in April-July. Under both normal and extreme conditions, substantial proportions of the total lake area will be warmed.

State water quality standards set for South Carolina[15] specify that water temperatures after adequate mixing may not exceed 90°F at any time, nor shall the water temperature be more than 3°F above the ambient monthly average temperature of the lake. The mixing zone for Lake Keowee has not been defined and will be determined after consultation with the applicant and the Environmental Protection Agency.

The duration of exposure, in addition to the excess temperature, is important in analyzing the possible effects on the biota within the affected area. Calculations (Table V-1) indicate that if an organism were entrained in the thermal plume near the discharge pipes, exposure to excessive temperatures could last for considerable time periods.

Thermal additions in the Hartwell headwaters (Keowee Dam tailrace) may contribute to a reduction in habitat for cold-water species in downstream areas. The effects of the thermal discharge from the Station will be felt in the Hartwell headwaters when the Keowee hydroelectric station is in operation. Little dilution water will be available in the upper Hartwell Reservoir, and the excess temperature released to the hydroelectric station tailrace, during August and September, can be expected to warm Hartwell 3°F or more in an area that will extend to below the point where the Little River arm converges with the Keowee River arm in Hartwell Reservoir.

Biological effects of a given temperature or temperature pattern may be different in different populations, at different ages, and in different life cycle stages, and such effects may depend on the temperature history of the individuals tested, as well as effects of other environmental factors.[16] Organisms usually experience daily or seasonal temperature fluctuations in their natural habitat, and these changes can be important prerequisites for completion of their life cycles. The temperature range tolerated by many species of organisms may be relatively narrow during early developmental stages (eggs and larvae), widening somewhat during immature stages, and finally narrowing again in adults. Often the tolerance range is more restricted during the reproductive phase than during other phases. Many of the mobile organisms, including fish, some zooplankton, and benthic animals, may avoid lethal temperatures by vertical and/or horizontal migration into a more suitable environment. The planktonic organisms are more susceptible to fluctuating temperatures from power plant operations, because they are dependent on water currents for a good deal of their mobility.

Table V-1. Oconee Nuclear thermal plume, time-temperature relationship

Time (min)	Monthly temperature[a] (°C)							
	Jan.	Feb.	Mar.	Aug.	Sept.	Oct.	Nov.	Dec.
60	18.7	19.4	21.1	31.1	33.0	26.8	21.3	16.3
120	18.7	19.4	21.1	31.1	32.9	26.8	21.3	16.3
180	18.6	19.3	21.0	31.1	32.9	26.7	21.2	16.2
240	18.5	19.3	20.9	31.0	32.8	26.7	21.2	16.2
300	18.4	19.2	20.9	31.0	32.7	26.6	21.1	16.1
360	18.3	19.1	20.8	31.0	32.6	26.4	21.0	16.0
420	18.0	18.9	20.6	30.9	32.4	26.3	20.8	15.8
480	17.8	18.7	20.4	30.9	32.1	26.1	20.6	15.7
540	17.4	18.3	20.1	30.8	31.5	25.8	20.3	15.4
600	16.7	17.9	19.7	30.7	29.8	24.1	19.5	15.0
660	13.9	16.5	19.1	30.6	28.4	22.6	17.3	12.9
720	11.8	14.6	17.3	30.3	27.4	21.4	15.9	11.3
780	10.3	13.3	16.2	30.1	26.8	20.6	14.7	10.0
840	9.2	12.3	15.3	29.8	26.3	19.9	13.9	9.1
900	8.4	11.6	14.6	29.6	25.8	19.5	13.3	8.4
960	7.8	10.9	13.9	29.3	25.4	19.1	12.8	7.9
1020	7.2	10.3	13.1		25.2	18.7	12.3	7.4
1080	6.7	10.0	13.0			18.6	12.0	7.1
Ambient	6.5	9.8	13.0	29.2	25.1	18.5	11.9	6.8

[a]The missing months do not have plumes that differ significantly from the ambient lake temperature.

(1) Freshwater Algae

A few species of aquatic algae can tolerate extremely high or low temperatures. It is unlikely that a species will flourish at all temperatures between the extremes it can tolerate; rather, there is a particular optimum temperature, less than the upper tolerance limit, at which the organism thrives. Several species of algae can tolerate water temperatures as high as 85°C (175°F), as found in thermal springs,[17] but optimal temperatures for the same species may range from 51° to 56°C (124° to 132°F).[18] Diatoms can tolerate temperatures near 0°C (32°F). Ulothrix zonata, a green algae can produce reproductive bodies (zoospores) at temperatures near 0°C (32°F).[19]

In unpolluted streams, diatoms grow best at 18°-20°C (64°-68°F), green algae at 30°-35°C (86°-95°F), and blue-green algae at 35°-40°C (95°-104°F).[20] Natural or artificial temperature increases, then, could induce predominance changes of species from diatoms to green algae to blue-green algae. Patrick has demonstrated, however, that no reduction in species or numbers occurred when the discharged water caused a temperature rise of 94°F or less in the receiving waters.[21]

The exposure time of phytoplankton to elevated temperature in Lake Keowee may be long enough to cause shifts in dominance from diatoms to green algae to the undesirable blue-green types of algae in small areas of the lake. The extent of this change cannot be predicted without more information on the species composition throughout the year. Algae attached to the discharge structure will be most apt to experience such changes, because they will be almost continually exposed to elevated temperatures. The surface areas affected will be local and probably will represent a small fraction of the total algal productivity in the system.

The effect of entrainment through the condensers during operation of a power plant is usually determined by examining the photosynthetic capacity of the algae. Generally, studies have indicated that the photosynthetic process is depressed as the temperature rises.[22] Results for the Chalk Point Plant showed that temperature rises of 8°C (14°F) stimulated photosynthesis when the natural water temperature was 16°C (60.8°F) or less but inhibited photosynthesis when temperatures were 20°C (68°F) or higher.[23] Studies on Lake Norman showed that, generally, photosynthetic rates were similar for lake and effluent water when incubated at the prevailing temperature for each source. Although some differences were significant, the effects of the skimmer wall on displacement of normal populations were not analyzed.[12]

(2) Zooplankton

Temperature increases tend to stimulate zooplankton growth during cooler seasons and to cause mortality during the late summer season when maximum temperature limits are exceeded. The maximum thermal tolerances of the majority of zooplankton species which have been studied range between 86° and 95°F.[24]

The impact of entrainment of organisms in the cooling water depends upon that proportion of the total receiving water volume that is diverted through the condensers. Potentially there are serious ecological implications at sites where a large proportion of a lake is recirculated within a short time for cooling water, but Lake Keowee is large enough for recovery of organisms with short regeneration times. Concentrations of zooplankton and phytoplankton were reduced after passage through the condensers at Merrimack Power Station.[23] Green and blue-green algae populations increased in the canal and were related to temperature. The effects were most prominent when the condenser cooling water was elevated to temperatures above 37.8°C (100°F) in July. Studies at the Turkey Point Power Plant in July 1969 indicated that 80% of the total zooplankton was dead at discharge temperatures of 40°C (104°F) but that mortality was reduced to 12% and 7% when the discharge temperature was 33°C (91.4°F).[25]

The precise effects of exposure of zooplankton populations to the elevated temperatures in the condensers of this station and in the thermal plume cannot be evaluated until the conposition of the zooplanktonic organisms is determined. However, it can be anticipated that during the months of August and September, the lengthy exposure to temperatures approaching or exceeding the thermal tolerance limits will cause a reduction in zooplankton organisms in the thermal plume from the discharge. The effect of entrainment on these organisms will be related to the quantities of organisms withdrawn.

(3) Bottom Organisms and Insects

River-bottom plants and animals decreased in number when the water temperature exceeded 30°C (86°F) in a study on the effect of warm water discharge to the river.[26] A 35°C (95°F) water temperature was found to cause a detrimental effect on the macroinvertebrate fauna of the Delaware River, especially the caddis fly, many of which were killed, while those that survived were extremely sluggish.[27] Studies on the shift of the composition of macroinvertebrate populations showed that no immediate kills resulted from a thermal increase of 14°C (25°F). However, persistent exposure to 35°C (95°F) over a 24-hr period caused a shift in the population composition.[28] In a study on the York River in Virginia, the benthic invertebrate populations were affected by thermal discharge, especially during the months of normally high temperatures.[22] The tolerance limit for a wide variety of adult organisms in the benthos appears to be close to 32°C (90°F), with extensive losses in numbers and diversity of organisms accompanying further temperature increases.[26] The heated effluent may alter the benthic communities in the immediate area of the discharge, but effects in the rest of Lake Keowee probably cannot be detected because the heated plume will rise to the surface or remain at an intermediate level.

The meroplankton stages (free-swimming larval stages of sessile forms) may offer considerable evidence of the thermal vulnerability of important forms. If heated waters are dispersed as a thin layer over cooler water, the diurnal migrations of zooplankters may also be influenced. Many microcrustaceans swim to the surface and feed at night and descend to cooler waters during the day. These animals may encounter a hot layer at the surface, and the response of such migrating species is unknown.

Thermal acclimation is of considerable significance to insects in their natural habitats. Times during which there is greatest danger of exposure to high temperatures are usually preceeded by periods during which temperatures rise or fall gradually. When extreme temperatures are approached, the insect in nature may already be acclimated to them. The specific time of day when maximum temperatures are encountered in nature is also usually preceded by several hours of gradual warming, allowing physiological acclimation to occur. The continued effects of these processes may increase the mortality threshold by a degree or more.[29]

Animals in areas where the water is affected by heated effluents may be prevented from reproducing or developing. Normal development of <u>Aedes</u> larvae does not occur after an exposure to 42°-44°C (108°-111°F). Sublethal temperature exposures seemingly destroy the internal developmental mechanism, and exposure to high temperatures may delay development, resulting in a later emergence.[30] Extremely high summer temperatures have been observed to suppress development of <u>Anopheles</u> larvae until early fall.[24] Caddis flies emerged two weeks earlier in heated zones of the Columbia River than in areas upstream of the heated discharge.[31]

The injurious effects of high temperature on immature stages of Anopheles quadrimaculatus apparently are cumulative. Pupae raised at 34°C (93.8°F) would not transform to adults at 35°C (95°F). Those kept at 25°C (77°F) would transform normally at 35°C. Seemingly, the more time spent at a given high temperature, the lower the developmental efficiency at that temperature.[32] Midge larvae were noted to be less abundant below a heated discharge where temperatures up to 28°C (81°F) were encountered. It was also pointed out that a hot surface layer of water could eliminate insects which come up to feed or emerge.[33]

In balanced ecological systems, the crustacea are essential links in the food chain of freshwater environments. Planktonic forms (e.g., Cladocera and Copepoda) can be found in dense populations. The presence or absence of a copepod species depends in part upon environmental temperature. Although some species of copepods were found above and below power plant outfall, species composition and diversity generally changed with temperature elevations of 7°-10°C (13°-18°F).[34] Seventeen to nineteen percent of the copepods and cladocerans were dead in samples from the discharge outfall at the Millikin Plant of Cayuga Lake.[35] The exposure time was not taken, but 8°-15°C (14.4-27.7°F) elevation was noted in the cooling water temperature.

The ecological consequences of lethal temperatures are obvious; the affected species will be eliminated from the heated area. Increases or decreases in an aquatic organisms's development rates may have profound effects on the aquatic ecosystems, in that more or less food production for invertebrate-feeding fish could upset the normal sequence of events upon which the ecosystem depends.

(4) Fish

Most fishes are poikilothermal animals whose body temperature follows changes in environmental temperatures rapidly and precisely. In most fishes the body temperature varies from that of the surrounding water by a small amount (0.9°-1.8°F).[36] A fundamental requirement, therefore, of fish is that external temperature should not vary greatly from temperatures of internal tissues.[37]

Adult fish are usually able to select their preferred temperatures, unless they are trapped in shallow waters or forced to migrate through heated or chilled areas. Temperature fluctuations may affect organisms in a variety of ways: (1) metabolic rates are changed, (2) reproduction is affected, and (3) spatial distribution may be increased or decreased. Temperature not only influences the distribution of a single species, it may modify the species composition of a community or an ecosystem. Since the perpetuation of game fish necessitates the maintenance of an early succession stage[38] (as opposed to a natural movement toward climactic-species dominants such as carp, catfish, etc.), the identification of the temperature requirements needed to maintain such a community is important.

In arriving at temperature criteria, to protect the species in a particular lake, it is necessary to estimate how far the ambient or natural temperature of that particular body of water may be altered without inducing adverse effects upon the biological species present. The criterion for the lake should be based on the temperature requirements of the indigenous species which are deemed important. Those species selected should include all life forms that may be directly or indirectly important in food chains or which interact with the species of interest.

Each species possesses a range of temperature that will ensure survival. This thermal range is determined by metabolic adjustments made while exposed to a previous holding (or acclimation) temperature. The capacity to acclimate is important in determining the upper thermal tolerance of a particular species and is dependent on the genetic background, environmental history, physiological condition, and age of the organisms involved.[16] Acclimation to various temperatures may involve alterations in diurnal vertical movements, migration, or other behavioral aspects, as well as biological rhythms.[26] Increased heat resistance is acquired usually at a rapid rate in the temperature range from 26° to 30°C (79° to 86°F), although a lag period probably occurs during which virtually no change takes place in the upper lethal temperature.[39]

The extreme ends of the temperature range are bounded by lethal thresholds which are quantitatively defined as the temperature at which 50% of the sample population will survive. These lethal thresholds are generally termed as "incipient lethal temperatures." Temperatures exceeding these threshold levels are considered extreme, and the organisms do not survive indefinite periods of exposure to them. Acclimation to a low temperature tends to alter the upper thermal limits downward, and acclimation to a high temperature tends to shift the upper limits upward. In this manner the ability to acclimate affects the temperature tolerance range. Tolerance limits and preferred temperatures for some fish in Lake Keowee and Hartwell Reservoir are shown in Table V-2.

An increase in temperature above the incipient lethal level does not mean that the organisms present will die instantaneously, but that death will occur if they are held at that temperature over an indefinite period of time. Thus the length of time that an organism can tolerate extreme temperature is also necessary in establishing criteria to protect aquatic species. The length of time (t, in minutes) that 50% of a population can survive an extreme temperature (T, in °C) can be calculated from a regression equation as follows:

$$\log_{10} t = A + BT, \qquad (1)$$

where A and B are intercept and slope, respectively, of the graph of log t versus T. The values of both A and B will not only be species dependent but will be influenced by the acclimation temperature of each exposure temperature.

The equations derived from research on thermal tolerance predict 50% mortality, and the established threshold temperatures reflect this degree of mortality; an added safety factor is needed to assure <u>no</u> mortalities. Several studies have indicated that reduction of the upper temperature threshold by 2°C (3.5°F) results in no mortalities within an equivalent exposure duration.[40]

The 2°C safety factor can be incorporated into Eq. (1) as follows:

$$1 \geq \frac{t}{10^{A+B(T+2)}} . \qquad (2)$$

When the right side of the equation for any particular species exceeds unity, then the species is considered to have been subjected to a temperature which may cause mortality.

Effects of changing temperatures in the plume can be estimated by summing the effects of incremental exposures for short time periods.[16] The thermal plume at the station is considered to be composed of several time intervals, each with an average temperature (Table V-1). Each time period is included in the calculation as if it were a single exposure; then the calculated values for all time periods are summed, as follows:

$$1 \geq \frac{t}{10^{A+B(T+2)}} + \frac{t'}{10^{A+B(T'+2)}} + \cdots \frac{t^n}{10^{A+B(T^n+2)}}, \qquad (3)$$

Table V-2. Tolerance limits and preferred temperatures for certain fishes found in Lake Keowee and Hartwell Reservoir

Fish	Acclimated to (°F)	Upper limit (°F)	Final preferendum (°F)
Micropterus salmoides	68.0	89.6	86.0–89.6
(largemouth bass)	86.0	93.2	
	86.0	97.5	
Lepomis macrochirus	50.0	82.4	90.1
(bluegill)	59.0	87.3	
	68.0	88.7	
	86.0	92.8	
	86.0	96.9	
Lepomis gibbosus	50.0	82.4	88.7
(sunfish)	86.0	95.2	
Pomoxis nigromaculatus	45.0	84.0	
(black crappie)			
Notropis crysoleucas	59.0	82.3	88.5
(golden shiner)	68.0	89.6	
	77.0	91.8	
	86.0	93.5	
	86.0	95.0	
Cyprinus carpio	68.0	88.0–93.0	89.6
(carp)	78.8	96.3	
Dorosoma cepedianum	77.0	93.8	83.0
(gizzard shad)	86.0	96.6	
	95.0	98.6	
Stizostedion vitreum	45.0	84.0	73.0
(walleye)			
Perca flavescens	41.0	70.3	75.6
(yellow perch)	50.0	77.0	
	59.0	81.9	
	77.0	85.5	

This table compiled from data taken from:

1. C. B. Wurtz and C. E. Renn, *Water Temperature and Aquatic Life*, prepared for Edison Electric Institute Res. Project No. 49, 1965, 99 pp.

2. "Temperature and Aquatic Life," Laboratory Investigation No. 6, Technical Advisory and Investigation Branch, Technical Services Program, Federal Water Pollution Control Administration, U.S. Department of the Interior, 1967.

3. George W. Bennett, "The Environmental Requirements of Centrachids with Special Reference to Largemouth Bass, Smallmouth Bass and Spotted Bass," in *Biological Problems in Water Pollution*, Third Seminar, 1962, Robert A. Taft Sanitary Engineering Center, Cincinnati, pp. 156–159, 1965.

where t, t', ... t^n are the successive time intervals in minutes and T, T', ... T^n are the average temperatures in each successive interval. This procedure is followed until the upper lethal threshold temperature, minus 2°C (minus 3.6°F), is exceeded or until the total plume has been considered. Information needed for predicting the mortality of a number of species of fish found in Lake Keowee is presented in Table V-3. The information includes (1) upper lethal thresholds, (2) coefficients A and B for the thermal resistance equation, and (3) the acclimation temperature (which is considered to be the ambient lake temperature outside the influence of the plume).

Estimates, using Eq. (3), of the effects on fish that might pass through or become trapped in the thermal plume are shown in Table V-3. When the ratio (column 7) exceeds 1.0, then it is assumed that the upper temperature tolerance level has been exceeded and that death will occur. Species analyzed were bluegill, largemouth bass, brown bullhead, channel catfish, and yellow perch.

During the month of September, when the plume temperature is highest, the ratio numbers all exceed 1.0 when the 2°C safety factor is applied. Thus, fish that become trapped in the plume and cannot escape to cooler areas of the lake will be subjected to excessive temperatures, and some mortality may occur. With the exception of the yellow perch, the ratios are less than 1.0 when the 2°C safety factor is not applied. The degree of mortality, then, can be expected to be less than 50% of the population but greater than no mortality. In addition to fish that are affected by the plume, any larvae or other life stages which pass through the condenser not only will be subjected to the increase in temperature in the condensers but will most assuredly be trapped in the plume after discharge.

Temperature, however, need not kill the fish directly for the effects to be lethal or damaging. Brook trout have been found to be comparatively slow in catching minnows at 63°F and virtually incapable of catching minnows at 70°F, resulting in the trout starving to death.[26] Occurrence of a fungus of the family Saprolegininiaceae on largemouth bass, bluegill, white bass, and crappie was noted in the Marshall Steam Plant discharge cove but not in other areas of the lake and was apparently associated with the warm-water discharge.[12] In addition the weakening of a species by the stresses of high temperature may make it easier prey for its predators. A small fish whose avoidance responses are slowed at

Table V-3. Time-temperature table for fish mortality

Species	Acclimation temperature[a] (°C)	Plume temperature (°C)	Time exposed (min)	A[b]	B[b]	Safety factor	Ratio	Upper threshold (°C)
Lepomis macrochirus	13.0	21.1	60	25.2708	0.7378	0	0.0000	30.5
	13.0	21.1	60	25.2708	0.7378	2	0.0000	
	18.5	26.8	120	28.0663	0.7826	0	0.0000	32.0
	18.5	26.8	120	28.0663	0.7826	2	0.0035	
	25,1	33.0	60	23.8733	0.6320	0	0.0577	33.0
	25.1	32.9	180	23.8733	0.6320	0	0.2072	
	25.1	31.5	540	23.8733	0.6320	0	0.2675	
	25.1	33.0	60	23.8733	0.6320	2	1.0589	
	29.2	31.1	180	25.7732	0.6581	0	0.0034	33.8
	29.2	31.1	180	25.7732	0.6581	2	0.0184	
Micropterus salmoides								
Juvenile	18.5	26.8	120	35.5107	1.0112	0	0.0000	32.0
	18.5	26.8	120	35.5107	1.0112	2	0.0004	
	25.1	33.0	60	19.9918	0.5123	0	0.0492	33.0
	25.1	32.9	180	19.9918	0.5123	0	0.1805	
	25.1	31.5	540	19.9918	0.5123	0	0.2560	
	25.1	33.0	60	19.9918	0.5123	2	0.5210	
	25.1	32.9	180	19.9918	0.5123	2	1.9101	
	29.2	31.1	180	17.5645	0.4200	0	0.0043	33.7
	29.2	31.1	180	17.5645	0.4200	2	0.0392	
Adult	18.5	26.8	120	50.8091	1.4638	0	0.0000	32.5
	18.5	26.8	120	50.8091	1.4638	2	0.0002	
	25.1	33.0	60	26.3169	0.6846	0	0.0113	34.5
	25.1	32.9	180	26.3169	0.6846	0	0.0403	
	25.1	33.0	60	26.3169	0.6846	2	0.2644	
	25.1	32.9	180	26.3169	0.6846	2	0.9419	
	25.1	31.5	540	26.3169	0.6846	2	1.1656	
Perca flavescens	6.5	18.6	180	7.0095	0.2214	0	0.6383	21.3
	6.5	18.0	420	7.0095	0.2214	0	0.3971	
	6.5	18.0	420	7.0095	0.2214	2	1.1009	
	11.9	21.0	300	17.6536	0.6021	0	0.0000	27.3
	11.9	21.0	300	17.6536	0.6021	2	0.0564	
	13.0	20.9	300	12.4149	0.3641	0	0.0000	27.7
	13.0	20.9	300	12.4149	0.3641	2	0.0251	
	18.5	26.8	120	15.3601	0.4126	0	0.0000	28.5
	18.5	26.8	120	15.3601	0.4126	2	0.0400	
	18.5	26.6	360	15.3601	0.4126	2	0.1392	
	25.1	33.0	60	21.2718	0.5909	0	1.0140	29.7
Ictalurus nebulosus	6.5	18.6	180	14.6802	0.4539	0	0.0000	27.8
	6.5	18.6	180	14.6802	0.4539	2	0.0008	
	11.9	21.0	300	16.4227	0.4842	0	0.0000	29.0
	11.9	21.0	300	16.4227	0.4842	2	0.0019	
	13.0	20.9	300	28.3281	0.8239	0	0.0000	31.0
	13.0	20.9	300	28.3281	0.8239	2	0.0007	
	18.5	26.6	300	23.9586	0.6473	0	0.0000	32.5
	18.5	26.6	300	23.9586	0.6473	2	0.0011	
	25.1	33.0	60	22.4970	0.5737	0	0.0163	33.8
	25.1	32.9	180	22.4970	0.5737	0	0.0593	

Table V-3 (continued)

Species	Acclimation temperature[a] (°C)	Plume temperature (°C)	Time exposed (min)	A[b]	B[b]	Safety factor	Ratio	Upper threshold (°C)
	25.1	31.5	540	22.4970	0.5737	0	0.0796	
	25.1	33.0	60	22.4970	0.5737	2	0.2204	
	25.1	32.9	180	22.4970	0.5737	2	0.7997	
	25.1	31.5	540	22.4970	0.5737	2	1.0736	
	29.2	31.0	360	24.2203	0.5917	0	0.0014	34.8
	29.2	31.0	360	24.2203	0.5917	2	0.0073	
Ictalurus punctatus								
Juvenile	25.1	33.0	60	34.7119	0.8816	0	0.0000	36.6
	25.1	33.0	60	34.7119	0.8816	2	0.0084	
	29.2	31.0	360	32.1736	0.7811	0	0.0000	37.8
	29.2	31.0	360	32.1736	0.7811	2	0.0001	
Adult	13.0	20.9	300	34.7829	1.0637	0	0.0000	30.4
	13.0	20.9	300	34.7829	1.0637	2	0.0000	
	18.5	26.6	300	39.4967	1.1234	0	0.0000	32.6
	18.5	26.6	300	39.4967	1.1234	2	0.0000	
	25.1	33.0	60	46.2155	1.2899	0	0.0135	33.5
	25.1	32.9	180	46.2155	1.2899	0	0.0435	
	25.1	31.5	540	46.2155	1.2899	0	0.0499	
	25.1	33.0	60	46.2155	1.2899	2	5.1186	

[a]Ambient lake temperature taken from Table V-1.
[b]Data supplied by C. C. Coutant, Ecological Sciences Division, Oak Ridge National Laboratory.

elevated temperatures may be eaten by a more heat-tolerant predator; thus the intolerant species may be reduced in numbers indirectly by elevated temperatures through the action of predators.

Fish attracted to discharge areas may be induced by the higher temperatures to spawn earlier than normal. Temperature is considered as an important factor in initiating spawning by many species of fish. Premature spawning or continuous spawning induced by the absence of the normal thermal periodicity may have many effects on the biological communities in the receiving waters, such as loss of progeny due to lack of proper food or species changes brought about by the overabundance of stenothermal species which immigrate into the heated effluent to breed. Few of the possible changes have been studied, and most investigations have been limited to observations that premature spawning does occur.

Bennett reported that nest construction by the largemouth bass begins at 56°F and spawning usually starts at 66°F.[41] Heating of the water in the shallow areas (1 to 4 ft) where the largemouth bass, and most other centrarchids, spawn will probably cause reproduction to occur earlier than in unaffected parts of Lake Keowee. Eggs or fry may subsequently be destroyed if exposed to colder temperatures resulting from a decrease in the discharge from the power plant, or if swept to lower depths or to more remote parts of the lake.

A small number of eggs observed in the discharge canal of Marshall Steam Plant in late February was believed to mark the onset of spawning. Pump tests soon after caused increased water discharges and decreased temperatures, and spawning apparently halted, since no additional eggs were seen.[42] White suckers (*Catostomus commersonni*) spawned earlier in the discharge canal at the Martin's Creek Power Plant than elsewhere in the Delaware River.[43] Ovaries in the white catfish and brown bullhead were found to be developing earlier in the discharge canal of the Connecticut River.[44] Cold-blooded aquatic organisms in areas warmed by heated effluents have been noted to grow at an accelerated rate, attain early sexual maturity, and have a shorter life span. Growth in warmer waters has also resulted in a decrease in adult size.[45] Fish that are attracted to warm water discharge areas of power plants and choose (by their temperature preference) to remain there may experience increased metabolic rates compared to seasonal rates normally experienced by that species. Winter accumulations of brown bullheads and white catfish in the discharge canal at the Connecticut Yankee Power Plant exhibited a significant decline in the weight-to-length ratio.[46] Fish tagged in winter and recaptured four months later had lost an average of 20% of their weight. Comparisons of tagged and untagged fish indicated that the weight loss was indicative of the entire canal population. River populations experienced some weight loss also but at a much lower rate.

The death of fish from exposure to temperature extremes is generally an uncommon occurrence. The more normal situation is the attraction of fish to warmed water during the cooler months and avoidance of upper thermal extremes in the warmer summer months. Studies at the Connecticut Yankee Plant[46] indicate that fish moved out of the discharge canal when temperatures reached 35° to 39°C (94-102.2°F) and returned when the water returned to the normal temperature of 34° to 35°C (92.2-94°F). Cessation of heating caused almost all the fish to move out of the discharge. Although temperature elevations during winter months may actually bring the temperature closer to optimum or preferred temperature for important species, metabolic acclimation to these higher levels can preclude safe return of the organism to ambient temperatures should the artificial heating suddenly cease (due to plant shutdown for repairs or fuel loading), or should the organism be driven from the heated area. Rapid onset of low temperatures probably results in a reduction in the ability of fish to acclimate and results in greater mortalities than are due to heat.[47] Deaths resulting from the inability of fish to rapidly acclimate to lowering temperature have been reported.[48,49] Consequently, should all three units of the station shut down quickly during times when ambient water temperatures are low, considerable loss of aquatic life would ensue. However, at this station, normally only one unit will be shut down at one time, and the heat discharged by the other two units will prevent extreme temperature drops in the discharge water.

d. <u>Mechanical Effects</u>

Mechanical damage to adult fish from the intake flow during normal Station operation will be minimized by the low intake velocity of 0.4 fps. The slow movement will allow most fish to move away from the retaining screens. The 3/8-in. openings in the fixed screens will exclude large fish, but some small ones will be drawn into the plant and through the condensers. A maximum velocity of 1.0 fps at the intake screens is projected for times of maximum drawdown, and it can be anticipated that fish could be pulled against the screens at this flow rate.[50]

The effluent discharge areas at both the nuclear plant and the hydroelectric plant are continually exposed to accelerated flow velocities, and the discharge velocity (4 fps) at the nuclear station discharge outfall will cause scouring and will probably eliminate all benthic organisms in the immediate area. The affected area, however, will be minute when compared with the total available habitat.

Damage to aquatic organisms will probably occur when the turbines at Keowee and Jocassee Dams are running. The velocities at the hydroelectric plant intakes will be approximately 22 and 17.5 fps, respectively, and will in all probability entrain some organisms. In addition, pumping water into Jocassee reservoir from Lake Keowee will be expected to cause some damage, since the intake velocity during the pumped storage operation will be 14 fps. Although such mortality may be attributable directly to the hydroelectric plants, studies should be made to insure that operation of the nuclear plant is not increasing the mortality (e.g., by attracting organisms to warm water or by their movement away from zones of low dissolved oxygen).

The presence or trapping of threadfin shad, a warm-water species, in the intake canal during winter may present a problem. If the shad die in large numbers, due to low temperatures in winter, as may happen many times at this latitude, the fixed intake screens may become clogged. The applicant has stated: "If winter kills of threadfin shad should result in accumulations on the intake screen, it is expected that disposal would be by land burial."[51]

Lake drawdown is projected as 3 ft and 6 ft for Lakes Keowee and Jocassee, respectively, when operation of the pumped storage facility occurs during periods of extended drought. Normal lake level fluctuations will be less than 2 ft for Lake Keowee and less than 4 ft for Jocassee. As shown in Appendix II-4, most of the species found in Lake Keowee (and presumably in Jocassee) spawn in the shallow water, and thus drawdown during the spawning months will result in loss of some eggs due to desiccation, heat, or predation. If the heated water discharge induces early spawning in some areas of the lake, then during these periods it may be desirable to control the lake levels so as to minimize mortality to eggs.

3. Biological Monitoring

The applicant states that he will monitor temperature and dissolved oxygen of the intake and discharge water and will institute a program to study productivity in the lake at strategic sites (not specified) by measuring biomass accumulations. "As outlined in this supplement, environmental baseline data have been established and are being continually updated. Through continuing environmental studies, such as Duke's limnological program, changes produced by continued construction and/or operation of Oconee Nuclear Station can be detected and assessed."[52] Harold W. Brown, Columbia University, and Charles M. Weiss, University of North Carolina, are listed as consultants. Dr. Weiss contributed a section of periphyton measurements to the Lake Norman studies and presumably will do so on the Lake Keowee project.

A project is planned by Robert M. Jenkins, Director of the National Reservoir Research Program, Department of the Interior, to study the "effects of heated water and pumpback operations on Keowee and Jocassee Reservoir fishery resources."[53] Included are plans to conduct quantitative sampling of plankton and benthos populations. Specific plans have not been formalized as of this date. Meetings are scheduled for March 29th, 1972, at Clemson, South Carolina, to further plan for this research effort.[54]

While it is evident that some plans are being made to study the effects of operation of Oconee Nuclear Station on the aquatic biota in Lake Keowee, no preoperational data (other than the fish inventories by the South Carolina Wildlife Resources Department fishery biologists) have been collected for Lake Keowee, nor have any detailed research plans been submitted.

The ecological studies performed so far are not adequate to supply data required for a comprehensive analysis of ecological impacts caused by plant operations. It is clear that to determine ecological significance of condenser effluent, the observed effects must be related to the population density, dynamics, and regeneration times of the aquatic organisms present in the affected areas. Additional information is needed before expanded detailed assessments of impacts on terrestrial and aquatic biota in and around Keowee Lake and Hartwell Reservoir can be made. It is evident that much of the information cannot be provided in the time before the first nuclear unit is scheduled for operation. However, the Applicant should start immediately to accumulate this information, in documentable form, in order to assess the impact required in subsequent reviews.

1. Inventories and biomass estimates of plants and animals in Lake Keowee and the upper reaches of Hartwell Reservoir, including the remnant of Keowee River between the two lakes, should be collected. Specific data on fish, zooplankton, insects, arthropods, phytoplankton, and rooted vegetation densities are needed. Seasonal studies, scheduled to measure critical components in life cycles, should be made of species and populations of organisms at various depths and locations in Keowee Lake and the upper part of Hartwell Reservoir, including the Keowee River. Particular attention should be paid to the thermal plume area and the water just below Keowee Dam. Effects of increased water temperature on chemical toxicity, resistance to lowered oxygen concentration, and increased susceptibility to parasites and disease need to be examined. Samples should be made in Lake Keowee of organisms in the intake canal and at the discharge outflow, as well as the physical and chemical water measurements to be taken by the Duke Power Company. Records should be kept of dead organisms on the intake screens and on the condition of organisms after transit through the cooling water system. Samples should be taken at times that coincide seasonally with important seasonal biological events, and measurements also should be made at night as well as during the day because of vertical and diurnal movements of organisms.

2. Inventories and biomass of animals (mammals, birds, reptiles, insects, amphibians, etc.) in the Keowee-Little River watershed are required. The animals and plants in the terrestrial parts of the Keowee-Toxaway Project should be subjected to careful accounting. Of particular concern is that rare species or those with specialized habitats are not endangered by the forestry or wildlife management programs.

Preoperational and operational studies should not be done by a separatist approach. That is, biological research should be integrated with the physical and chemical studies in such a manner that truly ecological analyses can be made. Biological factors interact with physical and chemical factors in so many ways that studies of living environments without reference to nonliving environments are oversimplified and misleading.

D. RADIOLOGICAL IMPACT OF PLANT OPERATIONS

The radiological impact from radioactive effluents released as gases and liquids from the three reactor units at the Oconee Nuclear Plant is assessed for individuals and the population within a 50-mile radius of the plant. The releases of these effluents will be as low as practicable, in accordance with 10 CFR 50,[55] and within the limits of 10 CFR 20.[56]

1. General Considerations

Potential pathways for radiation exposure due to radionuclides outside the body (external exposure) and radionuclides deposited within the body (internal exposure) that originate in radioactive effluents released by the plant are presented schematically in Fig. V-1. Those shown in the figure are not exhaustive, but they illustrate the principal pathways of exposure based on experience.

Immersion in air containing radionuclides results in external exposure, and inhalation of air containing the radionuclides results in internal exposure. In addition, radionuclides deposited on vegetation and on the ground can result in direct external exposure and in internal exposure through various food chains.

Swimming in rivers or lakes containing diluted liquid radioactive effluents can result in external exposure. Utilization of such water for drinking, fishing, and irrigation can result in internal exposures.

a. Dispersion of Gaseous Effluents

Average annual concentrations of radionuclides contained in the air and deposited on the ground at distances up to 50 miles from the plant have been estimated using an atmospheric transport model[57] incorporated in a computer program.[58] The deposition velocities used in the calculations were 10^{-6} cm/sec for the noble gases (krypton and xenon), 10^{-3} cm/sec for methyl iodide (CH_3I), and 1 cm/sec for molecular iodine (I_2) and particulate matter (rubidium and cesium).[59-62] In this model, the reduction of radionuclide concentrations in the air at ground level by radioactive decay and deposition are taken into account. Because the gaseous effluent will be released from building vents only 200 ft above grade, the ground level concentrations were calculated for a surface release. The site meteorological data used in the model are discussed in Sect. II and Appendix II-1.

b. Dispersion of Liquid Effluents

Liquid effluents from the plant will be released in the tailrace of the Keowee Hydroelectric Plant. After release into the tailrace, the effluent will be diluted by an average flow of 1100 cfs.[63] This water combines with the Keowee River which flows toward the Clemson-Pendleton water intake 13.7 miles downstream. Before reaching the intake, the concentration of radionuclides in the water will be further reduced by an additional stream flow of 357 cfs from tributaries of the Keowee River and by radioactive decay during a

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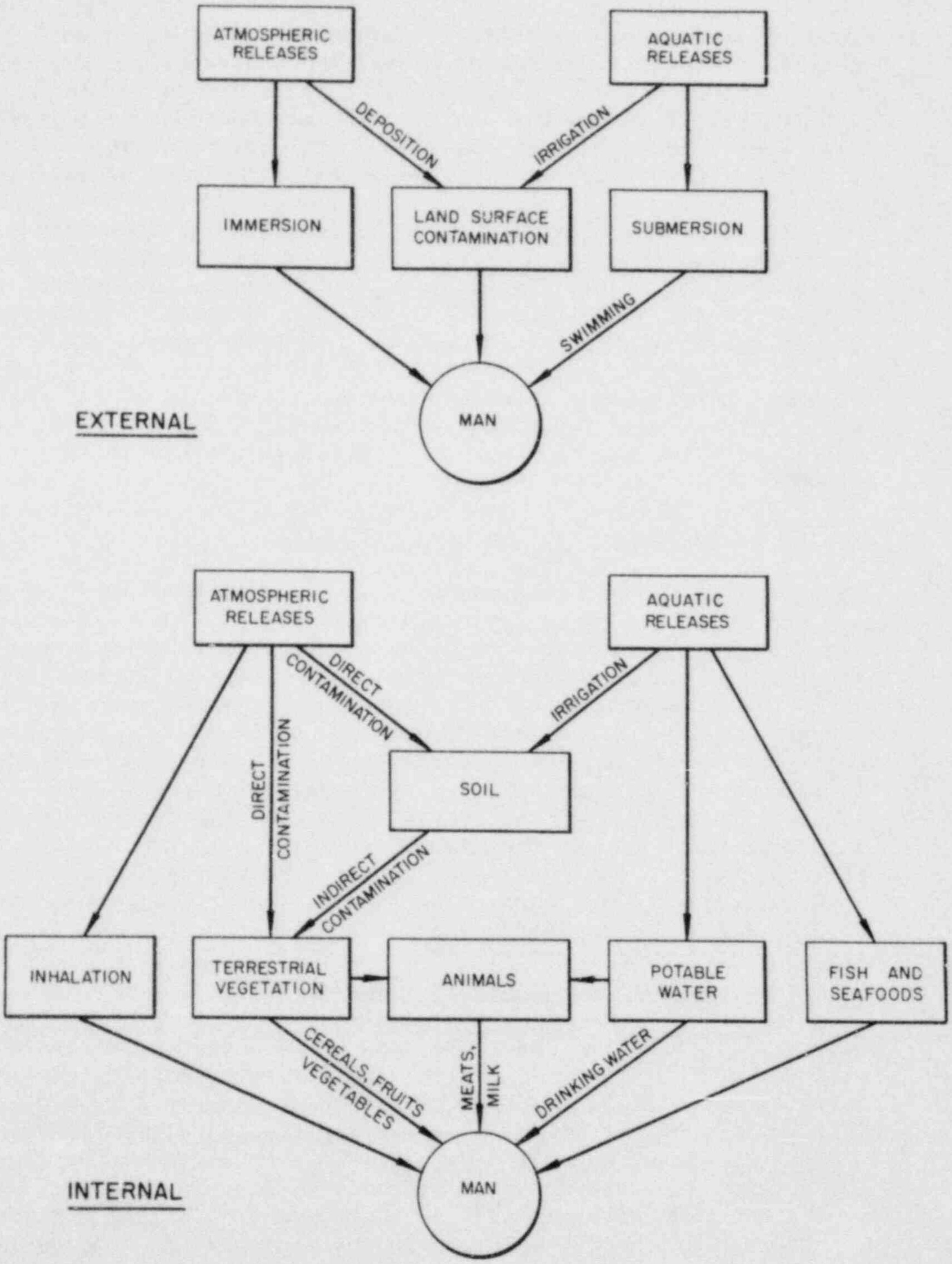

Fig. V-1. Pathways for radiation exposure of man.

transit time of 2.3 days or more, depending on the level of water backed up in the river from Hartwell Reservoir.[63]

A lake model[64] was used to calculate the radioactivity concentration as the radionuclides are dispersed in the main body of Hartwell Reservoir. The concentrations calculated with this model depend on both the mean residence time of water in the lake and the half-life of the radionuclides. An average volume of 2,000,000 acre-ft and an average release rate of 4400 cfs[65] were used in the calculations. Because the residence time for water in the reservoir is only 230 days, an equilibrium (for all radionuclide concentrations) will be reached within a few years. These concentrations were assumed for the Hartwell Reservoir and the water intake at Anderson.

2. Estimates of Radiation Dose to Man

Radiation doses to individuals (in millirems) and to the population (in man-rems) were estimated per year of release of radioactive effluents from normal operations of the plant. Exposures to radionuclides released by the plant were converted to estimates of radiation dose to individuals using models and data presented in Publication 2 of the International Commission on Radiological Protection[66] and other recognized texts on radiation protection.[67,68] Computer programs incorporating these models[69-70] were used to calculate the radiation dose from external exposure to radionuclides in air, in water, or on the ground and the radiation dose from internal exposure to inhaled or ingested radionuclides. Radioactivity taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay. Therefore, the radiation dose calculated for a given intake of radioactivity is an estimate of the total dose the individual would accrue during his lifetime as a result of that intake.

The radiation doses to the whole body and internal organs from exposure to penetrating radiation from external exposures are approximately equal, but they may vary considerably for internal exposure because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the whole body, thyroid, bone, liver, kidney, and gastrointestinal tract were considered for all pathways of internal exposure based on parameters applicable to an average adult.[66]

Radiation doses to the internal organs of children in the population will differ from those of an average adult because of differences in metabolism, organ size, and diet. Differences between the organ doses to a child and those to an average adult by more than a factor of 3 would be unusual for all pathways of internal exposure except the atmosphere-pasture-cow-milk pathway. For this pathway, the dose estimated to the thyroid of a one-year-old child from radioactive iodine in milk is 10 times that for an average adult.[71,72]

The population dose estimates are the sums of the whole-body doses to individuals within 50 miles of the plant. Whole-body doses from gamma exposures approximate those to gonads and therefore were used in the man-rem estimates because gonads have the most restrictive dose limits.[73,74] Since radiation doses to the whole body are relatively independent of age,[75] the man-rem estimates are based on whole-body doses calculated for adults.

Estimates of dose to individuals of less than 0.01 millirem and to the population of less than 0.1 man-rem are given for the sake of completeness but are not considered to be radiologically significant.

a. Dose from Exposure to Gaseous Effluents

The estimates of dose from exposure to gaseous effluents from the plant are based on the radionuclide releases given in Table III-13. Chemical forms of the radioactive iodine are assumed to be mainly organic iodine compounds (especially methyl iodide) for releases passing through a charcoal filter and molecular iodine (I_2) for releases without charcoal filtration.[76] Hence, the dose estimates for ^{131}I and ^{133}I are based on 0.78 and 1.14 Ci of methyl iodide released during buiding purges and on 0.024 and 0.03 Ci of molecular iodine released from the steam generator, respectively. The man-rem dose estimates are based on the population distribution from 1970 census data given in Table II-1.

(1) Immersion and Ground Contamination Pathways

The radiation dose to an individual from immersion in the gaseous effluent at the point of maximum exposure (the southern boundary of the 1-mile-radius exclusion area about the plant) is estimated to be 1.2 millirems. Radionuclides making important contributions to this dose are: ^{133}Xe (88% of the total), ^{88}Kr (6%), ^{131m}Xe (2%), ^{87}Kr (1%), ^{88}Rb from radioactive decay of ^{88}Kr (1%), and ^{85}Kr (1%).

The population dose for immersion is estimated to be 3.8 manrems, and the average dose to an individual of the population within 50 miles of the plant is estimated to be 0.0052 millirem. A summary of the population doses and the average individual doses as a function of radial distance from the plant is given in Table V-4.

For direct external exposure from radionuclides deposited on the ground, the radiation dose to an individual at the southern boundary of the exclusion area is estimated to be less than 0.01 millirem, and the dose to the population is estimated to be less than 0.1 man-rem.

(2) Inhalation Pathway

The estimated dose of less than 0.01 millirem to the whole body of an individual at the boundary of the exclusion area south of the plant is based on an inhalation rate for an average adult of 2×10^4 liters per day.[76] Corresponding estimates of dose to the gastrointestinal tract and thyroid are 0.03 millirem and 2.1 millirems, respectively. The radionuclides of primary importance in the inhalation pathway are ^{88}Rb for the dose to the gastrointestinal tract and ^{131}I for the dose to the thyroid.

The estimated dose to the population from the inhalation pathway is less than 0.1 man-rem.

(3) Food-Chain Pathways

Ingestion of radioactive particles and iodine deposited on vegetable crops is one possible food-chain pathway, and ingestion of radionuclides from milk and meat produced by animals pastured on areas exposed to gaseous effluents in the air is another. An additional pathway utilizing all of these mechanisms also exists for nuclides deposited on the soil and incorporated into food plants through their roots.

The only important contribution to radiation dose from exposure to gaseous effluents released from the Oconee Nuclear Station by food-chain pathways is from ^{131}I via the atmosphere-pasture-cow-milk pathway. Concentrations in milk are based on the value of 0.2 μCi of ^{131}I per liter from the presence of an equilibrium level of 1 μCi of ^{131}I per square meter of pasture.[77] In addition to radioactive decay of the iodine, the contamination on the pasture is assumed to decrease by one-half every 14 days because of weathering and grazing.[77]

Table V-4. Summary of estimates of annual radiation dose to the population from immersion in the gaseous effluents released by three reactor units at the Oconee Nuclear Plant

Radial distance from plant (miles)	1970 cumulative population	Cumulative population dose (man-rems/year)	Average individual dose (millirems/year)
0–1	0	0	0
0–2	146	0.036	0.25
0–3	478	0.064	0.13
0–4	1,068	0.093	0.087
0–5	2,274	0.15	0.064
0–10	37,831	1.1	0.029
0–20	93,038	1.6	0.018
0–30	363,543	2.7	0.0079
0–40	546,239	3.4	0.0062
0–50	730,291	3.8	0.0052

Radiation doses to an adult drinking milk from cows pastured close to the southern boundary of the exclusion area of the plant were estimated to be 1.6 millirems to the thyroid and less than 0.01 millirem to the whole body. Doses to the thyroid and whole body of an adult drinking milk from the closest dairy herd to the plant[78] (4.5 miles west) were estimated to be 0.10 and less than 0.01 millirem, respectively. These estimates of dose are based on consumption of 1 liter (about one quart) of milk per day by an average adult.[66]

A population dose of less than 0.1 man-rem was estimated by assuming that each of the 18,000 cows within 50 miles of the plant[65] produces 25 liters per day which is consumed by the population within this area.

b. Estimates of Radiation Dose from Exposure to Liquid Effluents

The estimates of dose from exposure to liquid effluents were based on the radionuclide releases given in Table III-12. All radionuclides released in the liquid effluent were assumed to be in chemical forms that are soluble in water.

(1) Submersion Pathway

If an individual is assumed to swim about 1 hr per day in Hartwell Reservoir during the three summer months (about 1% of a year), the estimated whole-body dose from direct external exposure to radionuclides contained in the water is less than 0.01 millirem. If it is further assumed that 10% of the individuals within 50 miles of the plant swim in Hartwell Reservoir 1% of a year, the estimated dose to the population is less than 0.1 man-rem.

(2) Drinking Water Pathway

Radiation doses to the whole body of an average adult drinking from the Clemson-Pendleton and Anderson water supplies were estimated to be 0.15 millirem and 0.05 millirem, respectively. In these estimates, it was assumed that the individual drinks 1.2 liters (about 2.5 pints) per day[66] from the respective water supplies. The radionuclide making the most important contribution to dose at both locations is ^3H (more than 50%). A population dose of 3.3 man-rems for these cities was estimated based on 1970 census data.

(3) Aquatic Food-Chain Pathways

The radiation dose to the whole body from consumption of fish was estimated to be 0.38 millirem. In this estimate, it was assumed that an average adult consumes 20 g/day[79] (about 5 oz/week) and that all fish consumed are from the Hartwell Reservoir. Concentrations of radionuclides in the fish were calculated by multiplying the radioactivity levels in water by accumulation factors for edible parts of fish.[80-83] The accumulation factor is defined as the ratio at equilibrium of the radionuclide concentration in fish flesh to the radionuclide concentration in water. The radionuclides making important contributions to dose via this pathway of exposure are: ^{134}Cs, ^{137}Cs, ^{58}Co, ^{60}Co, and ^{3}H.

A population dose from fish consumption is difficult to estimate because of the lack of fish harvest data for the Hartwell Reservoir. If it is assumed that 10% of the individuals living within 50 miles of the plant obtain 10% of their diet of fish from the Hartwell Reservoir, the estimated population dose is 2.8 man-rems.

(4) Terrestrial Food-Chain Pathways

Radiation doses from several of the pathways associated with land irrigation are disregarded in this statement because the agricultural use of water from the Hartwell Reservoir is very limited.[65]

3. Assessment of Dose to Man

A summary of the estimated radiation doses to individuals at points of maximum exposure to the gaseous and liquid effluents where the exposure pathways are operative is given in Table V-5, and a summary of the estimated population doses from exposure to the effluents released by the plant is given in Table V-6. The assessment of the potential radiological impact from these exposures can be given some perspective by comparison with (1) limits of 10 CFR 20 and (2) the doses from the natural radiation background. The radiation dose to the whole body and internal organs of an individual from the natural radiation background at sea level averages about 0.1 rem (100 millirems) per year.[68]

The largest estimate of radiation dose to the whole body of an individual from the gaseous effluent occurs at the southern boundary of the 1-mile-radius exclusion area about the plant. These estimates of dose have not been reduced by the shielding provided by houses against radionuclides contained in the air or deposited on the ground or by the supplemental feeding to cows of stored or commercial feeds. In the

Table V-5. Summary of the estimated radiation doses to individuals per year of release at points of maximum exposure to gaseous and liquid effluents from three reactor units at the Oconee Nuclear Station

Pathway	Location	Dose (millirems)	
		Whole body	Thyroid
	Gaseous effluents		
1. Direct radiation from air and ground	Southern boundary of exclusion area	1.2	1.2
2. Inhalation of contaminated air	Southern boundary of exclusion area	<0.01	2.1
3. Terrestrial food chains[a]	Southern boundary of exclusion area	<0.01	1.6
	Liquid effluents		
1. Drinking water	Clemson-Pendleton	0.15	0.25
2. Aquatic food chains	Hartwell Reservoir	0.38	0.38
3. Swimming	Hartwell Reservoir	<0.01	<0.01

[a]These doses are estimated for an adult drinking milk from a cow pastured near the site boundary. Estimates of dose to an adult drinking milk from the closest dairy herd to the plant are 0.10 millirem to the thyroid and less than 0.01 millirem to the whole body.

Table V-6. Summary of estimated radiation doses to the population per year of release of gaseous and liquid effluents from three reactor units at the Oconee Nuclear Station

Pathway	Population dose (man-rems)
Gaseous effluents	
1. Immersion and contaminated ground surface	3.8
2. Inhalation of contaminated air	<0.1
3. Terrestrial food chains	<0.1
Liquid effluents	
1. Drinking water	3.3
2. Aquatic food chains	2.8
3. Swimming	<0.1
Total population dose	10

estimates of dose by terrestrial pathways, it was assumed that the cow's food is obtained entirely from grazing. Without any consideration of these possible dose reduction factors, the sum of the dose estimates to the whole body of an individual at the southern boundary of the exclusion area is about 1% of the dose from natural background and less than 0.3% of the limit of 10 CFR 20.*

The sum of the estimated radiation doses to the thyroid at this location is approximately 5 millirems for an adult and 20 millirems for a child. A more realistic estimate of the dose to the thyroid of an individual at the location of maximum exposure to the gaseous effluent would be to assume consumption of milk from the closest dairy herd to the plant. For this situation, the sum of the thyroid dose estimates is about 4 millirems for an average adult and 5 millirems for a 1-year-old child. These estimates of dose to the thyroid of both an adult and a child are about 5% of the dose from natural background and less than 1% of the recommended dose limits.[73,74]

The largest estimates of dose to individuals from liquid effluents are at Clemson and Pendleton, where drinking water is withdrawn from the Keowee River. These estimates are based on reasonable dilution factors calculated from annual average stream flows. The total dose estimates from all pathways for individuals at this location are 0.64 millirem to the thyroid and 0.54 millirem to the whole body and other internal organs. These estimates of dose are less than 1% of the dose from natural background and less than 0.2% of the limits of 10 CFR 20. If the flow of water from the tailrace of the Keowee Hydroelectric Station is restricted for a period of about one month of the year, as discussed in Sect. III, the estimated dose to an individual for a one-year period including this month would still be less than 1 millirem. This estimate is based on a normal release of liquid effluents during the restricted flow of 30 cfs from the tailrace and additional dilution by an average stream flow of 357 cfs from tributaries of the Keowee River before the effluent reached the Clemson-Pendleton water intake.

These dose estimates indicate that the release of radioactive effluents from normal operation of the plant can be conducted well within the limits of 10 CFR 20 and can be maintained within the numerical guidelines of the proposed Appendix I of 10 CFR 50.[84]

The sum of the estimated population doses from exposure to both gaseous and liquid radioactive effluents released by the plant is

* There are no cows grazing at the exclusion area boundary, according to the applicant.

10 man-rems and is very small compared with the 73,000 man-rems that the population within a 50-mile radius receives each year from the natural radiation background. Hence, no discernible radiological impact on individuals and the population is expected from normal operations of the Oconee Nuclear Station.

4. Radiological Effects on the Biota

Organisms living in the effluent of the Station will be exposed to radiation from the radionuclides released in the discharge water. The total radiation dose will result from both an immersion dose (external) and an internal dose from radionuclides assimilated from food material or absorbed from the water.

The radiation dose estimates (Table V-7) are based on the assumption that the concentration of radionuclides in water remains constant. The water concentrations used for calculating the dose are listed in Table III-12. These concentrations were computed by assuming that the expected total animal release of radioactivity from the Station will be diluted by the annual average flow (1100 cfs) of the tailrace of Keowee Dam.

The immersion dose was computed by assuming that the organism remained continuously submerged.[85] The total immersion dose to an organism was less than 1 millirad/year.

Radionuclide concentrations in biota will not increase indefinitely in a situation where there is a constant input of radioactive materials. In fact, an equilibrium level, where outgo equals income, is reached relatively rapidly in the biota of an area.

Certain factors affect the metabolism of radionuclides. Temperature is of special importance in aquatic ecosystems, because the metabolic rate of plants and most animals in these systems is directly related to temperature. In general, lower temperatures cause reduced metabolic rates, and higher temperatures cause increased metabolism. The net result, however, in a natural system, will be about the same in terms of element metabolism. For example, increased metabolic rate causes increased intake of an element, but there is an increase in excretion rate of the element also. Conversely, reduced metabolic rate results in both reduced intake and excretion of an element.

In order to estimate the internal dose received by each group of organisms, the highest accumulation factors found in the literature[86,88] were used. Not all animals in each group would have the same accumulation factor. Some might tend to be lower, and thus

Table V-7. Calculated internal radiation dose rate to aquatic organisms growing in liquid effluents from the Oconee Nuclear Station

Radionuclide	Biological accumulation factor[a]			Dose rate (millirads/year)		
	Plants	Invertebrates	Fish	Plants	Invertebrates	Fish
^{89}Sr	3,000	4,000	150	0.25	0.34	0.013
^{91}Y	10,000	1,000	100	20	2.0	0.20
^{90}Y	10,000	1,000	100	0.67	0.067	0.0067
^{99}Mo	100	100	100	0.022	0.022	0.022
^{129m}Te	100	25.0	400	0.12	0.031	0.49
^{131}I	200	1,000	50.0	0.33	1.6	0.082
^{134}Cs	25,000	11,000	9500	330	140	130
^{135}Cs	25,000	11,000	9500	20	8.8	7.6
^{137}Cs	25,000	11,000	9500	12	5.3	4.6
^{140}La	500	200	10	1.4	0.14	0.014
^{140}Ba	10,000	1,000	100	0.086	0.034	0.0017
^{51}Cr	100	50	200	0.0013	0.00065	0.0026
^{54}Mn	35,000	140,000	25	20	80	0.014
^{55}Fe	5,000	3,200	300	0.079	0.051	0.0047
^{59}Fe	5,000	3,200	300	2.0	1.3	0.12
^{58}Co	2,500	[illegible]00	500	40	24	8.0
^{60}Co	2,500	1,500	500	4.1	2.4	0.81
^{3}H	1	1	1	0.11	0.11	0.11
Total				450	270	150

[a]Taken from refs. 83, 84, and 85.

the dose presented in Table V-7 is very probably an overestimation. The radiation doses were 450 millirads/year to aquatic plants, 270 millirad/year to aquatic invert ates, and 150 millirad/year to fish. The cesium, manganese, and cobalt radionuclides accounted for 93% of the total radiation dose to all three of the above components. Details of the method used for estimating the internal dose to biota are given in Appendix V-1.

An internal radiation dose was calculated also for a terrestrial animal or bird living near the plant. The dose to terrestrial organisms from external sources will be similar to the dose received by man (see previous sections) and is considered to be a small part of the total dose. While there are many pathways of internal radiation exposure to terrestrial organisms, one pathway was selected which would tend to maximize the dose received. The organism, in this case a duck, is assumed to consume only aquatic vegetation growing in the water near the point of discharge of the radionuclides. The total dose to the hypothetical duck was 1.7 rad/year (Table V-8), with ^{134}Cs contributing 94% of the dose. If the organisms consume other food in addition to the aquatic plants or if part of the feeding takes place other than in the immediate discharge area, then the nuclide concentration will be lower, and thus the radiation dose will be decreased.

To attain a true equilibrium concentration, the organism would have to spend a significant part of its total life span in the area, and this too is unlikely.

Voluminous literature relating to radiation effects on organisms has been published, but few studies have been conducted on the effects of chronic low-level radiation (from ingested radioactive material) on natural aquatic or terrestrial populations. The most recent and pertinent studies have been reviewed.[89-91] These reviews indicate that, while the existence of extremely radiosensitive organisms is possible and while increased radiosensitivity in organisms may result from environmental interactions, no organisms have yet been demonstrated to be sensitive to radiation levels found around the Station. There is a paucity of literature on the effects of chronic low-level radiation on terrestrial animals.[91] French[92] suggested a possible shortening of the life span in the pocket mouse induced by 0.9 rad of chronic gamma radiation per day; however, there is no information available to indicate that a detectable radiation effect would be found at a dose rate level of 1.7 rads/year for aquatic animals.

In summary, no detectable adverse effect is expected on the aquatic biota or terrestrial mammals as a result of the quantity of radionuclides to be released in the tailrace of Keowee Dam by the Oconee Nuclear Station.

Table V-8. Internal radiation dose rate to animals consuming only aquatic vegetation growing in effluent from the Oconee Nuclear Power Plant

Radionuclide	Biological accumulation factor	Internal dose rate (millirads/year)
^{89}Sr	6,520	5.3×10^{-1}
^{91}Y	0.386	1.7×10^{-2}
^{90}Y	8.35	2.6×10^{-5}
^{99}Mo	20.7	4.0×10^{-3}
^{129m}Te	36.0	3.4×10^{-2}
^{131}I	219	2.5×10^{-1}
^{134}Cs	234,000	1.6×10^{3}
^{136}Cs	39,600	1.7×10^{1}
^{137}Cs	252,000	8.5×10^{1}
^{140}La	0.242	2.0×10^{-5}
^{140}Ba	38.5	4.0×10^{-3}
^{51}Cr	1.92	1.4×10^{-5}
^{54}Mn	2,820	7.3×10^{-1}
^{55}Fe	33,300	5.3×10^{-1}
^{59}Fe	3,070	6.3×10^{-1}
^{58}Co	907	6.9
^{60}Co	1,030	8.0×10^{-1}
^{3}H	1.00	1.1×10^{-1}
Total		1.7×10^{3}

5. Environmental Radiation Monitoring

The applicant began a preoperational environmental radiation monitoring program in January 1969 to provide information on the background levels of radioactivity in the area of the Station prior to startup. These data have been reported in the Environmental Report (October 1971), Appendix F. The preoperational program included analyses of samples of water, airborne particulates, rain, settled dust, silt (river and lake bottom sediments), terrestrial vegetation, algae and/or plankton, bottom organisms, crustaceans, fish, milk, and animals. All samples were analyzed by gross alpha, gross beta, and gamma spectral techniques. Specific radionuclide analyses, performed by outside laboratories, were done for tritium in water and for ^{90}Sr and ^{137}Cs in milk, water, fish, and animal samples.

The applicant discussed and reviewed the preoperational environmental radiation monitoring program with the South Carolina State Board of Health, Division of Radiological Health, the South Carolina Pollution Control Authority, and the South Carolina Wildlife Resources Department. The U.S. Fish and Wildlife Service also reviewed the program.

The proposed minimum operational monitoring program, which is basically a continuation of the preoperational program with slight modifications, is given in Table V-9.[93] The applicant proposes to exercise some degree of flexibility in the frequency of sample collection and analysis based upon the quantities of radioactive liquid and airborne wastes released from the station. The environmental monitoring data will be correlated with information on radioactive waste releases and site meteorological data, with published information from the national radiological surveillance programs reported by the Environmental Protection Agency, and with environmental monitoring reports of other nuclear installations in the area. Cooperation with the various State and Federal agencies will continue.

The applicant's proposed operational environmental radioactivity monitoring program (Table V-9) may be adequate to demonstrate compliance with the requirements in 10 CFR Part 20, but its focus on some potential exposure pathways should be sharpened. For example, our assessment of radiological impacts indicates that terrestrial food chains may constitute an important exposure pathway for members of the public (see Tables V-5 and V-6). Specifically, the consumption of milk from dairy cattle near the plant appears to be important. If that is indeed the case, the quarterly collection and analysis of milk samples will not suffice. The sampling frequency will have to be on a weekly basis at least. This is an example of the type of adjustment in the applicant's proposed environmental monitoring program that will be considered in establishing the technical specifications.

Table V-9. Oconee operational environmental radioactivity monitoring program

Code of collection frequency
Monthly M – Quarterly Q – Annually A

Sampling point	Collection frequency: H_2O finished – water supply	H_2O raw – water supply	H_2O surface – river, lakes	Rain, settled dust – fallout	Air – particulate	Vegetation – terrestrial	Vegetation – aquatic and/or plankton, bottom organisms,[a] crustaceans	Bottom sediment – water supply & lakes	Radiation dose & rate – TLD and instrument	Animals – 1 mile radius	Fish – lakes	Milk – local dairies and nearby farms
Site: Visitors Center, station 1				M	M	Q			Q			
station 2				M		Q			Q			
station 3				M		Q			Q			
Bridge N of site on new 183 connecting canal			M									
Near liquid effluent release point (closest point where found downstream)							Q	Q				
1-mile radius of site (including Lake Keowee, upstream of release point)[b]			A[c]				Q			Q	A	
Lake Keowee cooling water discharge			M					Q				
At bridge on 183 existing			M					Q				
Site fence, various locations									Q			
Exclusion area, various locations									Q			
Salem: Volunteer Fire Dept. lot									Q			
Walhalla: Branch Road Substation				M					Q			
7.5 miles west of site on Hwy 183												Q
Nearby farms in prevailing wind directions												Q
Keowee: High School, Hwy 16						Q			Q			
Seneca: Oconee Memorial Hospital									Q			
Water supply, Lake Keowee intake	M	M										
Newry: former high school on S.C. 130									Q			
Hwy 27 at bridge			M				Q	Q				
Clemson: meteorology plot				M	M	Q			Q			
Water supply	M	M										
Intake, Hartwell Reservoir K-3								Q				
Central, S.C.: joint substation, Hwy 93									Q			
Liberty, S.C.: branch office yard									Q			
Six Mile, S.C.: microwave tower, Hwy 137									Q			
Pickens, S.C.: branch office yard				M					Q			
Miscellaneous: location, samples, and frequency vary							As required					
Anderson, S.C.: water supply	M	M										
Hartwell Reservoir: South of Keowee Dam, as close to liquid effluent release point as they can be obtained			A[c]								Q	

[a]Collection depends on availability.

[b]Lake Keowee, which is above the liquid effluent release point, is considered as a control.

[c]Lakes Keowee and Hartwell will be sampled annually for tritium analysis by outside service.

Notes: 1. Fish and animals will be collected in cooperation with the South Carolina Wildlife Resources Department.

2. Fish specimens will be collected from Lakes Keowee and Hartwell, subjected to gamma analysis, and analyzed for specific radionuclides found, as well as gross beta minus ^{40}K, ^{90}Sr, and ^{137}Cs.

VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents in the Oconee Nuclear Station, Unit 1, is provided through correct design, manufacture, and operation, and the quality assurance program used to establish the necessary high integrity of the reactor system, as considered in the Commission's Safety Evaluation dated December 29, 1970. Deviations that may occur are handled by protective systems to place and hold the plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, in spite of the fact that they are extremely unlikely, and engineered safety features are installed to mitigate the consequences of these postulated events.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using best estimates of probabilities and realistic fission-product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions were used for the purpose of comparing calculated doses, resulting from a hypothetical release of fission products from the fuel, against the 10 CFR Part 100 siting guidelines. The computed doses that would be received by the population and environment from actual accidents would be significantly less than those presented in the Commission's 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 "Supplement to the Environmental Quality Features of Keowee-Toxaway Project", dated October 1, 1971.

The applicants' report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment to Appendix D of 10 CFR Part 50 by the Commission on December 1, 1971 (36 F.R. 22851). Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high consequence end of the spectrum have a low occurrence rate, and those on the low consequence end have a higher occurrence rate. The examples selected by the applicant for these classes are shown in Table VI-1. The examples selected are reasonably homogeneous in terms of probability within each class, although the release of the waste gas decay tank contents is considered as more appropriately in Class 3. Certain assumptions which were made by the applicant, such as the assumption of no prior steam generator tube leaks in the evaluation of the steam generator tube rupture and the omission of the primary coolant source in evaluating secondary system incidents are questionable, but the use of alternative assumptions does not significantly affect overall environmental risks.

Regulatory Staff estimates of the dose which might be received by an individual assumed to be standing at the site boundary in the downwind direction, using the assumptions in the proposed Annex to Appendix D, are presented in Table VI-2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table VI-2. The man-rem estimate is based on the projected population (about 900,000) around the site for the year 2010.

To rigorously establish a realistic annual risk, the calculated doses in Table VI-2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operation 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 but events of this type could occur sometime during the 40 year plant lifetime. 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 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table VI-2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involves sequences of successive failures more severe than those required to be considered in the design basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is 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 the required 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 VI-2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an individual assumed to be at the site boundary to concentrations of radioactive materials within the Maximum Permissible Concentrations (MPC) of Table II of 10 CFR Part 20. The table also shows that the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which is approximately 120,000 man-rem/yr based on a natural background radiation level of 130 mrem/yr. 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. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

B. TRANSPORTATION ACCIDENTS

1. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste, described in Section III.E, is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive cargo. The shipper has essentially no control over the likelihood of an accident involving his shipment. Safety in transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated at the Federal level by both the Atomic Energy Commission (AEC) and the Department of Transportation (DOT). In addition, certain aspects, such as limitations on gross weight of trucks, are regulated by the States.

TABLE VI-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	AEC DESCRIPTIONS	APPLICANT'S EXAMPLE(S)
1	Trivial incidents	None
2	Miscelleous small releases outside containment	Frequent small spills and leaks. Infrequent larger pump seal or valve leaks. Releases due to piping failure.
3	Radwaste system failures	Inadvertent discharge of the contents of a reactor coolant waste receiver tank or waste gas decay tank.
4	Events that release radioactivity into the primary system	Not applicable.
5	Events that release radioactivity into primary and secondary systems	Normal operation with fuel failures and steam generator leaks. Transient operation with fuel failures and steam generator leaks. Steam generator tube rupture.
6	Refueling accidents inside containment	Dropped fuel assembly
7	Accidents to spent fuel outside containment	
8	Accident initiation events considered in design-basis evaluation in the safety analysis report	Steam line break accident. Rupture of waste gas decay tank. Loss-of-coolant accident.
9	Hypothetical sequences of failures more severe than Class 8	None

Table VI-2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTUALTED ACCIDENTS

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary[a]	Estimated Dose to Population in 50 Mile Radius, man-rem
1.0	Trivial incidents	(b)	(b)
2.0	Small releases outside containment	(b)	(b)
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.015	2.4
3.2	Release of waste gas storage tank contents	0.058	9.3
3.3	Release of liquid waste storage tank contents	<0.001	0.11
4.0	Fission products to primary system (BWR)		
4.1	Fuel cladding defects	N.A.	N.A.
4.2	Off-design transients that induce fuel failures above those expected	N.A.	N.A.
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	(b)	(b)
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	<0.001	<0.1
5.3	Steam generator tube rupture	0.019	3.1

Class	Event	Estimated Fraction of 10 CFR Part 20 limit at Site Boundary[(a)]	Estimated Dose to Population in 50 Mile Radius, man-rem
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.003	0.49
6.2	Heavy object drop onto fuel in core	0.052	8.5
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	0.002	0.34
7.2	Heavy object drop onto fuel rack	0.008	1.2
7.3	Fuel cask drop	N.A.	N.A.
8.0	Accident initiation events considered in design basis evaluation in the safety analysis report		
8.1	Loss-of-coolant accidents		
	Small Break	0.035	9.8
	Large Break	0.42	440
8.1(a)	Break in instrument line from primary system that penetrates the containment	N.A.	N.A.
8.2(a)	Rod ejection accident (PWR)	0.042	44
8.2(b)	Rod drop accident (BWR)	N.A.	N.A.
8.3(a)	Steamline breaks (PWR' c- side containment		
	Small Break	<0.001	<0.1
	Large Break	<0.001	<0.1

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary[a]	Estimated Dose to Population in 50 Mile Radius, man-rem
8.3(b)	Steamline breaks (BWR)		
	Small Break	N.A.	N.A.
	Large Break	N.A.	N.A.

(a) Represents the calculated fraction of a whole body dose of 500 mrem, or the equivalent dose to an organ.

(b) These releases will be comparable to the design objectives indicated in the proposed Appendix I to 10 CFR Part 50 for routine effluents (i.e., 5 mrem/yr to an individual from all sources).

Accidental releases of low-level contaminated material in sufficiently small amounts are unlikely to cause radiation injuries. Packaging for these materials is designed to remain leakproof under normal transport conditions of temperature, pressure vibration, rough handling, exposure to rain, etc. The packaging may release its contents in an accident.

For large quantities of radioactive materials, the packaging design (Type B packaging) must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire and immersion in water.[1]

In addition, the packaging must provide adequate radiation shielding to limit the exposure of transport workers and the general public. For irradiated fuel, the package must have heat-dissipation characteristics to protect against overheating from radioactive decay heat. For cold and irradiated fuel, the design must also provide nuclear criticality safety under both normal and accident damage tests.

Each package in transport is identified with a distinctive radiation label on two sides, and by warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[2] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. In case of an accident, procedures which carriers are required[3] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and the Department of Transportation. Radiological assistance teams are available through an inter-governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

2. Exposures During Normal (No Accident) Conditions

a. Cold Fuel

The transport of cold fuel for the Oconee reactors has been described in Section III.E.1. Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 9 shipments of 10 packages (2 fuel elements per package) with two drivers for each shipment, this would be a dose of about 0.02 man-rem* per year. The exposure of an individual in the general population near one of the transport trucks would be no more than about 0.005 mrem per shipment. If 10 members of the general public were so exposed, the total annual dose for the nine shipments would be about 0.5 man-rem. The radiation level associated with each truckload of cold fuel is less than 0.1 mrem/hr at 6 feet from the truck. The dose to other persons along the shipping route would be extremely small.

b. Irradiated Fuel

Each shipment (see Section III.E.2) from Oconee will carry 2 irradiated fuel elements. Based on actual radiation levels associated with a shipment of irradiated fuel, it is estimated that the individual truck driver would be unlikely to receive more than about 10 mrem in the 150 mile shipment. If the same truck driver drives 30 shipments in a year, he could receive as much as 300 mrem per year. On this basis, the total exposure of all drivers for the year, assuming 2 drivers on each shipment, would be about 2 man-rem per year for the three reactors at Oconee. If shipped by rail the exposure of the brakeman would be much less than the truck drivers. An individual in the general population who stands alongside the truck for five minutes could receive 1.3 mrem. If 10 members of the general public were so exposed during each shipment, the total annual exposure would be about 1.2 man-rem. Approximately 5×10^4 persons who reside along the 150 mile route over which the irradiated fuel is transported might receive a dose of 0.7 man-rem per year.**

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*Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 10^5 persons along the shipping route).

**In this case, the regulatory radiation level limit of 10 mrem/hr at 6 feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and 1/2 mile on both sides of the shipping route. A speed of 200 miles per day and an average population density of 330 persons per square mile were assumed.

The amount of heat released to the air from each cask will be about 10,000 Btu/hr. (For comparison, 35,000 Btu per hour is about equal to the heat released from an air conditioner in an average home.) Although the temperature of the air which contacts the loaded cask is increased a few degrees, because the amount of heat is small and is being released over the entire transportation, no appreciable thermal effect on the environment will result.

c. Solid Radioactive Wastes

As noted in Section III.E.3, demineralizer resins and evaporator concentrates containing some radioactive materials will be shipped from Oconee. Under normal conditions, the individual truck driver might receive as much as 15 mrem per shipment. If the same driver were to drive 25 truckloads during the year, he would receive an estimated annual exposure of about 400 mrem. The total exposure of all drivers for the year, assuming two drivers with each shipment, might be as much as 1.4 man-rem.

If a person were near the truck for a few minutes, at an average distance of 3 feet, he might be exposed to as much as 1.3 mrem. Approximately 90,000 persons who reside along the 300 mile route over which the solid waste is transported might receive a dose of 0.3 man-rem per year.*

3. Exposures Resulting from Postulated Accidents

a. Cold Fuel

The cold fuel to be transported to the Oconee Units has been described in Section III.E.1. Under accident conditions other than accidental criticality, the pelletized form of the uranium fuel, its encapsulation, and the low specific activity of the fuel limit the radiological impact on the environment negligible levels. Even for the higher radioactivity of plutonium recycle fuel, the form and encapsulation under credible accident conditions would limit the radiation effects on the environment to negligible levels.

*This dose was calculated on the same basis as the dose to the people along the route from irradiated fuel.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel elements under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which is unlikely to happen in other than an extremely severe accident.

The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote. If criticality were to occur in transport, persons within a radius of about 100 feet from the accident might receive a serious exposure but beyond that distance, no detectable radiation effects would be likely. Persons within a few feet of the accident could receive fatal or near-fatal exposures unless shielded by intervening material. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds and normally would not recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 feet. There would be very little dispersion of radioactive material.

b. Irradiated Fuel

Irradiated fuel will be shipped from Oconee to a licensed fuel recovery plant as described in Section III.E.2. Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel were estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

(1) Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 40-year life of the plant.

Leakage of liquid at a rate of 0.001 cc per second or about 80 drops/hour can usually be detected by visual observation of a large container. If leakage of contaminated liquid coolant were to occur and should go undetected, the amount would be so small that the individual exposure would not exceed a few mrem and only a very few people would receive such exposures.

(2) Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel elements penetrated, some of the coolant and some of the noble gases might be released from the cask. The probability of occurrence of such an accident is considered to be extremely remote.

In the highly unlikely event that such an accident were to occur, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[4] of the Environmental Protection Agency.

c. Solid Radioactive Wastes

As noted in Section III.E.3, about 45 truckloads of solid radioactive wastes will be transported each year from Oconee to a disposal site. The likelihood that radioactivity would be released as a result of waste being involved in an accident, lids on drums coming off, and some of the waste material getting outside of the drum is very small.

It is highly unlikely that a shipment of waste will be involved in a severe accident during the 40-year life of the plant. If it does happen that a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant.

Other solid waste from Oconee will be shipped in Type B packages, according to the applicant. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

In either unlikely event, spread of the contamination beyond the immediate area is unlikely and, although local clean-up might be required, no significant exposure to the general public would be expected to result.

4. Severity of Postulated Transportation Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and their consequences could be severe. Quality assurance for design, manufacture, and use of the packages, continued surveillance and testing of packages and transport conditions, and conservative design of packages ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk is extremely low. For those reasons, more severe accidents have not been included in the analysis.

5. Alternatives to Normal Transportation Procedures

Alternatives, such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station, have been examined. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

VII. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

The construction of the Keowee-Toxaway Project facilities, which includes the Oconee Nuclear Station, resulted in the clearing and flooding of about 26,000 acres of the basins of the Keowee and Little Rivers. In addition, 7,800 acres of farm and woodland were affected in the construction of transmission lines.

The following adverse effects can be expected in Lake Keowee as a result of the operation of the nuclear plant:

1. Any organisms entering under the skimmer wall and unable to escape the current in the intake canal will be entrained in the water passing through the condensers or trapped against the screens, if the organisms are sufficiently large. Some entrained organisms will die because of heat, impact, turbulence, or pressure change.

2. During part of the year, some organisms will be killed by the low oxygen levels in the area of the plant intake or of the discharge plume, while other organisms will be driven from those portions of the lake which are low in oxygen.

3. Because waste heat results from the operation of the plant, the dissipation of heat will have an unavoidable effect. The use of once-through cooling for the Station will result in altering the thermal pattern of the lake, and the increased temperature will result in the evaporation of about 32 million gallons of additional water per day from the reservoir.

4. The heat load on the lake will result in additional local fogging during some days of the year, although the area beyond the lake that will be affected is not expected to be large.

The filling of the reservoir has resulted in the loss of two historic sites and the partial coverage of several natural streams. The removal of 344 homes to allow the construction of the project must also be listed as an unavoidable effect.

In the Hartwell Reservoir headwaters, the dominant species will probably be those which can tolerate periodic surges of warm water released from the turbines of the hydroelectric station at Keowee

Dam and survive under the changes in water elevation which occur from operation of the Station (Section III.C). Some entrainment of organisms will occur when the Keowee and Jocassee hydroelectric stations are operating or when the pumped storage facility at the Lake Jocassee hydroelectric station is pumping water from Keowee Lake. During spawning seasons, the fluctuation in lake levels could result in a reduction in reproductive success for fish in the reservoirs if operation is not carefully controlled.

The release of chemicals and radionuclides from the operation of the plant will add to the existing chemicals in the water of Hartwell Reservoir. The concentrations will be sufficiently low that they are not expected to result in any detrimental effects to aquatic species or man.

The operation of the plant will result in some small increase in radioactivity and will create a very low probability risk of accidental radiation exposure to nearby residents. The operation of the plant will also result in the production of radioactive wastes which must be processed and stored.

The construction and operation of the plant will result in a change in the economic status of Oconee County which will affect the standard of living, result in changes in land use, and increase the demand for community services. To some residents of the area these changes may be considered adverse.

VIII. THE RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This section discusses the relationship between the construction and operation of the Oconee Nuclear Station, including the creation of the associated lakes, and the long-term productivity of the affected environment.

The environment in the present context consists of the land, water, and air (either locally or remotely) and all the associated qualities. Productivity is the quality of being creative or fertile or of having power to produce abundantly. Short-term is assumed to mean roughly the lifetime of the nuclear station (about 40 years), also approximately one human generation. Use refers specifically to the direct use of the land, water, and air in the vincinity of the plant and to the local and remote impacts. Accordingly short-term uses of the environment relate to the maintenance and enhancement of long-term productivity.

The short-term (40 years or less) uses of the environment are:

(1) For land

a. Covering by water to create lakes.

b. Clearing and grading for building sites, roads, transportation, communication, and covering by structures.

c. Posting, clearing, and planting for general protective purposes and for environmental enhancement.

(2) For water

a. Impounding streams to create lakes.

b. Subjecting to heating.

c. Subjecting to discharge of chemical and other wastes

(3) For air

a. Subjecting to gaseous wastes, including radioactive wastes

Except perhaps items 1a and 2a, the foregoing uses of the environment are generally detrimental to it in some respect. The damage in most of these cases (viz., 1b, 1c, 2b, 2c, and 3 a) is not serious, and the original qualities could be restored either by man's intervention or alternatively in due course by nature. All these effects are local and in the long view of the environment will not appreciably degrade its productivity or impede efforts towards enhancement.

Short-term uses 1a and 2a require special treatment in this case because the lakes created thereby are, in themselves, a beneficial feature. They constitute a new environment which acts to preserve and enhance the overall quality of the natural environment of the region. Furthermore, these same short-term uses have the benefit of controlling floods and thus further act to preserve environmental quality. Conversely, in examining the nature of the effects of building the lakes, it should be noted that if inundation of the land and streams be adverse to future usage, these features can be restored in future generations to their prior productivity.

The foregoing assessment of the short-term uses of the environment has considered the extent to which the productivity of the environment is reasonably well preserved on the whole by the Station and its associated project. There remains to be discussed the long-term productivity potential inherent in the project. The area surrounding the Station is one of the high-rainfall areas of the United States. The technology of electric power generation will without doubt continue to progress. Until effective means are found to utilize the heat that is necessarily wasted in the use of thermal energy sources or until a scientific breakthrough actually occurs such as to make possible nonthermal electric power production, large bodies of water will remain important to this use. The environment created for the Station should survive several generations of developments in nuclear power production. Hence the new environment created for this Station establishes the region as a source of electric power for an indefinite future.

In the general sense, there are two other long-term effects from the establishment of the Station and its associated project. These include: (1) improvement of basic information about the area, which consists of an accumulation of detailed knowledge about its biological, geological, meteorological, and ecological aspects; and (2) awareness of the noteworthy environmental features of the area and education on their preservation. Both of these consequences of the Station act to preserve the area's environment.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Operation of the Oconee Nuclear Station will result in some irreversible or irretrievable commitments of resources, in terms of local environmental impacts and of consumption of materials representing natural resources. The commitments through local impacts are essentially limited to the land utilized for the plant itself and the associated lake system. This commitment is reversible in the very long term. The construction and operation of the plant consume materials that will be irretrievable. These commitments of resources are consistent with the objective of attaining the widest range of beneficial uses of the environment.

Resources include land, water, and air in addition to those products thereof, such as minerals, trees, and game, which are the ingredients of goods and services. While reversibility and retrievability can be intrinsic properties of any resource commitment, there is also a factor of practicability to consider, viz., that to reverse or retrieve such a commitment could require an inordinate amount of human effort or alternatively one or more human generations by nature itself. In such case, the commitment is practically irreversible and irretrievable.

The following "resources" are committed irreversibly and irretrievably:

(1) In regard to the environmental components of land, water, and air

   a. Land committed for lake bottom, structures, transmission lines, or for other use that would preclude reconversion for a long time

   b. Small streams utilized to create the lakes

(2) In regard to products of the environment

   a. Nuclear fuel which is spent and converted into waste radioactive material

   b. Construction materials, including concrete and steel, which cannot be retrieved practicably

   c. Elemental materials, including iron, zirconium, and aluminum, which will become, either by themselves or in combinations with other materials, radioactive.

The construction and operation of the Station will in some degree curtail the range of beneficial uses of the environment. For example: the various structures, though attractive enough in their own right, will no doubt offend the nature lover; further, lake fishing may not really be a substitute for small stream fishing. The extent to which the range of uses of the environment is curtailed is not serious; the effective cost, in payment for the electric power produced, is understandable. Although some uses will be curtailed, new uses will be developed. The large bodies of water of natural quality that have been created to support the Station constitute a new environment for the surrounding area. The recreational areas will serve many people in the region.

X. NEED FOR POWER

The demand for power in the applicant's System (See Fig. I-1) is growing at a rate of 8.7% per year according to the applicant's recent (October 1971) supplementary environmental report and at a rate of 9.5% per year according to the Federal Power Commission's August 1970 projections.[1] The capacity provided by the Oconee Nuclear Station is needed to meet this demand and to provide a reserve capacity of 15 to 20%, a range generally recognized as desirable.

The rate of growth of power demand in the applicant's system is about the same as in other parts of the United States where industrial activity is expanding. The growth reflects both increasing population and increasing per capita consumption of electricity. Although the desirability and the means of limiting both types of growth are being debated today, there is no reason to expect that the power demands during the next several years will deviate significantly from the Federal Power Commission predictions.

Table X-1 lists the generating facilities of the applicant, including those that are expected to go into service in the near future. In Fig. X-1, the actual and predicted growth of the applicant's peak load and installed capacity is shown graphically for the period 1960 to 1975. It should be noted that almost one-third of the applicant's new generating capacity will be provided by Units 1, 2 and 3 of the Oconee Nuclear Station.

In order to meet the demand for power, even when some generating units are forced to shut down for maintenance or repair or during periods when interconnected systems need additional power, the applicant must have at any time a generating capacity appreciably greater than the load demand. This difference between peak demand and capacity, the reserve margin, is usually set at some fixed percentage (e.g., 15% to 20%) of the peak load.[2] In the present case, the applicant defines his planned reserve margin primarily in terms of the system characteristics:

Planned reserve = 0.05 x peak load + 2 x capacity of largest unit in system

The first term, 5% of the peak load, is intended to allow for weather extremes. The second term allows for scheduled or unscheduled (forced) outages of the largest generating unit; doubling this term allows for outages of more than one unit. In Fig. X-1, the

Table X-1. Duke Power Company Generating Facilities

Plant	Station Capacity, MW(e)	Gas Turbine Capacity, MW(e)	Year of First Operation[b]
Steam Stations:			
Tiger	30		1924
Buck	466[a]	90	1926
Riverbend	665[a]	120	1929
Cliffside	218[a]		1940
Buzzards Roost	15	159	1943
Dan River	375[a]	85	1949
Lee	480[a]	90	1951
Greenwood	40		1954
Allen	1183		1957
Marshall	2136		1965
Oconee, Units 1, 2 & 3 (Nuclear)	2658[c]		1971-73
Cliffside, Unit 5	575[c]		1972
Belews Creek	2288[c]		1974
McGuire, Units 1 & 2 (Nuclear)	2360[c]		1975-77
Urquhart		60[d]	
Hydro Stations:			
Great Falls	25		1907
Rocky Creek	27		1909
Ninety-Nine Islands	20		1910
Lookout Shoals	22		1915
Fishing Creek	42		1916
Wateree	72		1919
Lake James	19		1919
Dearborn	36		1923
Mountain Island	56		1923
Rhodhiss	27		1925
Wylie	55		1925
Cedar Creek	40		1926
Lake Hickory	37		1928
Lake Norman	372		1963
Keowee	140		1971
Jocassee	610[c]		1974

[a]These old steam plants have a heat rate that averages 10,676 Btu/kWhr.

[b]Year shown is first year of operation and does not reflect subsequent improvements, such as installation of gas turbines.

[c]Upon completion.

[d]A special case, since gas turbine is located outside the DPC district.

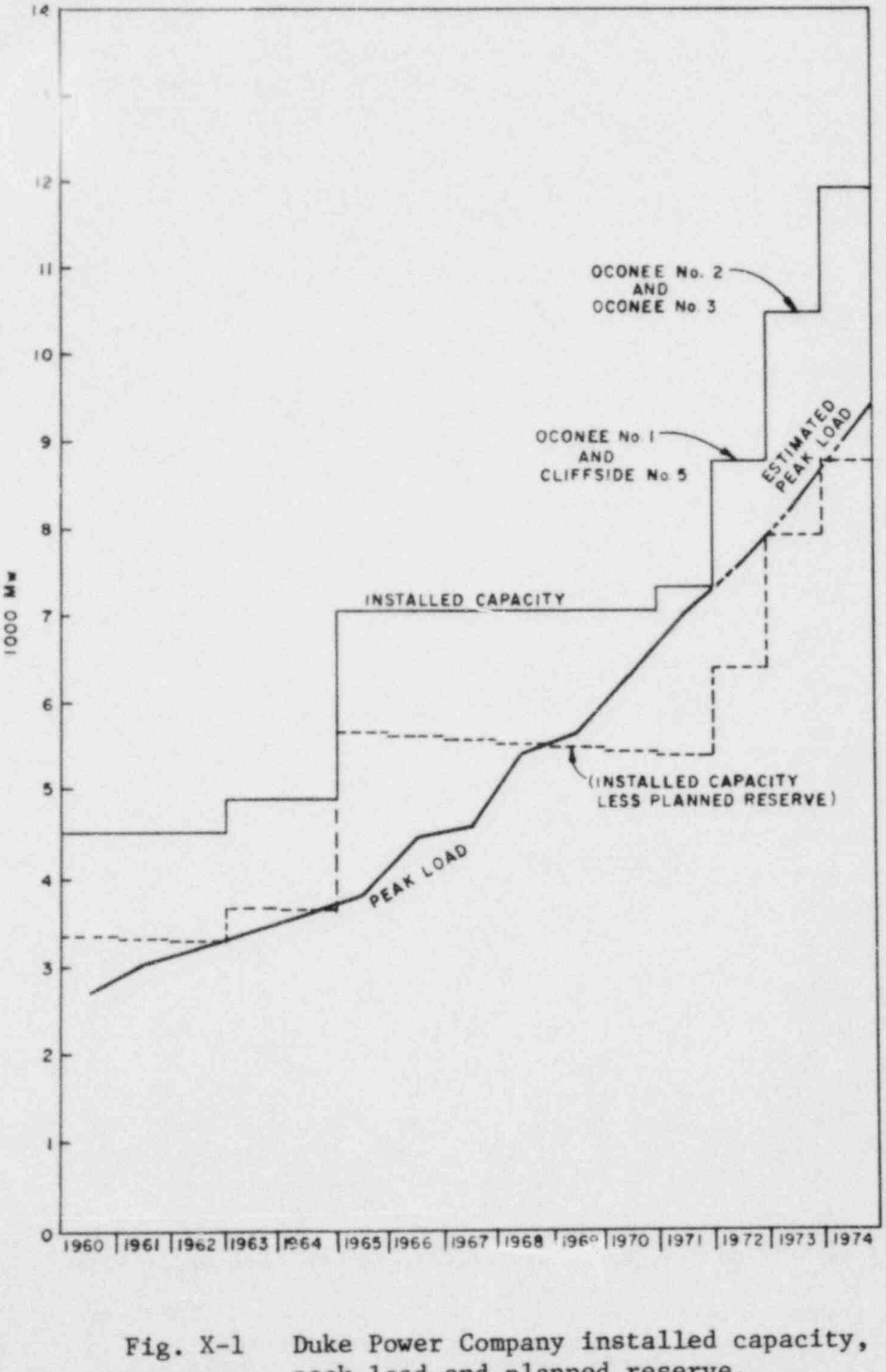

Fig. X-1 Duke Power Company installed capacity, peak load and planned reserve.

capacity-less-planned-reserve curve (the broken line) has been drawn assuming this definition. To be able to meet the peak demand, the broken line should be near or above the peak demand curve. It is apparent that until the Oconee units go into operation, the applicant will have a reserve margin substantially less than planned. In fact, the applicant has been operating for the last two years with a smaller reserve margin than is considered necessary to assure reliable power for the system's customers.

As noted by the Federal Power Commission[3,4] the availability of power from Oconee Unit 1 during the forthcoming 1972 summer peak period is most important, since the capability of the unit "represents a significant part of the potential new capacity which is sorely needed to meet projected 1972 summer demands." Specifically, with all scheduled plants (Oconee Unit 1, Cliffside No. 5) in operation this summer, the reserves would be 14.2% of peak load for the applicant and 12.2% for the Virginia-Carolinas subregion (which includes the applicant, Virginia Electric and Power Company, Carolina Power and Light Company, South Carolina Electric and Gas Company, Southeastern Power Administration). However, since the Cliffside No. 5 (fossil-fuel) unit is not expected to be in service in time to meet the summer peak, the reserves will be reduced to 6.4% for the applicant and 9.4% for the subregion. Without Oconee Unit No. 1, these reserves fall to precariously low values. If the first nuclear unit at the Surry Plant of the Virginia Electric and Power Company is also not in operation in the summer of 1972, the reserves for the subregion will be so low that there may be recurring and widespread power curtailments during the summer peak period.

It is apparent that, on the basis of anticipated loads and scheduled additions to generating capacity, the Oconee Nuclear Station units are needed not only by the applicant's system, but also by the Virginia-Carolinas subregion. Although the applicant is now purchasing some power from other utilities, it is questionable whether suitably large blocks of power can be purchased in the immediate future in order to compensate for the delay in Oconee and Cliffside.

Because of the trend to larger generating units and the problems associated with plant siting and transmission line routing, it is unlikely that the reserve situation in 1973 will differ markedly from the current one. As Fig. X-1 shows, it will take a few years for the applicant to build up the reserve margins to the planned level.

XI. ALTERNATIVES TO THE PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF THEIR ENVIRONMENTAL EFFECTS

A. ALTERNATIVES

The key to the type of power complex selected is the use of impounded water in storage reservoirs as a condenser-cooling medium, which eliminated the need for cooling towers. Other fuel sources were eliminated on the basis of economic considerations or availability. Our review has confirmed the validity of the economic appraisal.

Although there are several possibilities for the disposal of radioactive waste, the system selected by the applicant for Oconee appears to be adequate provided that the plant is operated in such a way that its radioactive releases satisfy the "as low as practicable" guidelines of the 10 CFR 20 and 10 CFR 50 regulations.

When the Keowee-Toxaway Project was being planned, the applicant considered a number of alternatives, including the purchase of power from other sources, the construction of fossil-fueled units, and the construction of nuclear-fueled units. The selection criteria were influenced by the available power generation sites, the location of the load centers to be supplied, the demand characteristics of the load, and the time available to provide the additional needed capacity. The applicant concluded that additional capability would have to be installed to satisfy his franchise obligations and that it would be least costly to install the required capacity within his own area of operation.

1. Power System Selection

Fossil-fueled generators are the primary source of power in the applicant's system. In recent years, the cost of coal in this region has steadily increased until, as the applicant reports, coal now costs about 46¢ per million British thermal units. As a consequence, the applicant estimated that the cost of power to the consumer would be lower from a nuclear-fueled system than from a fossil-fueled system and concluded that this cost differential warranted the selection of nuclear fuel.

The applicant further concluded that the requirements of the anticipated power demand could be most effectively satisfied by combining a pumped storage hydroelectric system with a nuclear installation. This combination allowed him to use part of the base-load capacity to operate the pumped storage system during off-peak periods and thereby realize more favorable power economics. In addition, the construction schedule for the project was compatible with the projected growth in power requirements.

2. Site Selection

The applicant's power distribution area has a variety of potential power plant sites. It was therefore possible to evaluate a number of alternative sites, giving consideration to land use, power transmission line routing, fuel supply, load center location, labor supply, water supply, site services, and access. The applicant's selection of a nuclear-fueled power station in combination with a pumped storage hydroelectric peaking plant imposed some additional requirements on the site.

The information available to us concerning alternative sites is not sufficient to determine whether the Oconee site has the best characteristics of any that were considered. The applicant identified one site having acceptable characteristics, which was rejected because its distance from the load center would have added about $1.2 million annually to transmission costs. Because the Oconee site is located in a region with a low population density, where the land had been comparatively unproductive, its commitment to this application should increase its economic productivity. The water supply at this site is well suited to the heat dissipation needs of the power station, and the land contours fit well with the water reservoir needs of the pumped storage system. Services and labor resources at the site were adequate. Therefore an alternative site would probably not have exhibited any overwhelming advantages. In any event, the advanced stage of construction precludes any practical consideration of alternative sites at this time, unless the environmental impact of the project on the site is unacceptable.

The applicant chose to take advantage of the new artificial lakes by developing a recreational area suitable for residential construction along the lake shore. This optional land use offers the potential for development of the site as a recreational center to serve the nearby metropolitan areas, such as Greenville, South Carolina.

3. Heat Dissipation

The nuclear power system must dissipate a substantial amount of heat. The methods available to the applicant were direct once-through cooling using the flowing stream, once-through cooling using the impounded water of the lake, and evaporative cooling towers. On the basis of economic considerations, the applicant selected the once-through cooling system using impounded water as the best alternative. Some uncertainties associated with the thermal effects on aquatic life were uncovered after this decision was made. Although advance knowledge of the thermal effects might have influenced the choice, there is no information to indicate that the alternative cooling methods would have resulted in less severe effects.

B. COST-BENEFIT ANALYSIS

Costs resulting from the licensing of the Keowee-Toxaway Project, of which the Oconee Nuclear Station is a part, include: changes in certain social and cultural circumstances in the surrounding community; a reassignment of land use, withdrawing some marginal agricultural production and eliminating some 340 residential units in usable condition; inundation of two historical sites; inundation of three trout streams; destruction of 21,354 acres of woodland suitable for providing cover for upland game; consumption of nuclear fuel; commitment of thermal capacity in the hydrological system; the general acceptance of a very low probability accident risk by the residents at the nuclear station site boundary; and the discharge of liquid waste into Hartwell Reservoir.

Benefits are expected to include: the addition of needed electrical capacity to support the economic growth of the area served by the applicant's power network; stimulation of the local economy through taxes, direct employment, and tourism; potential development of recreational areas; creation of a valuable recreational lake facility; and addition of a large industrial enterprise.

The increasing demand for power in North Carolina, South Carolina, and Virginia has resulted in a need for increased capacity in the area served by the applicant. The growing demand is, in part, a consequence of the region changing from production of low-income farm commodities to labor-oriented manufactured goods and supporting service industries. The main purpose of the Keowee-Toxaway Project, which includes the Oconee Nuclear Station, is to satisfy part of the power needs of the area.

The cost-benefit considerations related to the project are given in Table XI-1 (located inside back cover).

Land use, changes in the cultural and social conditions in the immediate vicinity of the Station, economic factors, ecological effects on the surrounding land and hydrological system, use of natural resources, and the environmental degradation resulting from the release of pollutants and the dissipation of waste heat must be weighed to establish a cost-benefit balance for the Keowee-Toxaway power installation.

1. Land Use

The combined nuclear and hydroelectric development in the Keowee-Toxaway Project has caused a reassignment of use to more than 50,000 acres (of the 157,000 total acres owned by the applicant) of cutover and regrown deciduous timberland and low-productivity farmland. All of this land was owned by the applicant. Approximately 340 residences were removed by the change in land use, and almost 900 residents were relocated. The applicant has indicated[2] that the planned use of the artificial lakes and adjoining land for recreational purposes and residential development along with the managed timber area will enhance its market value by some $55 million, almost six times its previous worth. Further, the recreational use of the lakes will be freely available to fishermen and water sport enthusiasts in the area at no direct expense to the users. In order to create the lake area, approximately 26,000 acres of land were flooded, and this reduced the area of terrestrial habitat for organisms and expanded the aquatic habitat.

The power transmission requirements have led to the establishment of electrical transmission corridors in the direction of the load centers located north, east, and south of the Oconee Station. Aesthetically damaging changes in the landscape because of the power lines are unavoidable. The land area immediately adjoining the Station is sufficiently homogeneous that no preferential routing is obvious. Aesthetic deterioration has therefore been minimized to some extent by the applicant's efforts to route the power transmission lines through valleys and less prominent land areas. In addition, the applicant's plan to foster cultivation of the transmission corridors as wildlife feeding areas is consistent with the Department of Interior's and the Department of Agriculture's "Environmental Criteria for Electric Transmission Systems."

Presumably, the new land use will increase the land value and add proportionately to the revenue from county property taxes. The new use will require some increase in county services, but the applicant has already absorbed some of the initial service cost by providing access roads to the lake area.

The lake residential area will be valuable to the residents of Oconee and Pickens Counties and metropolitan Greenville, South Carolina, which is only about 25 miles from the power plant site. This lake, being accessible and having clean water, will probably be of significant recreational value to the metropolitan area.

Should the applicant's land development plans materialize, the new land use will probably have an enhanced market value. The new land use does involve the loss of some marginal agricultural productivity, and the loss of residences mentioned above. The new land use therefore is a trade-off involving the loss of woodland, low-productivity farmland, and usable housing in exchange for potential new land developments of higher capital value with anticipated greater tax return and attractive recreational features. Many citizens of the area would consider the alteration of land use a beneficial change.

2. Cultural and Social Considerations

Both social and cultural circumstances within Oconee County have been altered by the Keowee-Toxaway Project. Direct effects are loss of the historical remnants of Fort Prince George, a pre-Revolutionary British outpost; the loss of Old Keoweetown, an Indian village of the Lower Cherokee Nation; and the loss of 344 houses and the displacement of about 900 residents living in the area flooded by the pumped storage reservoirs. Each of these must be reckoned as a societal cost, even though their quantitative value may not be large compared with values involved in other projects, such as urban renewal or flood control.

Construction of the installation has had little effect on community facilities and services. The applicant established special living facilities at the job site to accommodate construction forces and has drawn on locally based labor, so that there has been little change in the demand for community services or facilities during the construction program. Since construction has passed its peak (see Fig.XI-1), the impact of the construction work on the community should impose no future increase in demands on community facilities.

The power plant installations have become the focal point of the area and have converted the rural environment into one resembling the environment of a large civil works installation. The lake system, the cultural attraction of the Keowee-Toxaway visitor center, and the public interest arising from construction of the power plant have made the installation a tourist attraction. The isolated environment of an earlier period has vanished.

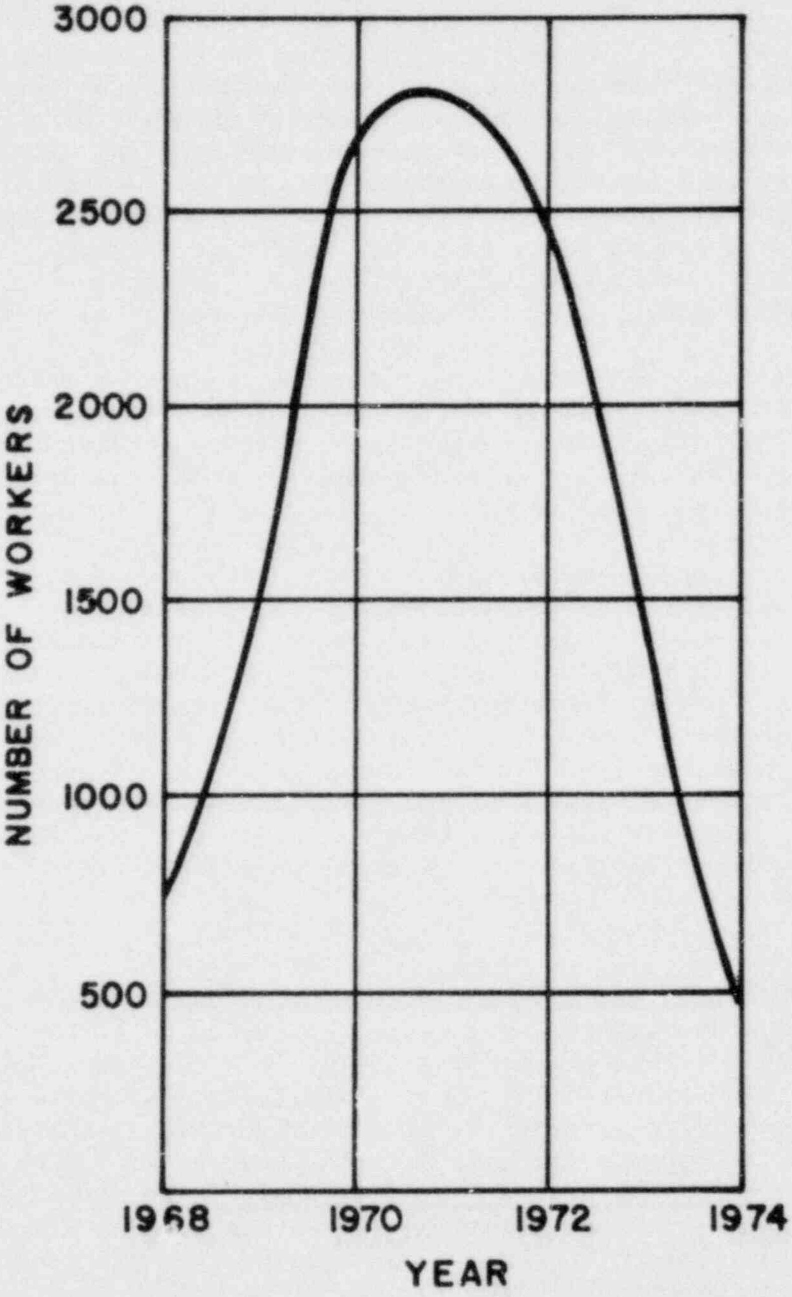

FIG. XI-1

NUMBER OF CONSTRUCTION EMPLOYEES,

1968 to 1974,

AT OCONEE NUCLEAR STATION

This change in living environment will undoubtedly be objectionable to some residents of the community. Most, however, will probably adjust readily to the circumstances and perhaps find new economic opportunity in the changed environment. Whether any real value can be assigned to this change in the cultural atmosphere is debatable. Measured in terms of human response, it is our judgment that the majority of the residents will feel a positive improvement in the living circumstances once the construction program has terminated.

Social attitudes will be affected in some measure by the financial benefits in taxes which Oconee County will receive from the power installation, since these taxes may be used to provide better community services such as improved schools, roads, sanitary facilities, and other public benefits.

The ultimate social impact may, in fact, be somewhat at variance with the short-term social attitudes. The influx of tourism and recreational activity will bring a demand for tourist facilities and services that will probably lead to increased commercial growth in the area. Some of the permanent power plant work force can be expected to settle nearby, and the lake front residential sites will eventually be used for new homes. This should generally lead to a standard of living which will probably be accompanied by a demand for more extensive community facilities. This new mode of life may eventually dominate the local social system.

3. Economic Factors

The electrical output of the Oconee station, amounting to more than 18 million megawatt-hours per year, represents more than $200 million gross annual worth of electrical energy to be distributed over the applicant's power network. This commodity will be converted into various manufactured products, electrically powered services, and living conveniences. The manufactured products will provide taxable goods to the areas served. The electrical energy directly contributes to the tax base, besides contributing to the affluence and productivity of the area served. Thus the generation of electrical power is the predominant economic benefit.

The economic value of the energy, however, is of little direct benefit to the local residents. To them, the main economic benefit is derived from the tax return on the real property at the lake shore and the direct tax on the industrial property. The applicant indicates a capital cost of $578 million for the power installation and another $63 million in cost for the acquired land. At present, the assessed property value of Oconee County is $19,069,040 which yields an annual tax return of approximately $2,050,000 per year. The new industrial and residential property could support a tax burden that will more than double the current local tax income; the actual tax income to Oconee County from the new property value, however, has not been reported. The regional economy will be further improved by the plant payroll (more than $1.5 million annual income received by the 170 employees), which will be spent primarily in Oconee, Pickens, Anderson, and Greenville counties.

To counterbalance this economic benefit, minor costs will result from the increase in traffic created by outside visitors, and increased demands for school facilities and residential services will result from residential growth in the Oconee area. However, there should be a substantial net gain in the community's financial income, which will be of direct benefit to the present and future residents of the area.

4. Ecological Effects

As was noted earlier, the reassignment of land use has altered both the terrestrial and aquatic systems in the Keowee-Toxaway Project land complex. The flooding of land and streams resulted in loss of terrestrial wildlife and loss of those organisms that are able to live only in streams. Lake organisms will become predominant. Although the size of the flooded area is substantial, it is small compared with the adjoining land of like features, which is essentially undisturbed.

The applicant has planned a managed forestry program for the balance of the land he owns. The use of this land is independent of the applicant's requirements associated with the Oconee Nuclear Station but is an extension of the applicant's land development activities. The managed forestry will probably result in the eventual displacement of some portion of the deciduous forest by rapid-growth softwoods. However, the rate of change will not be abrupt, and the effects are subject to the surveillance of State regulatory authorities.

The lake system created by the Jocassee and Keowee reservoirs greatly expands the aquatic ecosystem, and there is, as yet, limited information about its ultimate character. The cooling capacity in the reservoir is considered ample for the Oconee Nuclear Station. Potential impacts to the aquatic ecosystem from Station operation, however, do exist during certain periods of the year. The factors of most importance to this aquatic ecosystem are the distribution of temperature and oxygen within the lake system resulting from the thermal discharge of the power plant. Since it is expected that the lakes will be developed for recreational (sport) fishery, the applicant should take the necessary steps to assure that the impacts resulting from operation of the plant are minimized. Hence, surveillance of the effects on the aquatic ecosystem must be conducted by the applicant and any needed modifications indicated by the results of the surveillance must be made.

5. Natural Resources

Operation of the Oconee Nuclear Station makes the consumption of nuclear fuel inevitable. A commitment of approximately 76 metric tons of fissile material (^{235}U and/or ^{239}Pu) is projected over the life of the plant.

The once-through cooling system for dissipating waste heat from the Oconee Nuclear Station utilizes a significant fraction of the heat-absorbing capacity of the Keowee-Toxaway water system. Although the thermal load on this water system could be reduced by the use of cooling towers, there appears to be no need for at the present time. If future circumstances require it, cooling towers can be added.

The land use pattern of the area has changed, in that limits agricultural productivity has been removed and some fish production and managed forestry has taken its place. The change results from the applicant's exercise of his prerogatives as land owner, as regulated by local, State, and Federal agencies.

6. Environmental Degradation

The cumulative effect of the operation of a power plant of this size is certain to cause some change in the quality of the air, water, and land in the vicinity of the plant. Waste heat dumped to the lake system will raise lake temperatures and may increase the frequency of local fog conditions in the immediate vicinity of the lakes, but this should be only a minor impact. There are no major roads in the vicinity and no airport is within ten miles. If local fogging should occur it will probably affect only pleasure boaters, fishermen, and local residents.

The discharge of heated water will improve the fishing in the vicinity of the discharge during the winter, but will reduce the fishing area during late summer and early fall, when the high temperature will drive fish from the discharge area.

During two to three months of the year, water low in dissolved oxygen will be released from the plant as the result of withdrawing oxygen-deficient water from the hypolimnion and discharging it to the surface of the reservoir. (See Section III.D.1.c. and V.C.1.d.) Mobile organisms will leave the discharge area during this time and non-mobile forms in the area will be killed.

The Oconee plant will discharge some radioactive materials into Hartwell Reservoir, and some radioactive gaseous effluents will be discharged into the atmosphere. The AEC regulations, 10 CFR 20 and 10 CFR 50, require the applicant to control such discharges to assure that they will be as low as practicable.

Small increase in risk to the human population and to the environment is associated with the radioactivity released during operation of this nuclear power station.

7. Cost-Benefit Balance

While the summing of all costs and benefits cannot be purely quantitative, the anticipated benefits appear to be greater than the environmental costs. The balancing of benefits to costs, as shown in Table XI-1 and described in Appendix XI-1, appears to be reasonable.

The choice of nuclear fuel in preference to f sil fuel appears to be justified. The projection of the applicant's power requirements is based on the record of the past decade; the timing of the construction of the Keowee-Toxaway Project and the Oconee Nuclear Power Station is reasonable. The applicant's choice of the Oconee site is reasonable. The method of heat dissipation seems adequate but should be monitored as there is some concern over the localized low oxygen content for a small area of the lake due to the effects of the thermal plume. Radioactive waste releases to the environment are expected to meet the requirements of 10 CFR 20 and the criteria suggested in the proposed Appendix I of 10 CFR Part 50. Societal benefits in the local area are expected to be significant.

With the possible exception of the effects of plant effluents, the effects on the natural environment are those of change rather than degradation. This will be accompanied by a change in the pattern of living of those in the neighboring region. The influx of vacationers and tourists could have adverse effects on the quality of life as well as beneficial effects on the economics of the area. For this reason, the applicant and local government should work together so that maximum benefits of the Keowee-Toxaway Project will be realized.

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APPENDIX II-1

OCONEE METEOROLOGICAL DATA FOR COMPUTER

The basic data were furnished by the applicant for the Oconee Site. The data are from Appendix 2A of the applicant's Final Safety Analysis Report.

The tables of interest are found on pages 2A-12-a, 2A-12-b, and 2A-12-c of the FSAR, reproduced here as Table A-II-1. The tables were checked for accuracy, and one discrepancy was found on page 2A-12-c. This is noted on the table. Because the totals in both directions were off the same amount in the same direction, the number of observations of a west wind of 5.5-6.49 meters/second is a typographical error. The Tables A-II-2 to -7 were derived from the original; they contain only the number of observations for each stability condition with the additional following modifications:

1. The number of observed calms was omitted.
2. The last three columns were combined into one column.
3. The mean wind speed was used instead of the range.
4. The direction was changed from wind sector to the direction toward which the wind blows.
5. The East direction was placed first since the computer code is designed to calculate East first and proceed in a clockwise direction.

These modified tables are designated Table A-II-2, Table A-II-3, and Table A-II-4.

The next step was to combine Table A-II-3 and Table A-II-4 and assume that all these observations are F-Stability. This combination is shown in Table A-II-5.

Table A-II-1. Oconee meteorological survey (tower data): summary of Pasquill F, E, and D wind occurrences (number and percent) by sector and speed class for period June 19, 1968 through June 19, 1969[a]

Wind Sector	Item	Sector Total	1.0–3.2 0.45–1.49	3.3–5.5 1.5–2.49	5.6–7.8 2.5–3.49	7.0–10.0 2.5–4.49	10.1–12.3 4.5–5.49	12.4–14.5 5.5–6.49	14.6–16.7 6.5–7.49	16.8–19.0 7.5–8.49	19.1–21.2 8.5–9.49	>21.2 mph >=9.5 m/s
						Pasquill F (total valid observations: 8661)						
N	No.	499	131	260	95	12	1	0	0	0	0	0
	%	5.76	1.51	3.00	1.10	0.14	0.01	0.00	0.00	0.00	0.00	0.00
NNE	No.	166	68	66	29	3	0	0	0	0	0	0
	%	1.92	0.79	0.76	0.33	0.03	0.00	0.00	0.00	0.00	0.00	0.00
NE	No.	135	61	57	13	3	0	0	1	0	0	0
	%	1.56	0.70	0.66	0.15	0.03	0.00	0.00	0.01	0.00	0.00	0.00
ENE	No.	57	36	20	0	1	0	0	0	0	0	0
	%	0.66	0.42	0.23	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
E	No.	116	55	55	4	1	1	0	0	0	0	0
	%	1.34	0.63	0.64	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00
ESE	No.	65	30	32	3	0	0	0	0	0	0	0
	%	0.75	0.35	0.37	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE	No.	41	18	19	2	2	0	0	0	0	0	0
	%	0.47	0.21	0.22	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
SSE	No.	23	10	11	2	0	0	0	0	0	0	0
	%	0.27	0.12	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	No.	19	6	10	2	1	0	0	0	0	0	0
	%	0.18	0.07	0.12	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
SSW	No.	39	16	18	4	0	0	1	0	0	0	0
	%	0.45	0.18	0.21	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00
SW	No.	95	29	40	15	10	1	0	0	0	0	0
	%	1.10	0.33	0.46	0.17	0.12	0.01	0.00	0.00	0.00	0.00	0.00
WSW	No.	75	31	23	17	3	0	1	0	0	0	0
	%	0.87	0.36	0.27	0.20	0.03	0.00	0.01	0.00	0.00	0.00	0.00
W	No.	102	43	28	23	5	2	0	0	1	0	0
	%	1.18	0.50	0.32	0.27	0.06	0.02	0.00	0.00	0.01	0.00	0.00
WNW	No.	101	40	42	10	8	1	0	0	0	0	0
	%	1.17	0.46	0.48	0.12	0.09	0.01	0.00	0.00	0.00	0.00	0.00
NW	No.	222	87	105	21	9	0	0	0	0	0	0
	%	2.56	1.00	1.21	0.24	0.10	0.00	0.00	0.00	0.00	0.00	0.00
NNW	No.	352	110	188	52	2	0	0	0	0	0	0
	%	4.06	1.27	2.17	0.60	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Calm	No.	27	--	--	--	--	--	--	--	--	--	--
	%	0.31	--	--	--	--	--	--	--	--	--	--
Total	No.	2134	771	974	292	60	6	2	1	1	0	0
	%	24.64	8.90	11.25	3.37	0.69	0.07	0.02	0.01	0.01	0.00	0.00

Table A-II-1 (continued)

Wind Sector	Item	Sector Total	1.0–3.2 0.45–1.49	3.3–5.5 1.5–2.49	5.6–7.8 2.5–3.49	7.9–10.0 3.5–4.49	10.1–12.3 4.5–5.49	12.4–14.5 5.5–6.49	14.6–16.7 6.5–7.49	16.8–19.0 7.5–8.49	19.1–21.2 8.5–9.49	>21.1 mph >=9.5 m/s
						Pasquill E (total valid observations: 8656)						
N	No.	458	118	247	77	12	4	0	0	0	0	0
	%	5.29	1.36	2.58	0.89	0.14	0.05	0.00	0.00	0.00	0.00	0.00
NNE	No.	166	52	85	23	3	2	1	0	0	0	0
	%	1.92	0.68	0.98	0.27	0.03	0.02	0.01	0.00	0.00	0.00	0.00
NE	No.	138	40	61	26	10	1	0	0	0	0	0
	%	1.59	0.46	0.70	0.30	0.12	0.01	0.00	0.00	0.00	0.00	0.00
ENE	No.	55	18	23	9	4	1	0	0	0	0	0
	%	0.64	0.21	0.27	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00
E	No.	56	25	23	4	4	0	0	0	0	0	0
	%	0.65	0.29	0.27	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ESE	No.	42	18	20	1	2	0	1	0	0	0	0
	%	0.49	0.21	0.23	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00
SE	No.	41	4	29	5	3	0	0	0	0	0	0
	%	0.47	0.05	0.34	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00
SSE	No.	33	10	13	9	0	1	0	0	0	0	0
	%	0.38	0.12	0.15	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00
S	No.	32	9	14	3	2	4	0	0	0	0	0
	%	0.37	0.10	0.16	0.03	0.02	0.05	0.00	0.00	0.00	0.00	0.00
SSW	No.	51	6	20	7	13	4	1	0	0	0	0
	%	0.59	0.07	0.23	0.08	0.15	0.05	0.01	0.00	0.00	0.00	0.00
SW	No.	130	22	46	34	22	6	0	0	0	0	0
	%	1.50	0.25	0.53	0.39	0.25	0.07	0.00	0.00	0.00	0.00	0.00
WSW	No.	103	18	27	28	16	11	3	0	0	0	0
	%	1.19	0.21	0.31	0.32	0.18	0.13	0.03	0.00	0.00	0.00	0.00
W	No.	136	25	27	30	22	17	10	4	1	0	0
	%	1.57	0.29	0.31	0.35	0.25	0.20	0.12	0.05	0.01	0.00	0.00
WNW	No.	82	24	28	10	14	4	1	1	0	0	0
	%	0.95	0.28	0.32	0.12	0.16	0.05	0.01	0.01	0.00	0.00	0.00
NW	No.	89	36	31	8	6	8	0	0	0	0	0
	%	1.03	0.42	0.36	0.09	0.07	0.09	0.00	0.00	0.00	0.00	0.00
NNW	No.	127	54	54	15	3	1	0	0	0	0	0
	%	1.47	0.62	0.62	0.17	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Calm	No.	14	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
	%	0.16	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Total	No.	1753	479	748	289	136	64	17	5	1	0	0
	%	20.25	5.53	8.64	3.34	1.57	0.74	0.20	0.06	0.01	0.00	0.00

Table A-II-1 (continued)

Wind Sector	Item	Sector Total	1.0–3.2 0.45–1.49	3.3–5.5 1.5–2.49	5.6–7.8 2.5–3.49	7.9–10.0 3.5–4.49	10.1–12.3 4.5–5.49	12.4–14.5 5.5–6.49	14.6–16.7 6.5–7.49	16.8–19.0 7.5–8.49	19.1–21.2 8.5–9.49	>21.2 mph >=9.5 m/s
Pasquill D (total valid observations: 8619)												
N	No.	505	211	188	73	18	10	3	2	0	0	0
	%	5.86	2.49	2.18	0.85	0.21	0.12	0.03	0.02	0.00	0.00	0.00
NNE	No.	371	138	161	40	14	7	3	4	3	1	0
	%	4.30	1.60	1.87	0.46	0.16	0.08	0.03	0.05	0.03	0.01	0.00
NE	No.	566	121	163	145	72	34	15	13	3	0	0
	%	6.57	1.40	1.89	1.68	0.84	0.39	0.17	0.15	0.03	0.00	0.00
ENE	No.	374	76	100	85	77	23	10	3	0	0	0
	%	4.34	0.88	1.16	0.99	0.89	0.27	0.12	0.03	0.00	0.00	0.00
E	No.	336	97	117	66	41	8	6	1	0	0	0
	%	3.90	1.13	1.36	0.77	0.48	0.09	0.07	0.01	0.00	0.00	0.00
ESE	No.	213	84	90	29	6	4	0	0	0	0	0
	%	2.45	0.97	1.04	0.34	0.07	0.05	0.00	0.00	0.00	0.00	0.00
SE	No.	224	65	105	40	13	1	0	0	0	0	0
	%	2.60	0.75	1.22	0.46	0.15	0.01	0.00	0.00	0.00	0.00	0.00
SSE	No.	104	32	50	15	6	1	0	0	0	0	0
	%	1.21	0.37	0.58	0.17	0.07	0.01	0.00	0.00	0.00	0.00	0.00
S	No.	122	28	79	10	4	1	0	0	0	0	0
	%	1.42	0.32	0.92	0.12	0.05	0.01	0.00	0.00	0.00	0.00	0.00
SSW	No.	214	27	72	48	42	16	8	1	0	0	0
	%	2.48	0.31	0.84	0.56	0.49	0.19	0.09	0.01	0.00	0.00	0.00
SW	No.	406	79	131	77	57	34	27	1	0	0	0
	%	4.71	0.92	1.52	0.89	0.66	0.39	0.31	0.01	0.00	0.00	0.00
WSW	No.	254	71	54	50	17	27	20	7	3	2	3
	%	2.95	0.82	0.63	0.58	0.20	0.31	0.23	0.08	0.03	0.02	0.03
W	No.	287	63	70	38	25	31	29[b]	17	11	0	3
	%	3.33	0.73	0.81	0.44	0.29	0.36	0.34	0.20	0.13	0.00	0.03
WNW	No.	180	52	44	26	17	20	8	6	5	1	1
	%	2.09	0.60	0.51	0.30	0.20	0.23	0.09	0.07	0.06	0.01	0.01
NW	No.	203	81	62	26	18	9	3	3	0	1	0
	%	2.36	0.94	0.72	0.30	0.21	0.10	0.03	0.03	0.00	0.01	0.00
NNW	No.	200	102	58	25	9	3	3	0	0	0	0
	%	2.31	1.18	0.67	0.29	0.10	0.03	0.03	0.00	0.00	0.00	0.00
Calm	No.	52	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
	%	0.60	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
Total	No.	4611	1327	1544	793	436	229	135	58	25	5	7
	%	53.50	15.40	17.91	9.20	5.06	2.66	1.57	0.67	0.29	0.06	0.08

[a]From Duke Power Company, *Final Safety Analysis Report, Oconee Nuclear Station, Units 1, 2 and 3,* pages 2A–12a, 2A–12b and 2A 12c; Rev. 9, Aug. 11, 1970.
[b]Changed from 24.

Table A-II-2

NUMBER OF OBSERVATIONS OF D-STABILITY

Wind Toward	Wind Speed (meters/sec) 1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	Total
E	63	70	38	25	31	29	17	14	287
ESE	52	44	26	17	20	8	6	7	180
SE	81	62	26	18	9	3	3	1	203
SSE	102	58	25	9	3	3	0	0	200
S	211	188	73	18	10	3	2	0	505
SSW	138	161	40	14	7	3	4	4	371
SW	121	163	145	72	34	15	13	3	566
WSW	76	100	85	77	23	10	3	0	374
W	97	117	66	41	8	6	1	0	336
WNW	84	90	29	6	4	0	0	0	213
NW	65	105	40	13	1	0	0	0	224
NNW	32	50	15	6	1	0	0	0	104
N	28	79	10	4	1	0	0	0	122
NNE	27	72	48	42	16	8	1	0	214
NE	79	131	77	57	34	27	1	0	406
ENE	71	54	50	17	27	20	7	8	254
Total	1327	1544	793	436	229	135	58	37	4559

Table A-II-3

NUMBER OF OBSERVATIONS OF E-STABILITY

Wind Toward	Wind Speed (meters/sec) 1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	Total
E	25	27	30	22	17	10	4	1	136
ESE	24	28	10	14	4	1	1	0	82
SE	36	31	8	6	8	0	0	0	89
SSE	54	54	15	3	1	0	0	0	127
S	118	247	77	12	4	0	0	0	458
SSW	52	85	23	3	2	1	0	0	166
SW	40	61	26	10	1	0	0	0	138
WSW	18	23	9	4	1	0	0	0	55
W	25	23	4	4	0	0	0	0	56
WNW	18	20	1	2	0	1	0	0	42
NW	4	29	5	3	0	0	0	0	41
NNW	10	13	9	0	1	0	0	0	33
N	9	14	3	2	4	0	0	0	32
NNE	6	20	7	13	4	1	0	0	51
NE	22	46	34	22	6	0	0	0	130
ENE	18	27	28	16	11	3	0	0	103
Total	479	748	289	136	64	17	5	1	1739

Table A-II-4

NUMBER OF OBSERVATIONS OF F-STABILITY

Wind Toward	Wind Speed (meters/sec) 1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	Total
E	43	28	23	5	2	0	0	1	102
ESE	40	42	10	8	1	0	0	0	101
SE	87	105	21	9	0	0	0	0	222
SSE	110	188	52	2	0	0	0	0	352
S	131	260	95	12	1	0	0	0	499
SSW	68	66	29	3	0	0	0	0	166
SW	61	57	13	3	0	0	1	0	135
WSW	36	20	0	1	0	0	0	0	57
W	55	55	4	1	1	0	0	0	116
WNW	30	32	3	0	0	0	0	0	65
NW	18	19	2	2	0	0	0	0	41
NNW	10	11	2	0	0	0	0	0	23
N	6	10	2	1	0	0	0	0	19
NNE	16	18	4	0	0	1	0	0	39
NE	29	40	15	10	1	0	0	0	95
ENE	31	23	17	3	0	1	0	0	75
Total	771	974	292	60	6	2	1	1	2107

Table A-II-5

NUMBER OF OBSERVATIONS OF E- AND F-STABILITY

Wind Toward	Wind Speed (meters/sec) 1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	Total
E	68	55	53	27	19	10	4	2	238
ESE	64	70	20	22	5	1	1	0	183
SE	123	136	29	15	8	0	0	0	311
SSE	164	242	67	5	1	0	0	0	479
S	249	507	172	24	5	0	0	0	957
SSW	120	151	52	6	2	1	0	0	332
SW	101	118	39	13	1	0	1	0	273
WSW	54	43	9	5	1	0	0	0	112
W	80	78	8	5	1	0	0	0	172
WNW	48	52	4	2	0	1	0	0	107
NW	22	48	7	5	0	0	0	0	82
NNW	20	24	11	0	1	0	0	0	56
N	15	24	5	3	4	0	0	0	51
NNE	22	38	11	13	4	2	0	0	90
NE	51	86	49	32	7	0	0	0	225
ENE	49	50	45	19	11	4	0	0	178
Total	1250	1722	581	196	70	19	6	2	3846

Table A-II-6

FREQUENCY OF WIND SPEED UNDER D-STABILITY CONDITIONS AS A FUNCTION OF DIRECTION

Wind Toward	Wind Speed (meters/sec) 1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	Total
E	0.0075	0.0083	0.0045	0.0030	0.0037	0.0035	0.0020	0.0017	0.0342
ESE	0.0062	0.0052	0.0031	0.0020	0.0024	0.0010	0.0007	0.0008	0.0214
SE	0.0096	0.0074	0.0031	0.0021	0.0011	0.0004	0.0004	0.0001	0.0242
SSE	0.0121	0.0069	0.0030	0.0011	0.0004	0.0004	0	0	0.0239
S	0.0251	0.0224	0.0087	0.0021	0.0012	0.0004	0.0002	0	0.0601
SSW	0.0164	0.0192	0.0048	0.0017	0.0008	0.0004	0.0005	0.0005	0.0443
SW	0.0144	0.0194	0.0173	0.0086	0.0040	0.0018	0.0015	0.0004	0.0674
WSW	0.0090	0.0119	0.0101	0.0092	0.0027	0.0012	0.0004	0	0.0445
W	0.0115	0.0139	0.0079	0.0049	0.0010	0.0007	0.0001	0	0.0400
WNW	0.0100	0.0107	0.0035	0.0007	0.0005	0	0	0	0.0254
NW	0.0077	0.0125	0.0048	0.0015	0.0001	0	0	0	0.0266
NNW	0.0038	0.0059	0.0018	0.0007	0.0001	0	0	0	0.0123
N	0.0033	0.0094	0.0012	0.0005	0.0001	0	0	0	0.0145
NNE	0.0032	0.0086	0.0057	0.0050	0.0019	0.0010	0.0001	0	0.0255
NE	0.0094	0.0156	0.0092	0.0068	0.0040	0.0032	0.0001	0	0.0483
ENE	0.0084	0.0064	0.0059	0.0020	0.0032	0.0024	0.0008	0.0010	0.0301
Total	0.1576	0.1837	0.0946	0.0519	0.0272	0.0164	0.0068	0.0045	0.5427

Table A-II-7

FREQUENCY OF WIND SPEED UNDER F-STABILITY CONDITIONS AS A FUNCTION of DIRECTION

Wind Toward	Wind Speed (meters/sec)								Total
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	>8.00	
E	0.0081	0.0065	0.0063	0.0032	0.0023	0.0012	0.0005	0.0002	0.0283
ESE	0.0076	0.0083	0.0024	0.0026	0.0006	0.0001	0.0001	0	0.0217
SE	0.0146	0.0162	0.0035	0.0018	0.0010	0	0	0	0.0371
SSE	0.0195	0.0288	0.0080	0.0006	0.0001	0	0	0	0.0570
S	0.0296	0.0602	0.0205	0.0029	0.0006	0	0	0	0.1138
SSW	0.0143	0.0180	0.0062	0.0007	0.0002	0.0001	0	0	0.0395
SW	0.0120	0.0140	0.0046	0.0015	0.0001	0	0.0001	0	0.0323
WSW	0.0064	0.0051	0.0011	0.0006	0.0001	0	0	0	0.0133
W	0.0095	0.0093	0.0010	0.0006	0.0001	0	0	0	0.0205
WNW	0.0057	0.0062	0.0005	0.0002	0	0.0001	0	0	0.0127
NW	0.0026	0.0057	0.0008	0.0006	0	0	0	0	0.0097
NNW	0.0024	0.0029	0.0013	0	0.0001	0	0	0	0.0067
N	0.0018	0.0029	0.0006	0.0004	0.0005	0	0	0	0.00[illegible]2
NNE	0.0026	0.0045	0.0013	0.0015	0.0005	0.0002	0	0	0.0106
NE	0.0061	0.0102	0.0058	0.0038	0.0008	0	0	0	0.0267
ENE	0.0058	0.0059	0.0054	0.0023	0.0013	0.0005	0	0	0.0212
Total	0.1486	0.2047	0.0693	0.0233	0.0083	0.0022	0.0007	0.0002	0.4573

Appendix II-2

BIOTA OF THE KEOWEE-TOXAWAY AREA

Table A-11-8. Probable Bird Species Found in the Keowee-Toxaway Area

Gaviidae
- Gavia immer (common loon)

Podicipedidae
- Podiceps auritus (horned grebe)
- Podilymbus podiceps (pied-billed grebe)

Ardeidae
- Ardea herodias (great blue heron)
- Butorides virescens (green heron)
- Florida caerulea (little blue heron)
- Nycticorax nycticorax (black-crowned night heron)
- Botaurus lentiginosus (American bittern)

Anatidae
- Branta canadensis (Canada goose)
- Aix sponsa (wood duck)
- Anas platyrhynchos (mallard)
- Anas carolinensis (green-winged teal)
- Anas rubripes (black duck)
- Anas acuta (pintail)
- Anas strepera (gadwall)
- Mareca americana (American widgeon)
- Spatula clypeata (shoveler)
- Anas discors (blue-winged teal)
- Aythya americana (redhead)
- Aythya valisineria (canvasback)
- Aythya collaris (ring-necked duck)
- Aythya marila (greater scaup)
- Aythya affinis (lesser scaup)
- Bucephala elangula (common goldeneye)
- Bucephala albeola (bufflehead)
- Oxyura jamaicensis (ruddy duck)
- Mergus serrator (red-breasted merganser)
- Lophodytes cucullatus (hooded erganser)

Cathartidae
- Cathartes aura (turkey vulture)
- Coragyps atratus (black vulture)

Accipitridae

Accipter striatus (sharp-shinned hawk)
Accipter cooperi (Cooper's hawk)
Buteo jamaicensis (red-tailed hawk)
Haliaeetus leucocephalus (Southern bald eagle)
Circus cyaneus (marsh hawk)
Buteo lagopus (rough-legged hawk)
Buteo lineatus (red-shouldered hawk)
Buteo platypterus (broad-winged hawk)

Pandionidae

Pandion haliaetus (osprey)

Falconidae

Falco sparverius (sparrow hawk)
Falco columbarius (pigeon hawk)

Tetraonidae

Bonasa umbellus (ruffed grouse)

Phasianidae

Colinus virginianus (bobwhite)

Meleagridae

Meleagris gallopavo (wild turkey)

Rallidae

Coturnicops noveboracensis (yellow rail)
Fulica americana (American coot)
Rallus limicola (Virginia rail)
Porzana carolina (sora)
Rallus elegans (king rail)

Columbidae

Zenaidura macroura (mourning dove)

Alcedinidae

Megaceryle alcyon (belted kingfisher)

Picidae

Colaptes auratus (flicker)
Dryocopus pileatus (pileated woodpecker)
Dendrocopos pubescens (downy woodpecker)
Dendrocopos villosus (hairy woodpecker)
Campephilus principalis (ivory-billed woodpecker - this species is now probably extinct in this area)

Centurus carolinus (red-bellied woodpecker)
Melanerpes erythrocephalus (red-headed woodpecker)
Sphyrapicus varius (yellow-bellied sapsucker)

Tyrannidae
Tyrannus tyrannus (Eastern kingbird)
Contropus virens (wood pewee)
Myiarchus crinitus (great crested flycatcher)
Sayornis phoebe (Eastern phoebe)
Empidonax flaviventris (yellow bellied flycatcher)
Empidonax virescens (green-crested flycatcher)
Empidonax traillii (Traill's flycatcher)
Empidonax minimus (least flycatcher)

Alandidae
Eremophila alpestris (horned lark)

Hirundinidae
Hirundo rustica (barn swallow)
Progne subis (purple martin)

Corvidae
Corvus brachyrhynchos (common crow)
Cyanocitta cristata (bluejay)

Paridae
Parus carolinensis (Carolina chickadee)

Sittidae
Sitta carolinensis (white-breasted nuthatch)
Sitta canadensis (red-breasted nuthatch)

Certhiidae
Certhia familiaris (brown creeper)

Troglodytidae
Thryothorus ludovicianus (Carolina wren)
Troglodytes aedon (house wren)

Mimidae
Mimus polyglottus (mockingbird)
Dumetella carolinensis (catbird)
Toxostoma rufum (brown thrasher)

Turdidae

Turdus migratorius (robin)
Hylocichla mustelina (wood thrush)
Hylocichla fuscescens (veery)

Bombycillidae

Bombycilla cedrorum (cedar waxwing)

Vireonidae

Vireo solitarius (blue-headed vireo)
Vireo olivaceus (red-eyed vireo)

Parulidae

Mniotilta varia (black and white warbler)
Parula americana (parula warbler)
Dendroica caerulescens (black-throated blue warbler)
Dendroica fusca (Blackburnian warbler)
Seiurus aurocapillus (ovenbird)
Wilsonia citrina (hooded warbler)
Setophaga ruticilla (American redstart)
Icteria virens (yellow breasted chat)

Thraupidae

Piranga rubra (summer tanager)
Piranga olivacea (scarlet tanager)
Richmondena cardinalis (cardinal)
Pheucticus ludovicianus (rose-breasted grosbeak)
Hesperiphona vespertina (evening grosbeak)

Fringillidae

Junco hyemalis (slate-colored junco)
Spinus pinus (pine siskin)
Passerina cyanea (indigo bunting)
Pipilo erythrophthalmus (towhee)
Carpodacus purpurens (purple finch)
Aimophila aestivalis (pine sparrow)
Spizella passerina (chipping sparrow)
Spizella pusilla (field sparrow)
Passerella iliaca (fox sparrow)

Compiled from:

1. Eugene P. Odum, "Bird Populations of the Highlands (North Carolina) Plateau in Relation to Plant Succession and Avian Invasion," *Readings in Population and Community Ecology*, ed., William E. Hazen, W. B. Saunders Company, Philadelphia, 1964.

2. South Carolina Wildlife (John Culler, ed.) 17(3) (summer 1970).

3. Information supplied by Dr. James Hebrard, Department of Zoology, Clemson University, Clemson, S.C.

Table A-II-9. Mammalian Species Probably Found in the Keowee-Toxaway Area

Didelphidae
- Didelphis virginiana (opossum)

Soricidae
- Sorex fumeus (smoky shrew)
- Sorex longirostris (Bachman's shrew)
- Cryptotis parva (least shrew)
- Blarina brevicauda (short-tailed shrew)

Talpidae
- Scalopus aquaticus (Eastern mole)

Vespertilionidae
- Myotis keenii (Say's bat)
- Lasionycteris noctivagans (silver-haired bat)
- Pipistrellus subflavus (pipistrelle)
- Eptesicus fuscus (big brown bat)
- Lasiurus borealis (red bat)
- Nycticeius humeralis (twilight bat)

Leporidae
- Sylvilagus floridanus (cottontail rabbit)
- Sylvilagus aquaticus (swamp rabbit)

Sciuridae
- Marmota monax (woodchuck)
- Tamias striatus (chipmunk)
- Sciurus carolinensis (gray squirrel)
- Sciurus niger (fox squirrel)
- Glaucomys volans (flying squirrel)
- Tamiasciurus hudsonicus (red squirrel)

Castoridae
- Castor canadensis (beaver)

Muridae
- Rattus rattus (black rat)
- Rattus norvegicus (Norway rat)
- Mus musculus (house mouse)

Cricetidae

Neotoma floridana (wood rat)
Peromyscus leucopus (white-footed mouse)
Peromyscus maniculatus (deer mouse)
Ochrotomys nuttalli (golden mouse)
Sigmodon hispidus (cotton rat)
Oryzomys palustris (rice rat)
Microtus pinetorum (pine mouse)
Ondatra zibethica (muskrat)
Microtus pennsylvanicus (meadow vole)
Reithrodontomys humulis (harvest mouse)

Zapodidae

Zapus hudsonicus (meadow jumping mouse)

Canidae

Vulpes fulva (red fox)
Urocyon cinereoargenteus (gray fox)

Ursidae

Euarctos americanus (American black bear)

Procyonidae

Procyon lotor (raccoon)

Mustelidae

Mustela frenata (large brown weasel)
Mustela vison (mink)
Lutra canadensis (otter)
Spilogale putorius (spotted skunk)
Mephitis mephitis (striped skunk)

Felidae

Lynx rufus (bobcat)

Suidae

Sus scrofa (wild boar)

Cervidae

Odocoileus virginianus (Virginia white-tailed deer)

Compiled from:

1. William J. Hamilton, *The Mammals of the Eastern United States*, Comstock Publishing Co., Ithaca, N. Y., 1943.

2. Frank B. Golley, South Carolina Mammals, The Charleston Museum, Charleston, S.C., 1966.

3. W. H. Adams, "New Locality Records of Two North Carolina Mammals," J. Mammalogy 46(3): 419, 1965.

4. Information supplied by Dr. W. K. Willard, Department of Zoology, Clemson University, Clemson, S.C.

Table A-II-10. Amphibian Species Probably Found in the Lake Keowee-Lake Jocassee Area

Caudata (salamanders)

Salamandridae
- Notophthalmus viridescens viridescens (red spotted newt)

Ambystomidae
- Ambystoma maculatum (spotted salamander)
- Ambystoma opacum (marbled salamander)

Plethodontidae
- Desmognathus fuscus fuscus (Northern dusky salamander)
- Desmognathus ochrophacus (mountain salamander)
- Desmognathus monticola (seal salamander)
- Desmognathus quadramaculatus (black-bellied salamander)
- Plethodon cinereus (Eastern red-backed salamander)
- Plethodon glutinosus (slimy salamander)
- Plethodon jordani clemsonae (Jordan's salamander)
- Hemidactylium scutatum (Eastern four-toed salamander)
- Aneides aeneus (green salamander)
- Gyrinophilus porphyriticus (spring salamander)
- Pseudotriton ruber schencki (black-chinned red salamander)
- Pseudotriton montanus montanus (Baird's red salamander)
- Eurycea bislineata cirrigera (Southern two-lined salamander)
- Eurycea bislineata wilderae (Blue Ridge two-lined salamander)
- Eurycea longicauda guttolineata (three-lined salamander)

Anura (frogs and toads)

Bufonidae
- Bufo americanus (American toad)
- Bufo woodhousei (Fowler's toad)

Hylidae
- Hyla crucifer (Northern spring peeper)
- Hyla versicolor (Eastern gray treefrog)
- Pseudacris triseriata (upland chorus frog)
- Acris crepitans (Northern cricket frog)

Ranidae
- Rana palustris (pickerel frog)
- Rana pipiens (Northern leopard frog)

Rana clamitans (Green frog)
Rana catesbeiana (bullfrog)
Rana sylvatica (wood frog)

Microhylidae
Gastrophryne carolinensis (Eastern narrow-mouth toad)

Compiled from:

1. Sherman C. Bishop, Handbook of Salamanders, Hafner Publishing Co., New York, 1962, 555 pp.

2. Roger Conant, A Field Guide to Reptiles and Amphibians, Houghton Mifflin Co., Boston, 1958, 366 pp.

3. Information supplied by Dr. E. D. Brodie, Department of Zoology, Clemson University, Clemson, S.C.

Table A-II-11. Reptilian Species Probably Found in the Lake Keowee-Lake Jocassee Area

Testudines (turtles)

Chelydridae
Chelydra serpentina (snapping turtle)

Kinosternidae
Sternothaerus odoratus (stinkpot turtle)
Kinosternon subrubrum (Eastern mud turtle)

Emydidae
Terrapene carolina (Eastern box turtle)
Chrysemys picta (Eastern painted turtle)
Pseudemys concinna (river cooter)
Clemmys muhlenbergi (bog turtle)

Trionychidae
Trionyx spinifer (spring softshell turtle)

Squamata (lizards and snakes)

Iguanidae
Anolis carolinensis (green anole)
Sceloporus undulatus (Northern fence lizard)

Anguidae
Ophisaurus attenuatus (Eastern slender glass lizard)

Teiidae
Cnemidophorus sexlineatus (six-lined racerunner)

Scincidae
Lygosoma laterale (ground skink)
Eumeces fasciatus (five-lined skink)
Eumeces laticeps (broad-headed skink)
Eumeces inexpectatus (Southeastern five-lined skink)
Eumeces anthracinus (Southern coal skink)

Colubridae
Virginia valeriae (smooth earth snake)
Storeria occipitomaculata (Northern red-bellied snake)

Storeria dekayi wrightorum (midland brown snake)
Natrix sipedon sipedon (Northern water snake)
Regina septemvittata (queen snake)
Thamnophis sirtalis (Eastern garter snake)
Thamnophis sauritus (Eastern ribbon snake)
Heterodon platyrhinos (Eastern hognose snake)
Carphophis amoenus (Eastern worm snake)
Diadophis punctatus punctatus (Southern ringneck snake)
Diadophis punctatus edwardsi (Northern ringneck snake)
Coluber constrictor (Northern black racer snake)
Masticophis flagellum (Eastern coachwhip snake)
Opheodrys aestivus (rough green snake)
Pituophis melanoleucus (Northern pine snake)
Elaphe obsoleta (black rat snake)
Elaphe guttata (corn snake)
Cemophora coccinea (scarlet snake)
Lampropeltis doliata (scarlet king snake)
Lampropeltis calligaster (mole snake)
Lampropeltis getulus (Eastern king snake)
Tantilla coronata (Southeastern crown snake)

Viperidae

Agkistrodon contortrix (Northern copperhead)
Crotalus horridus horridus (timber rattlesnake)

Compiled from:

1. Roger Conant, A Field Guide to Reptiles and Amphibians, Houghton Mifflin Co., 1958, 366 pp.

2. Information supplied by Dr. E. D. Brodie, Department of Zoology, Clemson University, Clemson, S.C.

Table A-II-12. An Inventory of the Fish Species Found in Lake Keowee
(Taken from "Population Studies, Lake Keowee," South Carolina Wildlife Resources Department, 1968-1969 and 1969-1970)

Esocidae
- *Esox americanus* (grass pickerel)
- *Esox niger* (chain pickerel)

Catostomidae
- *Minytrema melanops* (spotted sucker)
- *Carpiodes carpio* (carpsucker)
- *Moxostoma carinatum* (redhorse sucker)
- *Hypentilium nigricans* (hog sucker)
- *Moxostoma rupiscartes* (striped jump rock)

Cyprinidae
- *Cyprinus carpio* (carp)
- *Notropis galacturus* (whitetail shiner)
- *Notemigonus crysoleucas* (golden shiner)
- *Nocomis bigutta* (hornyhead chub)
- *Semotilus atromaculatus* (creek chub)
- *Nocomis leptocephala* (bluehead chub)
- *Notropis* (unidentified shiner)

Ictaluridae
- *Ictalurus platycephalus* (flat bullhead)
- *Ictalurus punctatus* (channel catfish)
- *Ictalurus nebulosus* (brown bullhead)
- *Noturus* spp. (madtom)
- *Ictalurus catus* (white catfish)

Centrarchidae
- *Micropterus salmoides* (largemouth bass)
- *Micropterus coosae* (redeye bass)
- *Pomoxis nigromaculatus* (black crappie)
- *Pomoxis annularis* (white crappie)
- *Lepomis macrochirus* (bluegill)
- *Lepomis cyanellus* (green sunfish)
- *Lepomis auritus* (redbreast sunfish)
- *Chaenobryttus gulosus* (warmouth)

Lepomis microlophus (redear sunfish)
Lepomis gibbosus (pumpkinseed)

Percidae
Perca flavescens (yellow perch)
Stizostedion vitreum (walleye)
Etheostoma, *Percina*, etc. (darters)

Table A-II-13. Fish population data from studies conducted on Lake Keowee, South Carolina Wildlife Resources Commission 1968–1969 and 1969–1970

Species	Fingerling				Intermediate				Harvestable				Total				Percent of population by weight	
	1968		1969		1968		1969		1968		1969		1968		1969			
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	1968	1969
Grass pickerel							1	0.10							1	0.10		0.03
Spotted sucker							5	0.85							5	0.85		0.31
River carpsucker	21	0.45			1	0.05							22	0.50			0.86	
Redhorse sucker	392	3.35	5	0.00	1	0.10	153	10.95					393	3.45	158	10.95	5.93	4.07
Hog sucker	8	0.10			1	0.30	10	0.90					9	0.40	10	0.90	0.68	0.33
Carp	614	18.30	7	0.50			621	164.50			3	8.45	614	18.30	631	173.45	31.48	64.53
Whitetail shiner	1671	4.30											1671	4.30			7.39	
Golden shiner	1	0.00			21	0.40	2	0.05			2	0.15	22	0.40	4	0.20	0.68	0.07
Hornyhead chub	9	0.40	4	0.20									9	0.40	4	0.20	0.68	0.07
Creek chub	3	0.15											3	0.15			0.25	
Unident. shiner			158	2.05			199	3.45							357	5.50		2.04
Flat bullhead	49	0.40	33	0.15	13	1.70	14	1.00	3	0.85	13	3.20	65	2.96	60	4.35	5.07	1.61
Channel catfish									1	1.40			1	1.40			2.40	
Brown bullhead	139	2.15			8	0.30							147	2.45			4.21	
Madtom	12	0.30	1	0.00									12	0.30	1	0.00	0.51	
Largemouth bass	224	3.08	214	2.75	72	5.25	64	5.85			12	8.10	296	8.33	290	16.70	14.32	6.21
Redeye bass	21	0.15											21	0.15			0.25	
Black crappie	241	5.80	641	5.50	38	1.65	10	0.40	1	0.70	70	14.80	280	8.15	721	20.70	14.20	7.70
White crappie			1	0.00							1	0.20			2	0.20		0.07
Bluegill sunfish	389	1.30	2890	4.73	93	0.85	126	3.35	7	1.70	46	4.85	489	3.85	3062	12.75	6.62	4.74
Green sunfish	50	0.10	185	0.35	32	0.40	6	0.15			2	0.15	82	0.50	193	0.65	0.86	0.24
Redbreast	156	0.45	688	1.20	12	0.30	118	3.20	6	0.55	12	0.80	174	1.30	818	5.20	2.23	1.93
Warmouth	98	0.55	736	1.45	25	0.30	243	7.90			49	4.40	123	0.85	1028	13.75	1.46	5.11
Redear sunfish			1	0.00			45	1.55			4	0.30			50	1.85		0.68
Yellow perch			5	0.05			7	0.15							12	0.20		0.07
Walleye							1	0.10							1	0.10		0.03
Darters	7	0.00											7	0.00				
	4101	41.03	5569	18.93	317	11.60	1627	204.60	18	5.20	214	45.40	4440	58.13	7410	268.75		

Table A-II-14. An Inventory of the Fish Species Currently Comprising the Population of Hartwell Reservoir

Esocidae
- *Esox niger* (chain pickerel)

Clupeidae
- *Dorosoma cepedianum* (gizzard shad)
- *Dorosoma petenense* (threadfin shad)

Catostomidae
- *Minytrema melanops* (spotted sucker)
- *Carpiodes carpio* (carpsucker)
- *Moxostoma carinatum* (redhorse sucker)
- *Hypentilium nigricans* (hog sucker)

Cyprinidae
- *Cyprinus carpio* (carp)
- *Notropis galacturus* (whitetail shiner)
- *Notemigonus crysoleucas* (golden shiner)
- *Nocomis bigutta* (hornyhead chub)
- *Semotilus atromaculatus* (creek chub)
- *Nocomis leptocephala* (bluehead chub)
- *Notropis* (unidentified shiner)
- *Notropis hudsonius* (spottail shiner)

Ictaluridae
- *Ictalurus platycephalus* (flat bullhead)
- *Ictalurus punctatus* (channel catfish)
- *Ictalurus nebulosus* (brown bullhead)
- *Noturus* spp. (madtom)
- *Ictalurus catus* (white catfish)

Serranidae
- *Morone saxatilis* (striped bass)
- *Morone chrysops* (white bass)
- *Morone saxatilis*
  X *Morone chrysops* (hybrid)

Centrarchidae
- *Micropterus salmoides* (largemouth bass)
- *Micropterus coosae* (redeye bass)
- *Pomoxis nigromaculatus* (black crappie)
- *Pomoxis annularis* (white crappie)
- *Lepomis macrochirus* (bluegill)

Lepomis cyanellus (green sunfish)
Lepomis auritus (redbreast sunfish)
Chaenobryttus gulosus (warmouth)
Lepomis microlophus (redear sunfish)
Lepomis gibbosus (pumkinseed)

Percidae
Perca flavescens (yellow perch)
Stizostedion vitreum (walleye)

Compiled from:

1. Robert M. Jenkins, "Estimation of Fish Standing Crop, Sport Fish Harvest, and Angler Use for Keowee and Jocassee Reservoirs, in Duke Power Company's Keowee-Toxaway Project, Oconee and Pickens Counties, South Carolina," U.S. Department of Interior, Division of Fisheries Research, National Reservoir Research Program, February 4, 1972 (data supplied by Otho May and Donald Archer, South Carolina Wildlife Resources Department).

2. Annual Progress Report, July 1, 1970, through June 30, 1971, South Carolina Wildlife Resources Department, District II, Hampton Williams, 1971.

Appendix II-3

COMMERCIAL FORESTRY PRODUCTIVITY OF OCONEE AND PICKENS COUNTIES AND NEARBY COUNTIES OF THE SOUTH CAROLINA PIEDMONT REGION AFFECTED BY DUKE POWER COMPANY

The two counties directly affected by the removal of 26,000 acres flooded by the Keowee-Toxaway Project were estimated by Forest Service Survey[1] to have the following respective net average annual wood growth rate for 1966 (gross growth of utilizable tree parts minus mortality for year):

County	Board feet per acre per year	Cubic feet per acre per year
Oconee	$\frac{37,200,000}{329,000 \text{ acres}} = 128$	$\frac{14,500,000}{329,000 \text{ acres}} = 44.1$
Pickens	$\frac{35,600,000}{223,500 \text{ acres}} = 159$	$\frac{11,400,000}{223,500 \text{ acres}} = 51$

Economic values in the cost-benefit analysis do not reflect current or future resource values of the flooded acreage or the 131,000 acres of land still owned by Duke Power Company. Comparison with counties further downstream on the more level parts of the Piedmont Plateau are given in Table A-II-15. The forest types are separated into pine and "other softwood" (mainly hemlock near the mountains, with small volumes of red cedar throughout) and hardwood. Table A-II-16 shows removal by cutting sawtimber and pulpwood; Table A-II-17 gives the volume or inventory which was being increased by growth and depleted by mortality as well as by removal. Since the survey was completed in February 1967, most data apply to some time in 1966.

Table A-II-18 provides a comparison of land ownership for the same counties. In 1967, land now in the project area included corporate, miscellaneous individual private categories, and some farmers' land. Totals for each ownership category of commercial forest land for an 18-county region of the Piedmont Plateau are also given. Table A-II-19 indicates land categories by forest type groups which are standardized for forest survey purposes. Such tables do not distinguish between a wide variety of local ecological communities which lend interest to the landscape for residents and visitors, yet even the main type groups do show important differences between the mountain border region and the more rolling Piedmont Plateau. White pine-hemlock forest is restricted to northern Oconee and Pickens Counties, and apparently is being depleted significantly by project clearing and other removals (see "other softwood" in Table A-II-16). The lower parts of Oconee and Pickens counties resemble the remainder of the Piedmont region in having extensive yellow pine forest, oak-pine mixtures and oak-hickory and other deciduous forest.

Species composition for the Piedmont region, traversed by Duke Power Company lines, is shown by the species breakdown of Table A-II-20. Loblolly pine constitutes most of the volume of pines; it is planted near the mountains but is not so common naturally there as in the counties further southeast. Shortleaf and Virginia pines are more important than loblolly in the Keowee-Toxaway Project area. Oaks and hickories are most prominent on dry sites, but productivity is higher than average on more moist sites. Sweet gum (Liquidambar styraciflua) is also widespread but is most prominent and productive on wet bottomlands. Yellow poplar (Liriodendron tulipifera) occurs on all but the driest sites and reaches large size and economic importance, especially where growing on deep soils or lower slopes. Besides the other commercially valuable species listed, a large number of trees and shrubs have great value in the scenic attractiveness for visitors to and residents of the mountain border counties. It is not clear that the timber and game management objectives of the applicant are sufficiently concerned with the ecological impact of their land operations after the reservoirs are complete.

REFERENCE FOR APPENDIX II-3

1. William H. B. Haines, Forest Statistics for the Piedmont of South Carolina, U. S. Forest Service Resource Bulletin SE-9, Southeastern Forest Experiment Station, Asheville, N.C., July 1967.

Table A-II-15. Net annual growth of sawtimber and growing stock on commercial forest land, by species group and county, 1966

County	Sawtimber (millions of board feet)					Growing stock (millions of cubic feet)				
	All species	Pine	Other softwood	Soft hardwood	Hard hardwood	All species	Pine	Other softwood	Soft hardwood	Hard hardwood
Abbeville	22.9	15.2		3.9	3.8	8.4	4.9	0.1	1.7	1.7
Anderson	22.9	11.1	0.1	4.3	7.4	8.9	4.0	0.1	1.2	3.6
Oconee	37.2	18.0	2.6	4.4	12.2	14.5	6.7	0.9	1.4	5.5
Pickens	35.6	14.1	1.0	9.1	11.4	11.4	4.7	0.4	1.7	4.6

Table A-II-16. Annual removals of sawtimber and growing stock on commercial forest land

County	Sawtimber (millions of board feet)					Growing stock (millions of cubic feet)				
	All species	Pine	Other softwood	Soft hardwood	Hard hardwood	All species	Pine	Other softwood	Soft hardwood	Hard hardwood
Abbeville	29.4	22.3		6.0	1.1	9.8	7.2	0.1	1.9	0.6
Anderson	19.0	12.1		4.0	2.9	6.0	3.5		1.5	1.0
Oconee	39.8	14.8	13.0	.4	11.6	12.5	5.5	2.6	0.1	4.3
Pickens	15.4	2.8	2.9	1.5	8.2	6.5	2.2	0.6	1.0	2.7

Table A-II-17. Volume of sawtimber and growing stock on commercial forest land, by species group and county, 1967

County	Sawtimber (millions of board feet)					Growing stock (millions of cubic feet)				
	All species	Pine	Other softwood	Soft hardwood	Hard hardwood	All species	Pine	Other softwood	Soft hardwood	Hard hardwood
Abbeville	334.3	186.5	0.9	100.3	46.6	152.6	73.6	1.9	41.4	35.7
Anderson	281.4	113.8	3.7	76.4	87.5	152.2	60.9	2.2	31.2	57.9
Oconee	639.1	278.3	60.2	51.3	249.3	270.8	109.6	15.7	28.4	117.1
Pickens	540.3	200.1	14.2	85.3	240.7	230.1	75.8	5.7	35.0	113.6

Table A-II-18. Area of commercial forest land, by owndership class and county, 1967

County	Area (thousands of acres)								
	All ownerships	National forest	Miscellaneous federal	State	County and municipal	Forest industry[a]	Farmer	Miscellaneous private	
								Corporate	Individual
Abbeville	212.5	20.8	0.8		0.3	48.7	14.2	14.2	113.5
Anderson	207.6		7.0	5.2	0.1	8.0	58.2	25.0	104.1
Oconee	329.0	65.7	5.4	7.3	2.1	0.9	91.7	50.4	105.5
Pickens	223.5		0.8	8.8	0.2	1.6	40.8	44.9	126.4
18-county total	4453.9	328.1	40.4	30.1	14.0	520.8	1183.3	225.3	2111.9

[a]Not including 4300 acres of farmer and miscellaneous private lands leased to forest industry.

Table A-II-19. Area of commercial forest land, by forest-type group and county, 1967

County	Area (thousands of acres)					
	All type groups	White pine-hemlock	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Elm-ash-cottonwood
Abbeville	212.5		119.3	34.7	58.5	
Anderson	207.6		89.5	37.4	68.2	12.5
Cherokee	133.7		61.1	32.1	40.5	
Chester	271.1		159.6	57.2	47.9	6.4
Edgefield	230.0		142.7	58.3	26.3	2.7
Fairfield	386.3		288.7	46.8	41.0	9.8
Greenville	257.8		63.0	41.4	149.2	4.2
Greenwood	212.5		120.9	36.8	54.8	
Lancaster	231.4		130.8	41.3	50.7	8.6
Laurens	290.1		151.3	40.3	86.4	12.1
McCormick	212.8		142.8	45.2	13.7	11.1
Newberry	320.0		231.2	55.7	18.5	14.6
Oconee	329.0	4.6	120.8	69.3	125.1	9.2
Pickens	223.5	4.1	62.4	48.9	104.0	4.1
Saluda	166.3		117.0	16.7	32.6	
Spartanburg	261.4		145.9	33.3	82.2	
Union	251.7		122.5	40.3	75.1	13.8
York	256.2		115.9	57.9	78.1	4.3
Total	4453.9	8.7	2385.4	793.6	1152.8	113.4

Table A-II-20. Volume of growing stock on commercial forest land, by species and diameter class, 1967

Species	Volume in specified diameter class (inches at breast height)					
	(millions of cubic feet)			(millions of board feet)		
	All classes	5.0–6.9 in.	7.0–8.9 in.	All classes	21.0–28.9 in.	29.0 in. and larger
Softwood						
Longleaf pine	5.9	0.4	0.7	21.2		2.0
Shortleaf pine	675.1	132.1	177.2	1490.2	12.1	
Loblolly pine	1110.9	118.8	172.8	3426.9	172.7	6.2
Virginia pine	127.3	25.0	32.9	243.9	3.8	
Pitch pine	5.5	0.6	1.6	12.6		
Table-Mountain pine	2.4		0.3	7.8		
Eastern white pine	18.1	0.9	1.8	64.0	26.0	3.1
Eastern hemlock	3.4	0.3	0.4	12.5	3.4	
Other Eastern softwoods	36.9	12.8	10.6	41.5	—	—
Total softwoods	1985.5	290.9	398.3	5320.6	218.0	11.3
Hardwood						
Select white oaks[a]	244.4	24.2	36.9	476.4	55.2	11.8
Select red oaks[b]	67.1	3.7	8.9	152.7	24.7	2.3
Other white oaks	93.5	8.3	10.6	193.4	19.2	
Other red oaks	352.2	30.2	56.9	688.0	56.4	25.7
Hickory	123.6	11.2	15.7	268.6	28.3	5.0
Hard maple	3.2	0.2	0.2	6.2		
Soft maple	57.5	5.3	7.2	101.6	17.3	5.5
Beech	20.5	0.4	1.7	52.8	18.3	2.7
Sweet gum	264.2	32.1	37.5	598.1	62.9	1.9
Tupelo and blackgum	23.2	1.3	3.9	42.8	4.8	
Ash	46.0	4.3	8.7	90.4	7.3	
Cottonwood	21.1	0.2	0.2	79.2	18.8	33.8
Basswood	0.8			2.7		
Yellow poplar	192.1	10.3	18.4	557.1	52.1	13.9
Black walnut	2.9	0.2		8.7	1.2	
Black cherry	0.6	0.1	0.5			
Elm	48.4	5.3	12.3	64.6	3.0	
Sycamore	27.1	0.4	1.3	80.8	17.1	4.6
Birch (except yellow)	32.2	2.5	6.3	60.5	14.9	
Other Eastern hardwoods	21.9	3.1	2.7	35.7	—	—
Total hardwoods	1642.5	143.3	229.9	3560.3	401.5	107.2
All species	3628.0	434.2	628.2	8880.9	619.5	118.5

[a]Includes white, swamp white, and swamp chestnut oaks.
[b]Includes cherrybark and Northern red oaks.

Appendix II-4

AQUATIC COMMUNITIES IN LAKE KEOWEE

Specific information has not been collected on the plankton and benthic communities in Lakes Keowee and Jocassee. A brief, generalized account of community organization in the life zones characteristic of lakes in this region follows.

The phytoplankton communities in both the limnetic and littoral zones of lakes typically consist of diatoms, blue-green algae, green algae, and green flagellates (Euglenidae, Volvocidae, etc.). Diatoms (Bacillariaceae) have silica shells and an abundance of carotenoid pigment in the chromatophores which masks the green chlorophyll.[1] Diatom populations in a lake may fluctuate as a single spring increase in numbers or as two noticeable pulses, one in early spring and the other in the fall. The exact mechanisms involved in such population fluctuations have not been fully delineated, but they seem to be interactions between environmental factors, temperature, nutrient availability, and physiology and reproductive capacity of the algae.[2] Diatoms are usually the most abundant algae of larger lakes, and species such as Asterionella and Melosira are generally present. The variety of green algae (Chlorophyta) may be considerable in lakes. In Lake Norman, North Carolina, 24 genera were identified, but the densities were lower than those of the diatoms.[3] Commonly found genera include Pediastrum, Staurastrum, and Spirogyra.

Blue-green algae (Cyanophyta) are simple single-celled or colonial algae with diffuse chlorophyll which is masked by blue-green pigment. These algal types are ecologically important in that a large biomass may develop in lakes. In lakes the Cyanophyta may exhibit a late summer pulse. In the littoral zone, especially in stagnant embayment waters, filamentous forms such as Oscillatoria may occur in large numbers.[4]

The zooplankton community encompasses a variety of species of animals which generally remain suspended or move freely in the water column. Zooplankters feed on phytoplankton and bacteria and act as a vital link in aquatic food chains by converting energy from their food organisms into food for larger invertebrates and fish. The limnetic zooplankton is usually made up of a few species in which the abundance of individuals is great. Copepods, cladocerans, and rotifers are generally of first importance. Bosmina and Daphnia are usually the most numerous genera of cladocerans found in lake samples. Keratella, Conochiloides, Polyarthra, and Synchaeta are common genera of rotifers found in lakes. The zooplanktonic crustacea are filter-feeders, feeding on bacteria and phytoplankton, and may exhibit pulses at the same time as the phytoplankton upon which they depend.

Benthic communities in most lakes offer a wide variety of organisms, ranging from those which inhabit the bottom near the shore to those living in the profundal regions (bottom area where light penetration is reduced and contact with the hypolimnetic waters is the normal condition). Typical benthic organisms are tubificid oligochaetes, mollusks, and dipterans such as Chaborus and Chironomus.[4]

Lake fish usually are free to move between the littoral and the limnetic zone; however, many species spend a large part of their time in the littoral zone, establishing territories and breeding there. In Southern lakes, top minnows are abundant in the vegetation zones, with some species, such as bass, generally representing the end of the food chain in the lacustrine ecosystem.

Most adult freshwater fish feed on fairly large organisms; however, some forms, such as the gizzard shad, have strainers and are plankton feeders. In large lakes the gizzard shad form an important link between producers and game fish. Their presence enables game fish, such as bass, to exist on a shorter food chain and to be independent of the littoral zone, which is often unavailable to the game fish because of the raising and lowering of water levels to comply with flood control commitments. Important aspects in the species or family life cycles of fish found in Keowee and Hartwell reservoirs follow.

Esocidae (pickerel--grass and chain). The grass pickerel is a fish found principally in heavily vegetated, slow-moving streams and sometimes lakes. Temperature preference has been noted to be 26.6°C (78.8°F).[5] The chain pickerel is a solitary fish which moves into shallow water at night and into deeper waters during the day. Both types are spring spawners, but the grass pickerel has been found to occasionally spawn in the early fall as well.[6] Chain pickerel have been reported to spawn at 16°C (60.8°F) in Alabama.[7] Spawning usually occurs in shallow areas where vegetation is abundant. The eggs are adhesive and adhere to bottom materials or in glutinous strings on vegetation. The young, when hatched, tend to remain in the shallow waters and display little or no dispersion throughout the first summer's growth.[8]

Invertebrates (cladocerans, ostracods, amphipods, and insect larvae) are the chief foods for the young of both species, while insect larvae, crayfish, and forage fish comprise the diet of intermediate size and adult fish.

Catostomidae (suckers). Suckers have soft-rayed fins and extensible sucking mouths. They are spring spawners and usually spawn in shallows where loose gravel can be used to bury the eggs.[6] The white sucker (Catostomus commersoni) has an upper temperature tolerance of 29°C (84.2°F) when acclimated to 25°C (77.0°F).[5]

Young suckers may feed primarily on copepods, dipterans, cladophorans, and detritus material, while the adults use chironomid larvae, amphipods, annelids, and other bottom organisms as food.

Cyprinidae (carp and shiners). Carp and some other members of the Cyprinidae, especially shiners, have been transplanted extensively in freshwater lakes in North America. Shiners are used for bait by sports fishermen and are a substantial part of the bait industry.[6] Small cyprinid species and young of larger cyprinids are important in the food chains of game fish and other vertebrates. Spawning of carp of Alabama has been noted to begin in March, with surface temperatures of 14 to 17°C (57.2-62.6°F), and becomes most active when temperatures reach 18 to 20°C (64.4-68°F).[7] The eggs are scattered by the female and adhere to plants or debris or sink to the bottom, where they are left to lie unguarded.[9] Shiners begin to spawn in May, and both species have adhesive eggs which are scattered over plants and debris in shallow waters.

The preferred temperature of the carp has been found to be 32.0°C (90°F) and that of the shiner 30.0°C (86°F). The carp, when acclimated to 20°C (68°F) and 26°C (78.8°F), has an upper temperature tolerance of 31°-34° (87.8°-93.2°F) and 35.7°C (87.8°F), respectively.[10] The common shiner (Notropis cornutus) has an upper tolerance of 31°C (87.8°F) when acclimated to 20°C (68°F) and 30°C (86°F).[5]

Young shiners have been found to feed on entomostracans and phytoplankton and adults on zooplankton, algae, and insect larvae. Carp feed almost exclusively on bottom fauna, chironomids, zooplankton, and phytoplankton.

Ictaluridae (catfish and bullheads). The majority of the members of the Ictaluridae inhabit quiet slow-moving waters. Most of the larger species are utilized for human consumption. Spawning occurs in late spring or the early summer (May to June) but has been noted to occur in March in Florida. Channel catfish usually spawn when the water temperature reaches 21°-27°C (69.8°-80.6°F), with most spawning occurring at 22°C (71.6°F).[3] Nests are constructed in relatively shallow areas (less than 4 ft in depth) by the male.[6]

The fry feed on zooplankton, aquatic insects, and bottom arthropods, while the adults utilize insects, fish eggs, molluscs, and plants.[7] The temperature tolerance of the Ictaluridae is quite wide, and some members of this family appear to be somewhat resistant to thermal increases. Lethal temperatures for the brown bullhead and the channel catfish are listed below.[7]

Species	Acclimation temperature (°C)	Acclimation temperature (°F)	Maximum lethal temperature (°C)	Maximum lethal temperature (°F)
Brown bullhead	5	41	28.6	83.5
	10	50	30-30.2	86-86.4
	20	68	33-33.4	91.4-92.1
	25	77	35-35.5	95.0-95.9
	30	86	36.5-37	97.7-98.6
	36	96.8	37.5	99.5
Channel catfish	15	59	30.3	96.5
	20	68	32.8	91.0
	25	77	33.5	92.3

Centrarchidae (sunfish, crappie, bass). The family Centrarchidae includes the largemouth, smallmouth, and spotted basses, sunfishes (including bluegill), and crappies (black and white). Spawning usually occurs in the spring, and nests are formed by the males in shallow water. Most fry depend on zooplankton (Cyclops, Daphnia, small crustaceans) and phytoplankton for food, while the adults feed on invertebrates, fish, frogs, and other aquatic species.

Largemouth bass. Nest building by the largemouth has been noted to occur at 13.3°C (56°F), with actual spawning delayed until the temperature reached 18.9°C (66°F).[11] The range of spawning temperature is generally between 60° and 68°F, in areas where substrates such as sand, gravel, roots or aquatic vegetation are available. The nest is made in shallow water (1 to 2 ft), and the eggs sink to the bottom of the nest and become attached to material in the nest. Average egg production per nest is 4000-5000. Deaths of embryos have been reported when the water temperature dropped from the sixties to below 50°F.[12] Maximum growth of fry occurred between 81.5°F (27°C) and 86°F (30°C).[13] The young are found at the 6-inch depth when the water temperatures are between 70° and 75°F.[14] Young largemouth bass stay in compact schools for several weeks and stay close to the shore, where they feed on zooplanktonic organisms during late May and early June.[15]

The largemouth shows a temperature preferential of 30°-32°C (86°-89.6°F)[5] with lethal temperatures shown below.[11]

Acclimation temperature (°C)	Acclimation temperature (°F)	Maximum lethal temperature (°C)	Maximum lethal temperature (°F)	Minimum lethal temperature (°C)	Minimum lethal temperature (°F)
20	68	32.5	90.5	5.5	41.9
25	77	34.5	94.1		
30	86	36.4	97.5	11.8	53.3

Largemouth bass required 2.0 ppm of oxygen to swim against a current flowing 0.8 fps, at 77°F (25°C).[16]

Bluegill. This species is another spring spawner, with the male creating a saucer-shaped depression in the shallow water bottom (2 to 6 ft is generally preferred). The females are attracted to the nest, where spawning takes place. The adhesive eggs cling to debris or rocks in the nest. Eggs from several females may be fertilized by a single male, and the subsequent reproductive capacity can lead to overcrowding and consequent stunted growth.[6] Spawning has been noted to occur at water temperatures of 67°-80°F (20°-26°C)[17] (generally April or May).

Preferred food for the bluegills consists of chironomids.[17]

Temperature preference is 32.3°C (88.2°F), with upper temperature tolerances listed below.[17]

Acclimation temperature (°C)	(°F)	Maximum lethal temperature (°C)	(°F)	Minimum lethal temperature (°C)	(°F)
15	59	30.7	87.3	2.5	36.5
20	68	31.5	89.0	5.0	41.0
30	86	33.8	92.9	7.5	45.5

Crappie (black and white). Crappies spawn in late spring (March to July), with water temperature being the primary determinant. Black crappies usually spawn when water temperatures reach 58°-68°F (14.5°-20.5°C). The white crappies generally begin spawning at 64°-68°F (17.5°-20.5°C).[18] The male builds the nest, usually in water 3 to 8 ft deep, in a gravel or soft bottom area. The young spend a few days in the shallow waters and then migrate into the deeper areas.[14] The adult crappie moves into the shallow water to feed at night in the warmer months, and as the temperature becomes cooler it retires into deeper water. Fry generally feed on zooplankton and aquatic insects, while the adults rely on crustaceans, insects, and other fish. Catch rate of the white crappie was positively correlated with the biomass of mayflies and gizzard shad.[19]

Percidae (yellow perch and walleye). The yellow perch spawns in the spring when the water temperature approaches 50°F (10°C).[6] Eggs are laid in a gelatinous string on the bottom of the shallow areas or among vegetative growth. Acclimation and lethal temperatures are listed below.[20]

Acclimation temperature (°C)	(°F)	Maximum lethal temperature (°C)	(°F)	Minimum lethal temperature (°C)	(°F)
5	41	21.3	70.3		
10	50	25.0	77.0	1.1	34.1
15	59	27.7	81.9		
25	77	29.7	85.5	3.7	38.7

In general, walleye prefer maximum summer temperatures of 77°F (25°C).[21] With an acclimation temperature of 45°F (7.5°C), the upper temperature limit is 84°F (29.0°C). In the spring, when the water temperature reaches 50°F, the female moves along the shoreline, depositing her eggs over the loose gravel, boulders, or sand. The eggs are then fertilized by the male, who trails along behind.

Distribution patterns for young-of-the-year walleye in Southern lakes are unknown, but in the Northern lakes there are indications of a movement to the pelagic area soon after hatching.[22] It was recommended by the South Carolina Wildlife Resources Department that plans for stocking walleye in Lake Keowee be discontinued until the effect of utilizing the hypolimnion as cooling water by the applicant could be adequately assessed.[23] A self-sustaining population inhabits Hartwell Reservoir, and the project has already had some effect on the spawning habitat in that impoundment (see Section IV - Impacts of Plant Construction).

Clupeidae (threadfin and gizzard shad). Even though these two fresh-water species have little direct food or commercial value, they are important as forage for many game fish, particularly during the shad's first year. Gizzard shad inhabit large rivers, reservoirs, lakes, and estuaries. Both gizzard and threadfin shad seem to spawn most frequently in the spring. Gizzard shad spawn in shallow water in April to June when temperatures reach 10°-21°C (50°-69.8°F).[7] Spawning of gizzard shad occurred in Norris Lake, Tennessee, from May to June with surface temperatures of 23°-29°C (73.4°-84.2°F).[24] The eggs are demersal and adhesive, attaching to the vegetation in the spawning area. Threadfin usually spawn at approximately 21°C (70°F) but have been reported to spawn at 14°-17°C (57-63°F) in April and 18°C (65°F) in May.[7] Hatching has been documented to occur after 95 hr at 62°F (16.5°C) and 36 hr at 80°F (26°C).[25]

Threadfin shad will spawn in open waters but usually spawn under brush, with the eggs adhering to the vegetation. Young-of-the-year gizzard shad have been observed to school, but after the first year, little schooling behavior was noted.[24] Threadfin are noted for traveling in schools, with the different age classes usually in separate schools.[26]

Mortality of threadfin shad usually occurs when temperatures fall to around 7°C (45°F), but survival has been noted at a temperature of 1.1°C (34°F).[3] Gizzard shad acclimated to 35°C (95°F) had a lethal limit of 36.5°C (98°F), but sudden temperature changes seemed to cause mortality. As in the case of the gizzard shad, sudden temperature changes often produce high mortality among threadfin shad. Among individuals from the lower Tennessee River, subjected to water cooled from 60° to 50°F, there was a high mortality below 45°F (7°C), with very few fish surviving below 40°F (4°C).[27]

Both the threadfin and gizzard shad are essentially filter feeders. During both the fry and adult stages, both species feed primarily on protozoans, rotifers, tendipedids, oligochaetes, diatoms, and other planktonic forms.

Serranidae (striped and white bass).

Striped bass. The striped bass is a highly adaptable species which exists from the cold Canadian rivers to the warmer inland waters of Florida, in both fresh and salt waters. Adults usually migrate up rivers from their salt-water habitats to spawn in fresh waters. Striped bass have been successfully stocked in inland lakes, where spawning usually occurs in the headwater regions. These bass distribute their eggs in areas of considerable current, since the eggs are semibuoyant and depend upon the current to keep them off the bottom, in order to have successful reproduction.[28] The lowest temperature at which striped bass will spawn, as based on egg collections, appears to be 58°F (14°C). The peak of spawning appears to occur between 60° and 67°F (15.5°-17.5°C).[29]

Food of the young striped bass is composed mainly of copepods, cladocerans, and other zooplankton form. Clupeids are the mainstay of the adult bass diet.

White bass. White bass have been introduced into reservoirs and lakes in North and South Carolina, although the area of greatest commercial importance is the Mississippi River drainage from Wisconsin to the Gulf of Mexico.[30] The males tend to migrate to the spawning areas prior to the arrival of the females. The spawning period throughout their range is from April through June, at temperatures ranging from 58° to 75°F (14°-21.5°C) and usually at a depth of 3 to 6 ft. Several males gather around a single female, that scatters demersal eggs near the surface. They are fertilized as they sink and adhere to gravel, rocks, and vegetation.

The young, after hatching, remain in the shallows around the shore and feed primarily on crustaceans and insects. Forage fish (especially clupeids) comprise the majority of food for the adults. Threadfin shad were noted to be more important than gizzard shad in the diet of white bass in Beaver Reservoir.[31] This was attributed to the occurrence of more larval threadfin in the surface waters, thus increasing their vulnerability to white bass predation. White bass were most numerouss in the shallow littoral zones of Lake Carl Blackwell when mayflies were abundant in August through September.[19]

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Appendix III-1

EXPECTED SURFACE TEMPERATURES AND VERTICAL TEMPERATURE PROFILES FOR LAKE KEOWEE AND THE HARTWELL RESERVOIR

The applicant's analysis of the heat dissipation in Lake Keowee and Hartwell Reservoir is discussed in Section III.D.1. Figures showing the expected surface temperature distributions and the vertical temperature profiles are on the following pages.

The values of the basic parameters used in preparing the figures are summarized in the tabulations below:

Lake Keowee - Expected Surface Temperature

Condition	Ambient Surface Temp.	Surface Elev.	Intake Temp.	Discharge Temperature Monthly Average	Discharge Temperature Maximum Daily	Figure
Normal Conditions						
August	83°F	797 ft	73°F	89°F	--	A-III-1
"	83	797	76	--	92°F	A-III-2
December	54	792	54	74°F	--	A-III-3
"	58	792	58	--	84°F	A-III-4
Extreme Conditions						
August	86°F	785 ft	82°F	98°F	--	A-III-5
"	86	785	85	--	101°F	A-III-6
December	53	779	53	73°F	--	A-III-7
"	57	779	57	--	77°F	A-III-8

Appendix III-1 (continued)

Lake Keowee - Vertical Temperature Profile for each Month

Condition	Location	Figure
Normal Year	3000 ft from discharge	A-III-9
	at the skimmer wall	A-III-10
Extreme Year	3000 ft from discharge	A-III-11
	at the skimmer wall	A-III-12

Hartwell Reservoir - Expected Surface Temp.

	Ambient	Keowee Discharge Temp.		
Condition	Surface Temp.	Monthly Average	Max. Daily Average	Figure
Extreme Conditions				
January	53°F	59°F	--	A-III-13
	53	--	59°F	A-III-14
Normal conditions				
February	47°F	52	--	A-III-15
	47	--	52	A-III-16

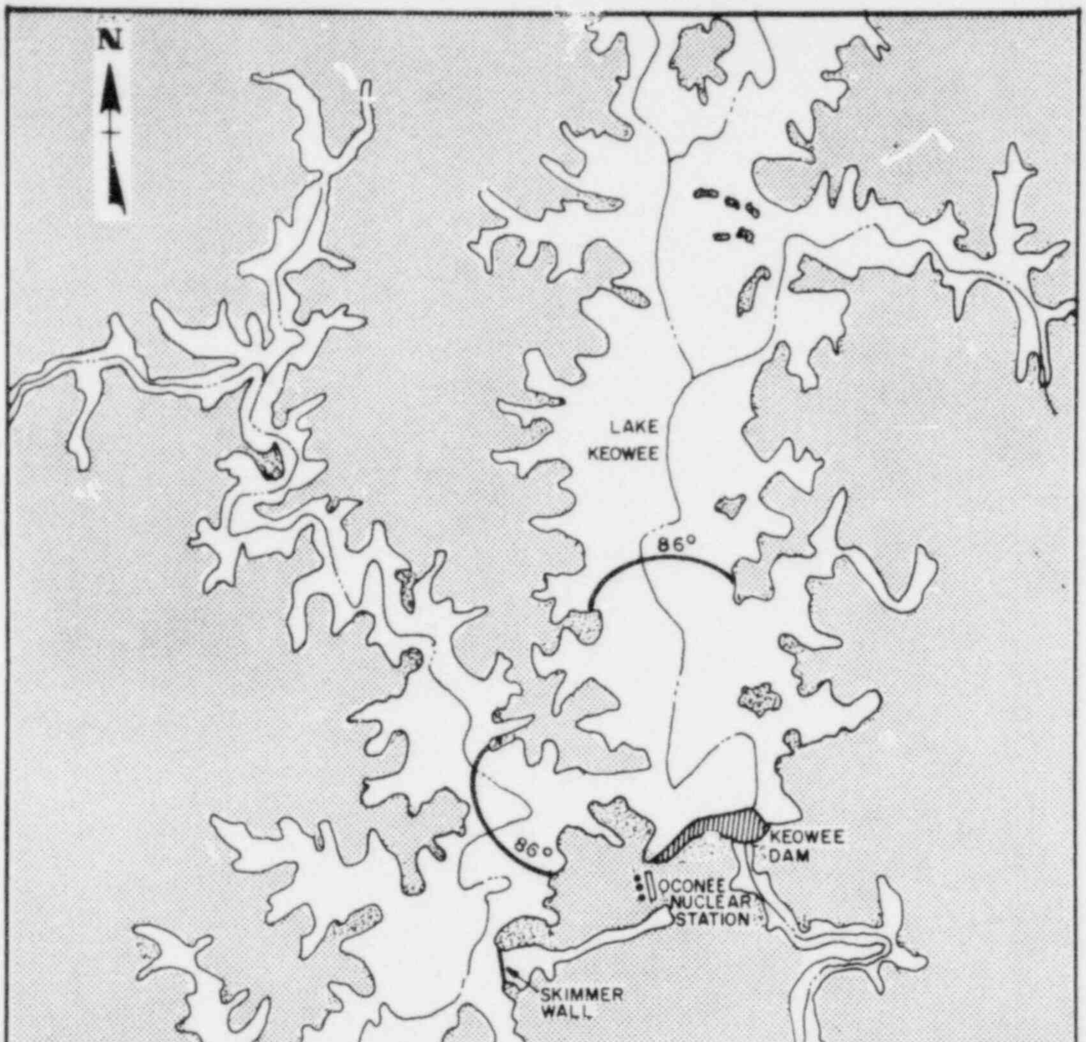

Fig. A-III-1. Expected surface temperature of Lake Keowee under normal conditions during August when the monthly average discharge temperature is 89°F, the ambient surface temperature is 83°F, and the intake temperature is 73°F.

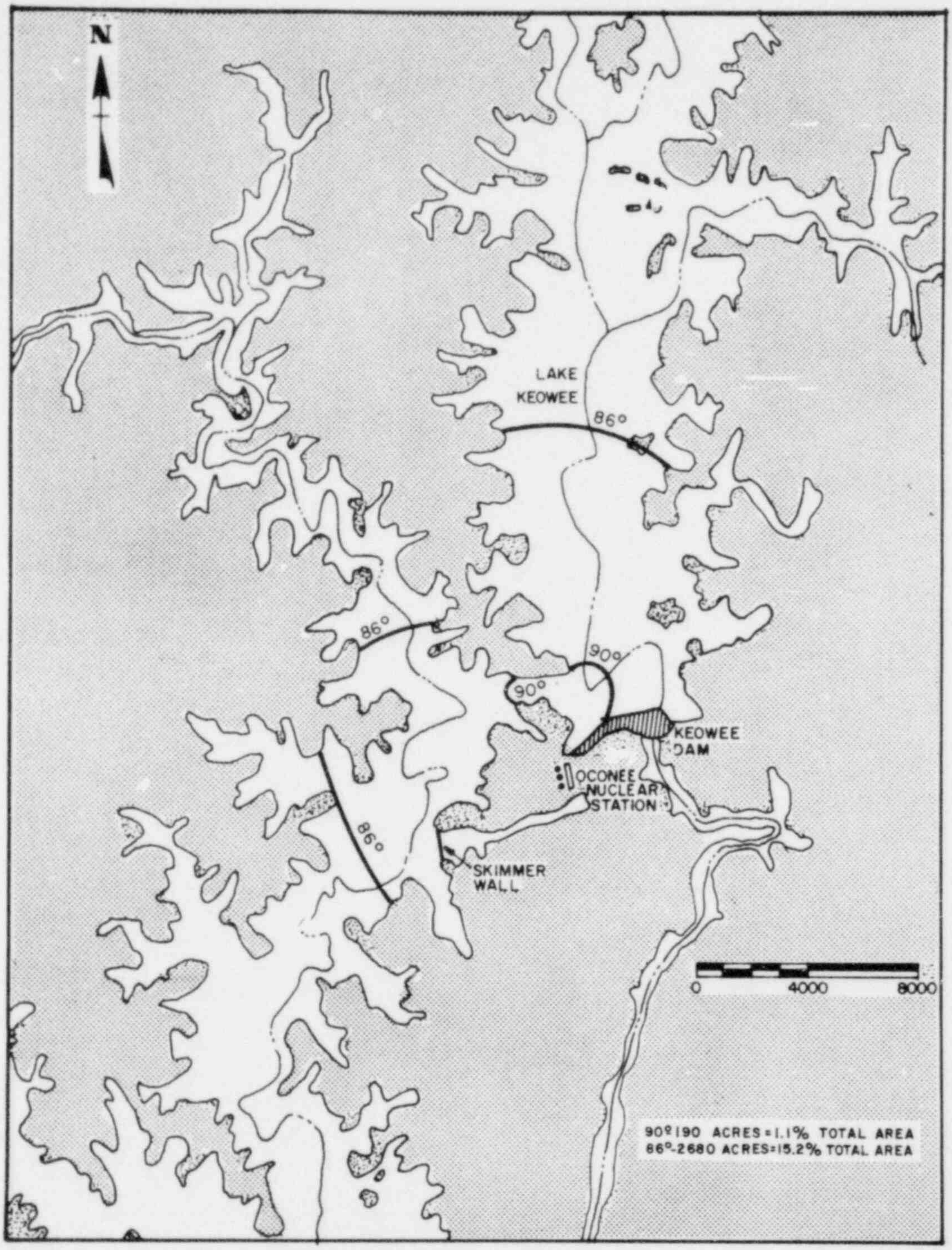

Fig. A-III-2. Expected surface temperature of Lake Keowee under normal conditions during August when the average daily maximum discharge temperature is 92°F, the ambient surface temperature is 83°F, and the intake temperature is 76°F.

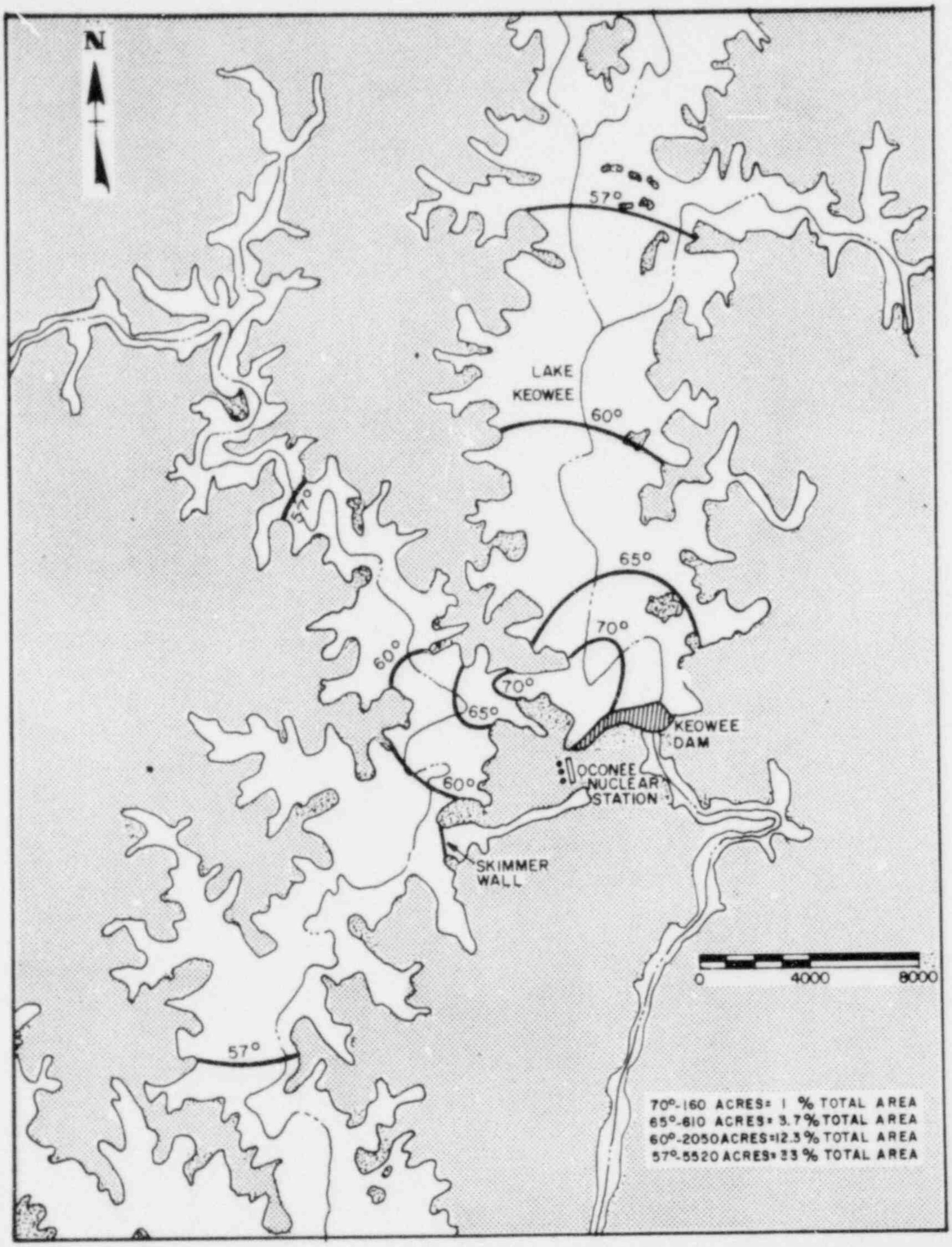

Fig. A-III-3. Expected surface temperature of Lake Keowee under normal conditions during Decembeı when the monthly average discharge temperature is 74°F, the ambient surface temperature is 54°F, and the intake temperature is 54°F.

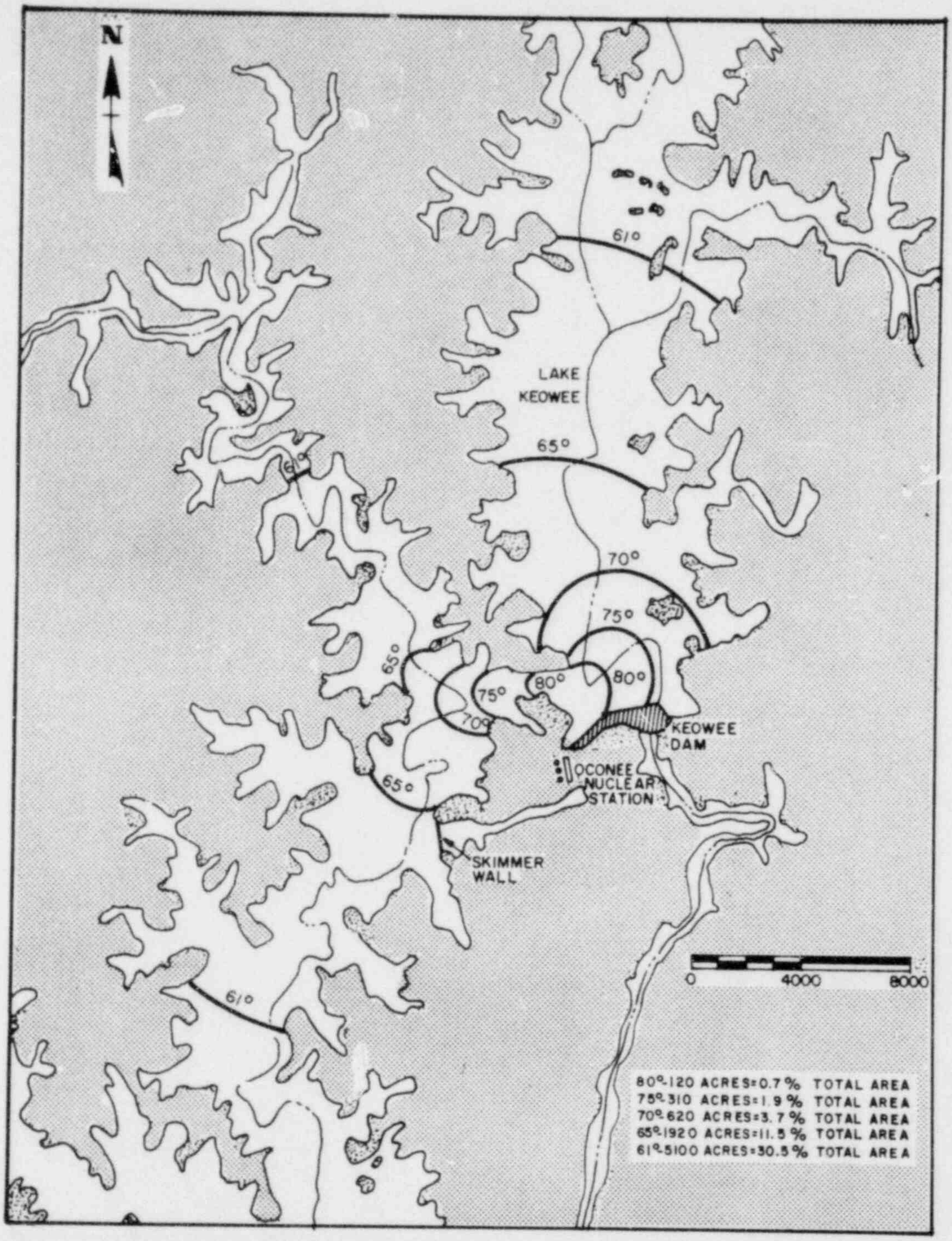

Fig. A-111-4. Expected surface temperature of Lake Keowee under normal conditions during December when the maximum daily average discharge temperature is 84°F, the ambient surface temperature is 58°F, and the intake temperature is 58°F.

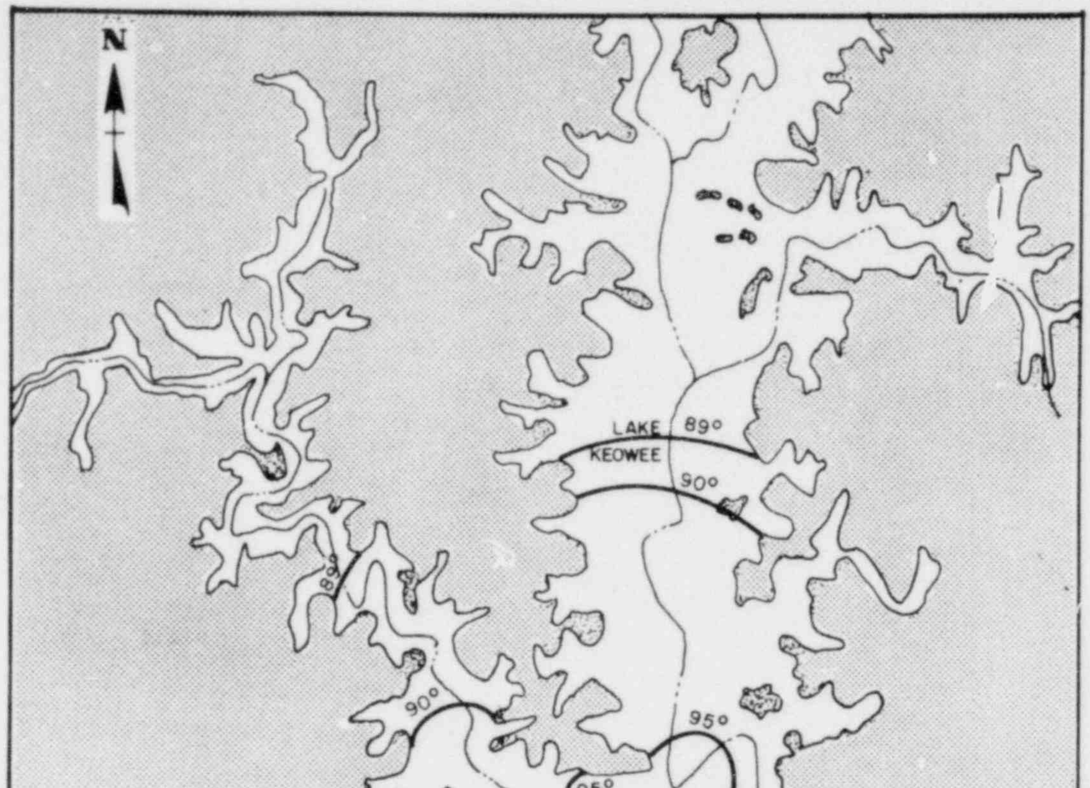

Fig. A-III-5. Expected surface temperature of Lake Keowee under extreme conditions during August when the monthly average discharge temperature is 98°F, the ambient surface temperature is 86°F, and the intake temperature is 82°F.

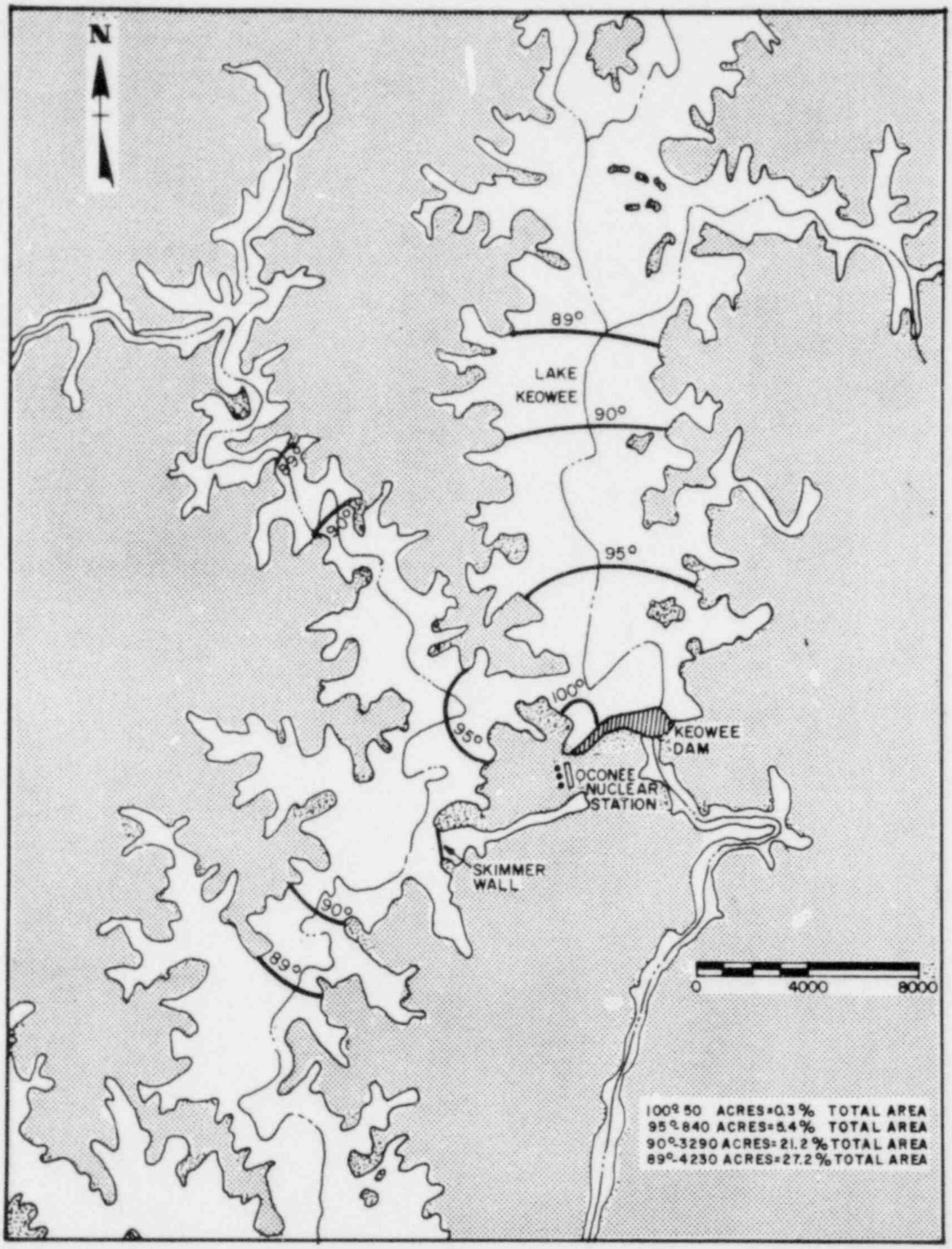

Fig. A-III-6. Expected surface temperature of Lake Keowee under extreme conditions during August when the maximum daily average discharge temperature is 101°F, the ambient surface temperature is 86°F, and the intake temperature is 85°F.

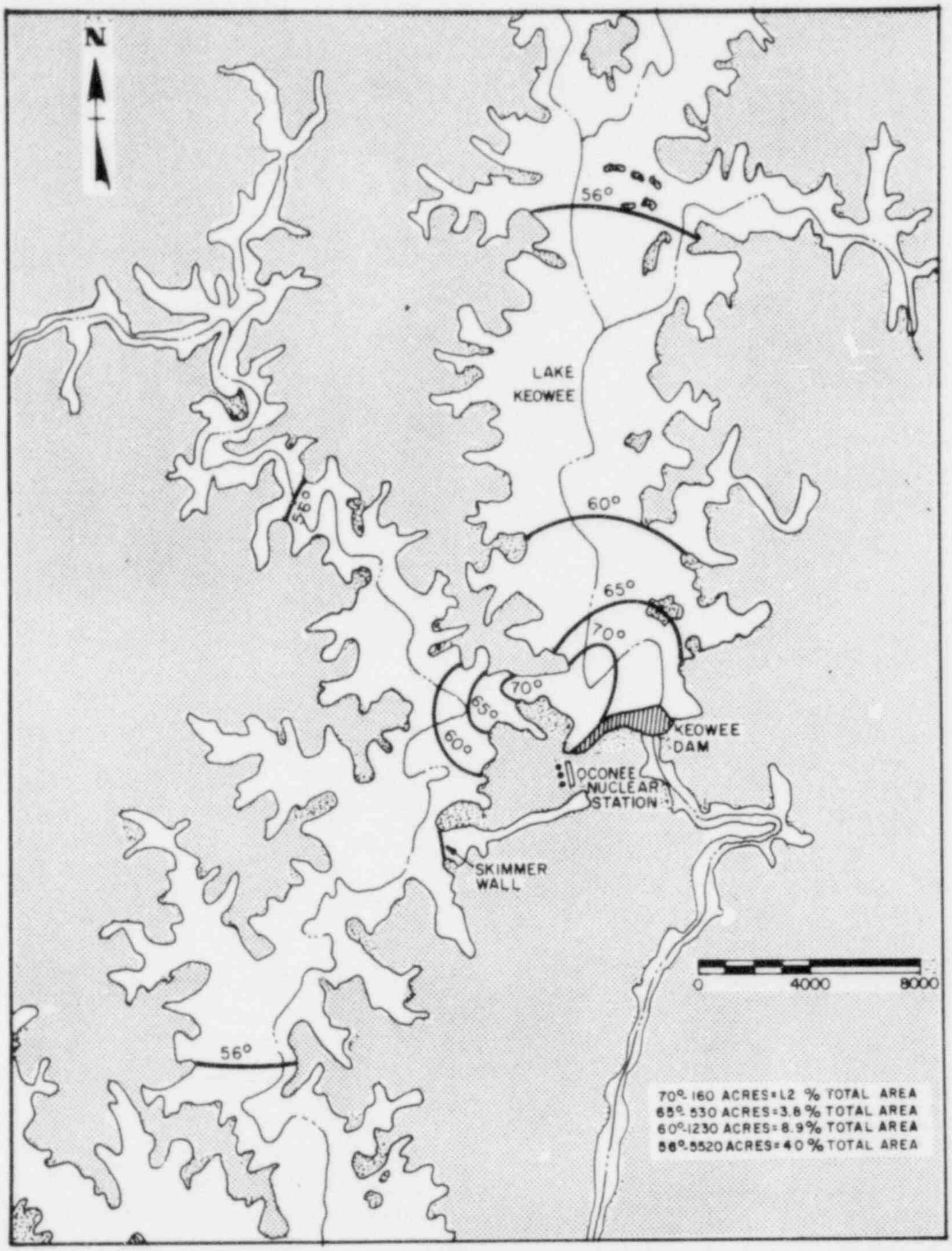

Fig. A-III-7. Expected surface temperature of Lake Keowee under extreme conditions in December when the monthly average discharge temperature is 73°F, the ambient surface temperature is 53°F, and the intake temperature is 53°F.

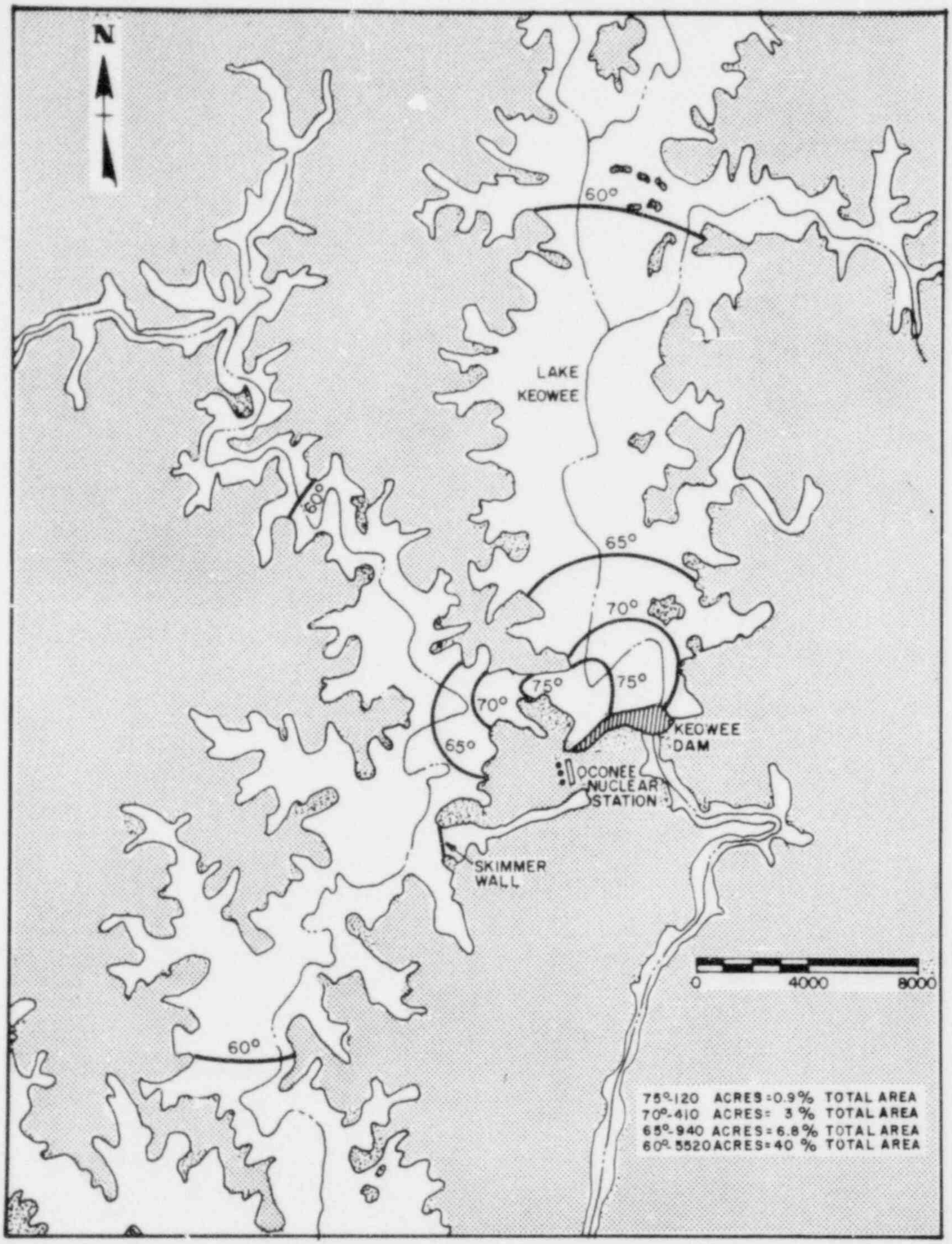

Fig. A-III-8. Expected surface temperature of Lake Keowee under extreme conditions in December when the maximum daily average discharge temperature is 77°F, the ambient surface temperature is 57°F, and the intake temperature is 57°F.

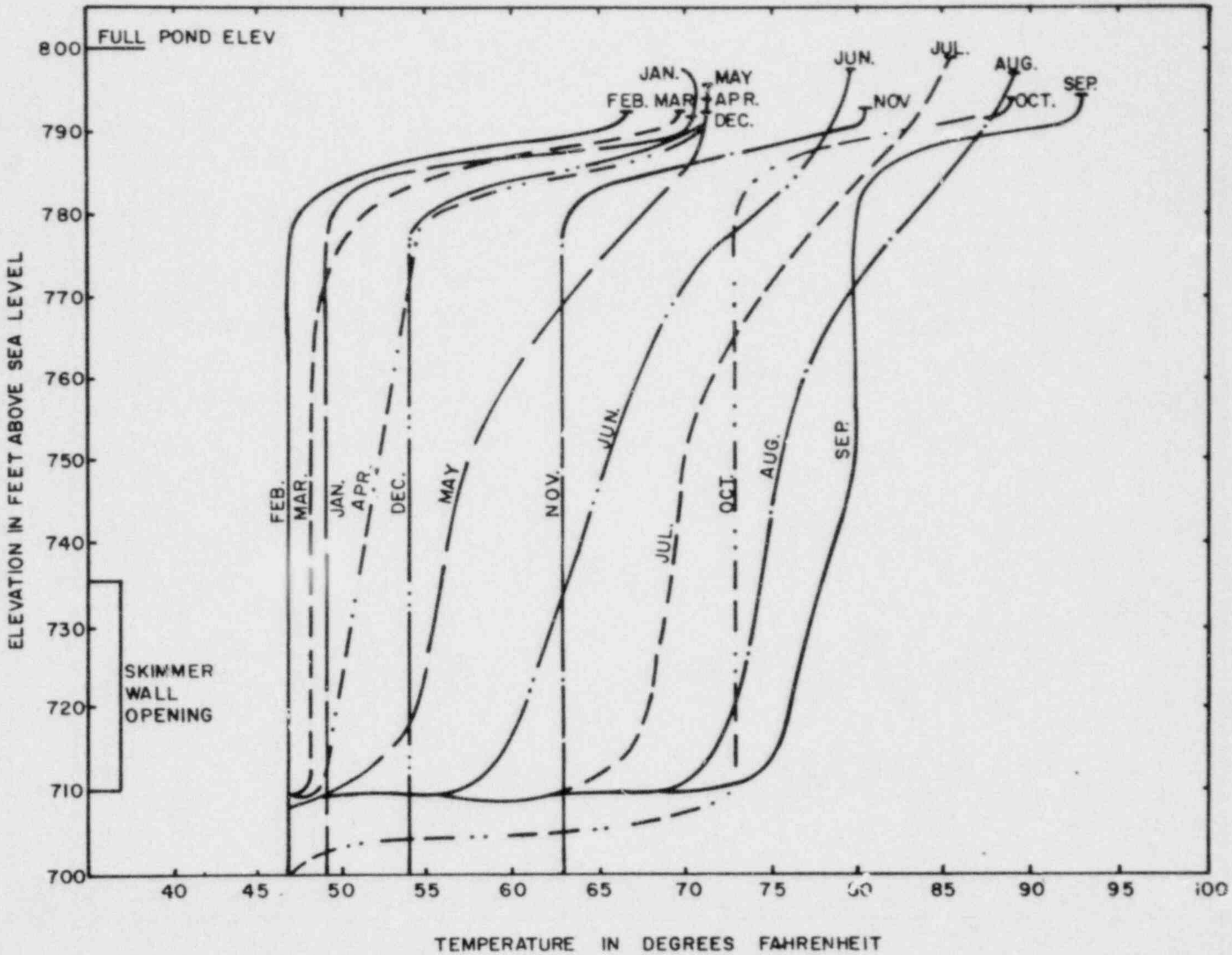

Fig. A-III-9. Vertical temperature profile 3,000 ft from discharge in Lake Keowee for each month during a normal year.

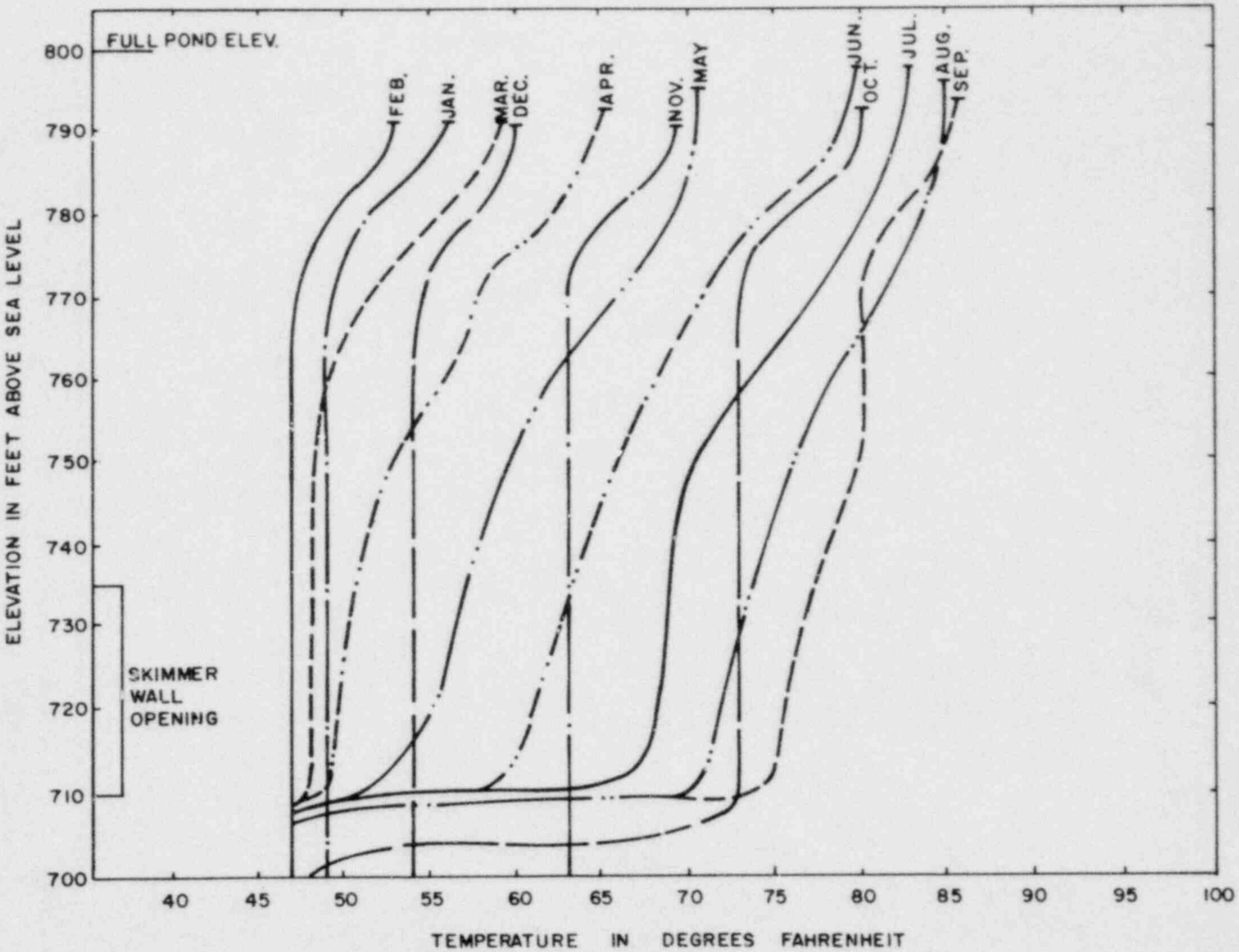

Fig. A-III-10. Vertical temperature profile at the skimmer wall in Lake Keowee for each month during a normal year.

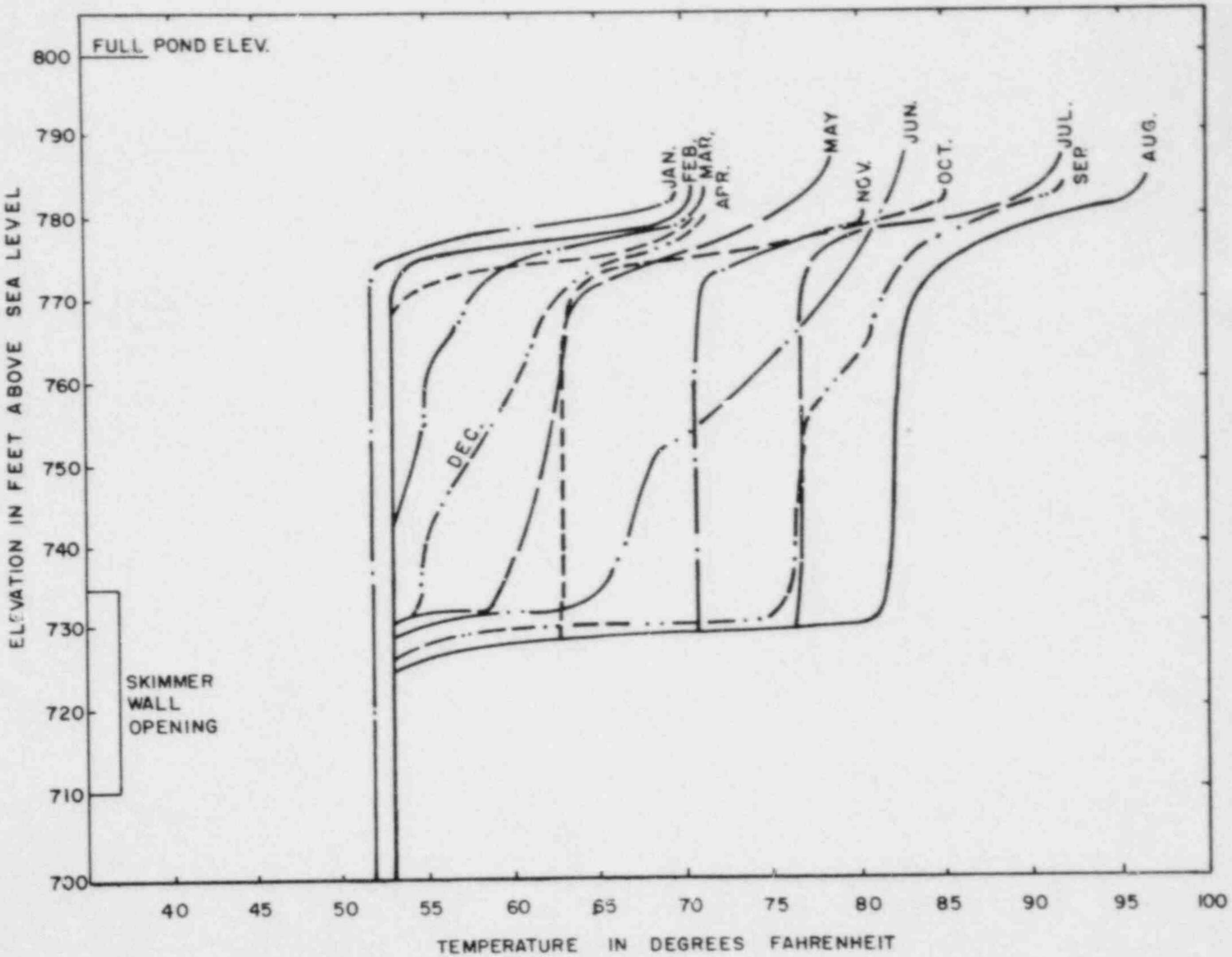

Fig. A-III-11. Vertical temperature profile 3,000 ft from discharge in Lake Keowee for each month during an extreme year.

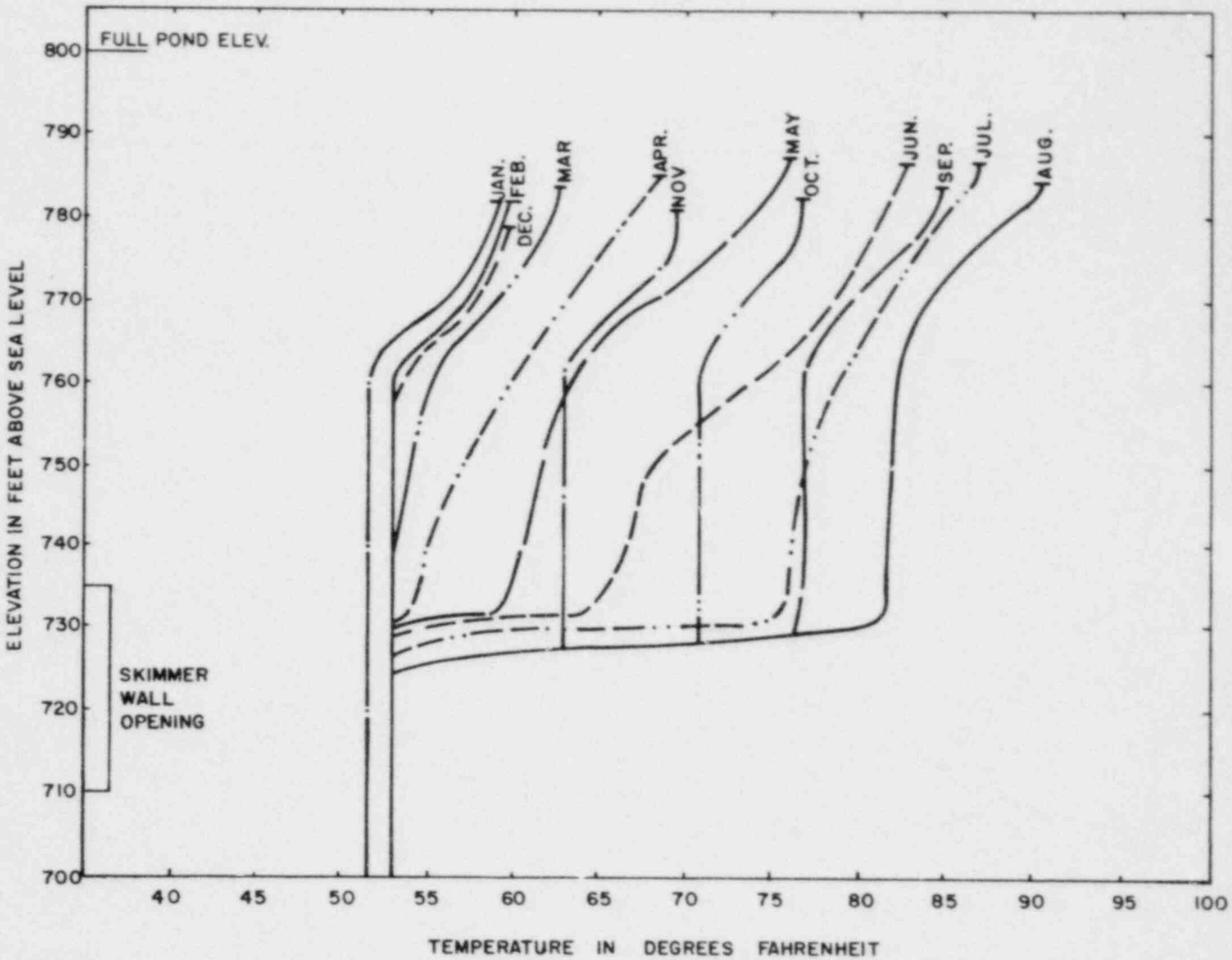

Fig. A-III-12. Vertical temperature profile at the skimmer wall in Lake Keowee for each month during an extreme year.

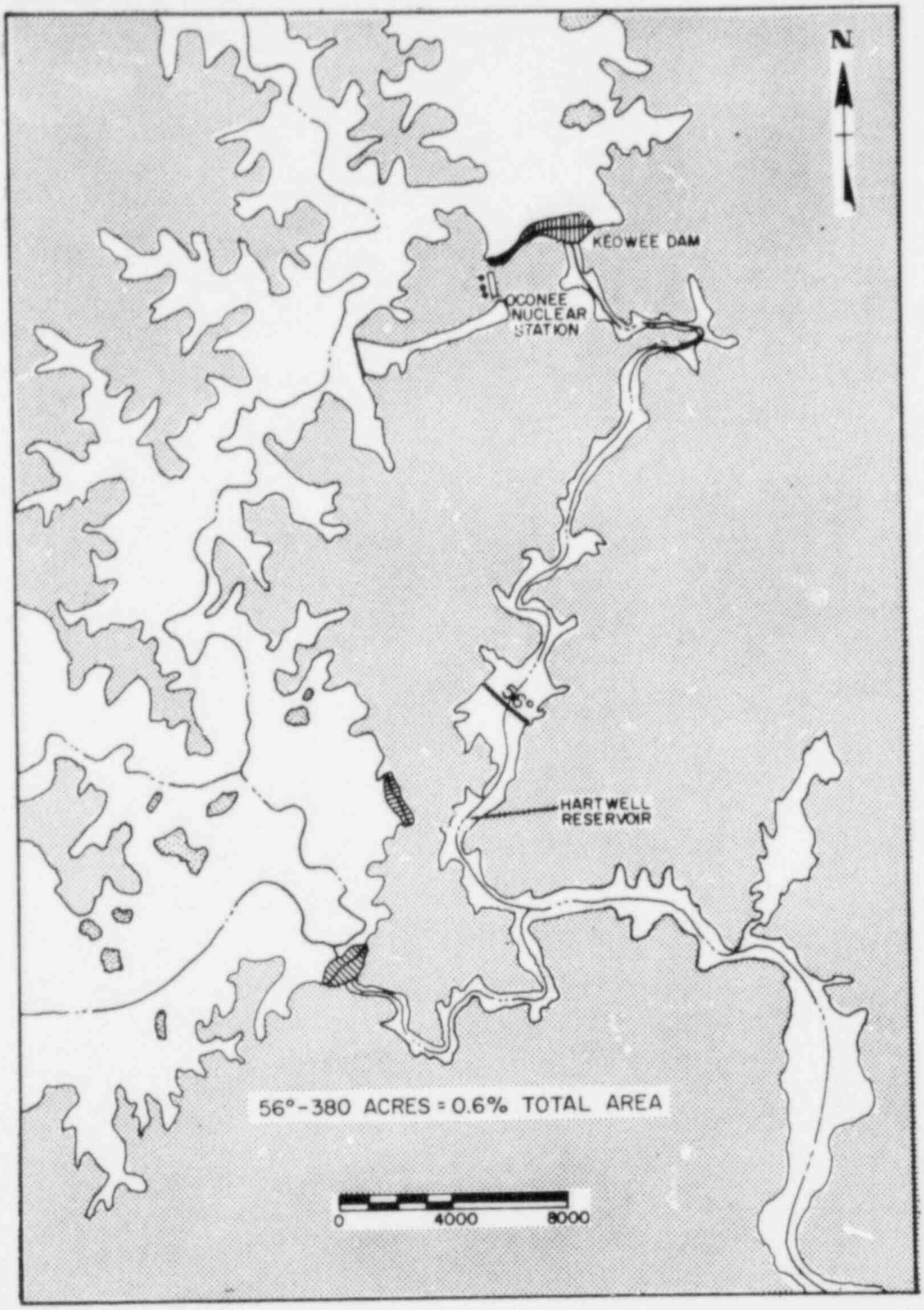

Fig. A-III-13. Expected surface temperature of Hartwell Reservoir during extreme conditions in January when the monthly average Keowee discharge temperature is 59°F and the ambient surface temperature is 53°F.

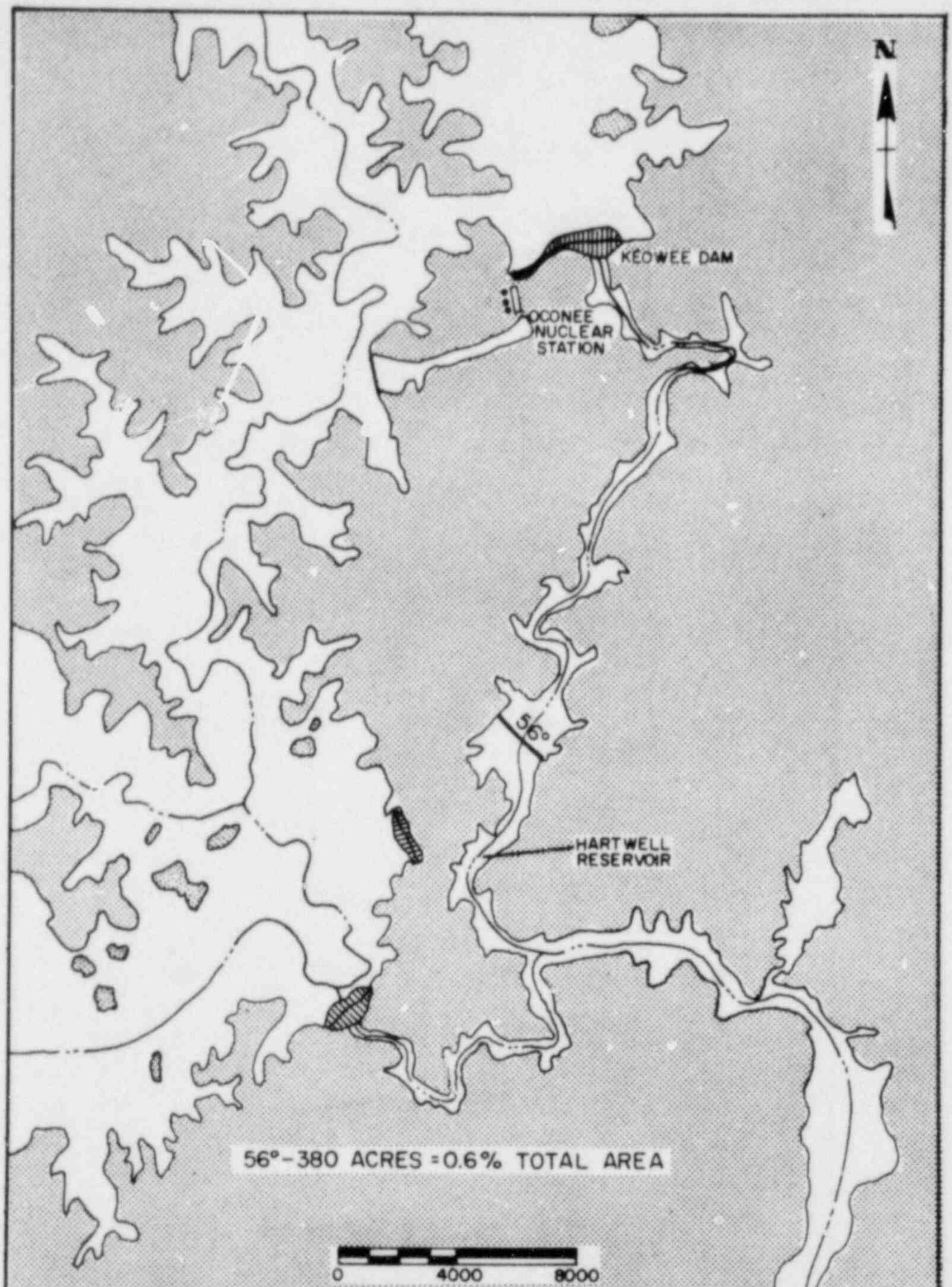

Fig. A-III-14. Expected surface temperature of Hartwell Reservoir during extreme conditions in January when the maximum daily average Keowee discharge temperature is 59°F and the ambient surface temperatu:e is 53°F.

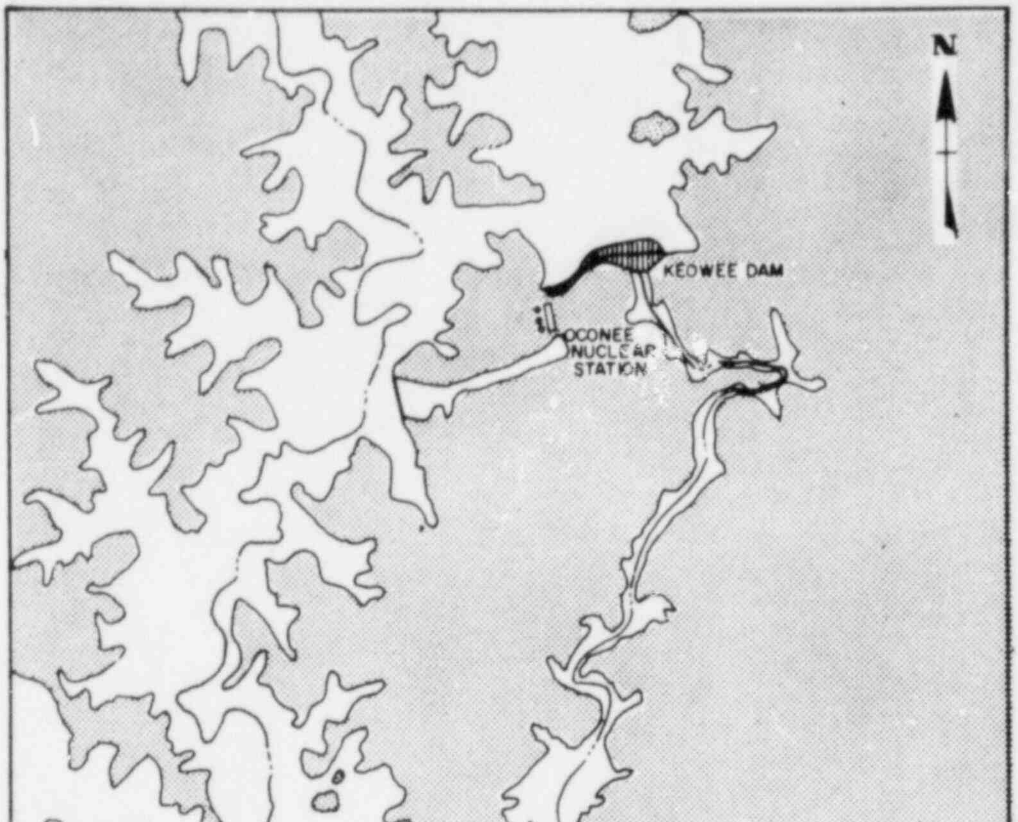

Fig. A-III-15. Oconee Nuclear Station, expected surface temperature in Hartwell Reservoir for monthly average discharge temperature under normal conditions in February. Ambient surface, 47°F; Keowee discharge, 52°F.

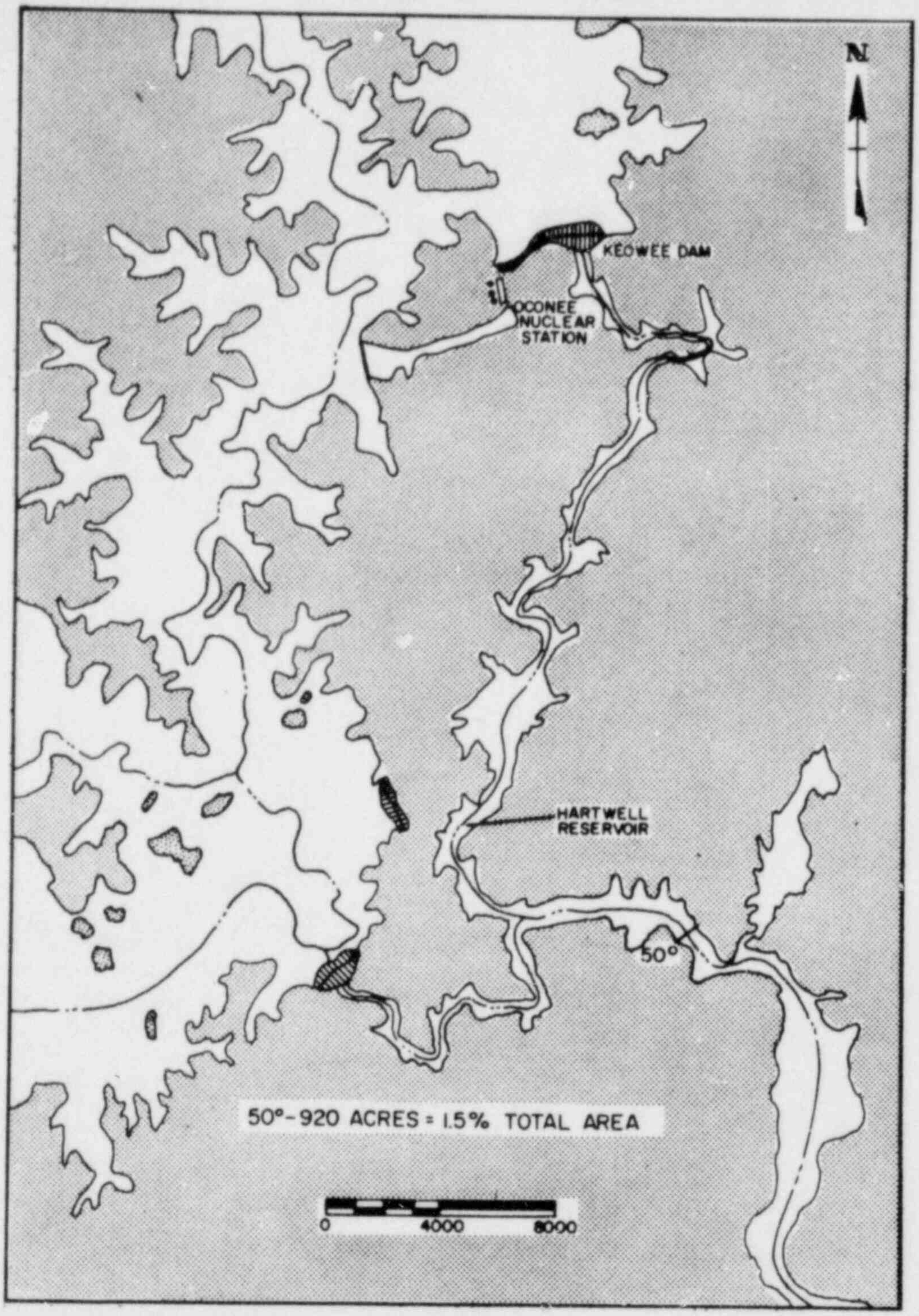

Fig. A-III-16. Oconee Nuclear Station, expected surface temperature in Hartwell Reservoir for maximum daily average discharge temperature under normal conditions in February. Ambient surface, 47°F; Keowee discharge, 52°F.

APPENDIX III-2

SUMMARY OF RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS 1959-1970

This appendix summarizes discharges of radioactive wastes from the pressurized water reactors operating in the United States from 1959 to 1970, except for the Saxton Nuclear Experimental Reactor, which has a net electrical capacity of only 3.25 megawatts.

It should be noted that 10 CFR Part 20 provides alternatives for determining permissible limits to the activity of radioactive liquid effluents. One of the limits specifically mentioned is 1×10^{-7} microcurie per cubic centimeter, which is sufficiently restrictive that it can be used for mixtures of fission and corrosion products in liquid waste from light water nuclear power reactors without any identification of the radioisotopic composition of the mixture. Other alternatives require knowledge of the identity and concentration of the radionuclides present and establishing that certain isotopes are not present. Typical compositions of radioactivity in water from light water power reactors are such that much higher limits are expected to be available to the licensee if he wishes to support them by adequate radiochemical analyses. The values reported in Table III-2-1 were calculated using the limit of 1×10^{-7} microcurie per cubic centimeter, except as noted.

The corresponding 10 CFR Part 50 guideline (June 9, 1971) is 0.2×10^{-7} microcurie per cubic centimeter, a value one-fifth as large as the 10 CFR Part 20 limit; 10 CFR Part 50 makes no provision for analysis for specific radionuclides. Therefore the percent of limit values in Table III-2-1 (for 10 CFR Part 20 limits) may be converted to the percent of the 10 CFR Part 50 guideline by multiplying these values by 5, except for the instances where the licensee analyzed the discharge for specific radionuclides. In these cases, the 10 CFR Part 50 guideline of a maximum discharge of 5 curies per reactor can be used for comparative purposes.

The values for 1959-1968 are from "Radioactive Waste Discharges to the Environment from Nuclear Power Facilities," J. E. Logsdon and R. I. Chissler, U.S. Dept. of Health, Education and Welfare, PB-19071- (BRH/DER 70-2) March 1970.

The values for 1969 are from Hearings Before the Joint Committee on Atomic Energy. Congress of the United States, 91st Congress, Second Session, on Environmental Effects of Producing Electric Power, January 27-30, February 24-26, 1970, Appendix 10, pp. 2316-2317.

The values for 1970 are from B. Kahn, B. Shleien, and C. Weaver, in Vol. 2 of U.S. Papers for the Fourth United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, Sept. 6-16, 1971, Session 3.3-28- to 3.3-45, A/Conf-49/P-087.

Table A-III-1

RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS

Annual Liquid Wastes, Gross Beta-Gamma Less Tritium

Reactor	Shippingport		Yankee		Indian Point I		San Onofre		Conn. Yankee		Ginna	
Location	Pennsylvania		Mass.		New York		California		Connecticut		New York	
Year Critical	1967		1960		1962		1967		1967		1969	
Net Elect. Cap., Mw	60*		175		255		430		575		425	
	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit
1970			.034	.14	7.8	.28+	3.8	6.3	22	3.7+	9.3	4.5
1969	.019	.07	.019	.07	28	1.5+	8	14	12	1.4+	.02	.4
1968	.08	.35	.008	.03	34.6	1.65+	1.6	2.35	3.9	5.35		
1967	.07	.31	.055	.02	28.0	1.55+	.32	.46	.22	.01		
1966	.06	.27	.036	.13	43.7	70.1						
1965	.14	.62	.029	.1	26.3	43						
1964	.53	2.34	.002	.01	13.0	22						
1963	.19	.84	.003	.01	.164	.26						
1962	.09	.40	.008	.03	.130	.22						
1961	.13	.57	.008	.03								
1960	.21	.93										
1959	.08	.37										

*Modified to 150 Mwe in 1965.

+Based on radionuclide analysis.

Table A-III-2

RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS

Tritium in Liquids

Reactor	Shippingport		Yankee		Indian Point I		San Onofre		Conn. Yankee		Ginna	
Location	Pennsylvania		Mass.		New York		California		Connecticut		New York	
Year Critical	1957		1960		1962		1967		1967		1969	
Net. Elect. Cap., Mw	60*		175		255		430		575		425	
	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit
1970			1500	.21	410	.03	4800	.26	7400	.36	110	.005
1969			1200	.014	1100	.07	3500	.2	5200	.24	<1	<.001
1968	35.2	.0053	1170	.15	787	.045	2350	.11	1740	.08		
1967	34.8		1690		297				221			
1966	27.3		1920		125							
1965	3.04		1300									
1964	1.39											
1963	2.17											
1962	1.33											
1961	13.2											
1960	99.0											
1959	64.0											

*Modified to 150 Mwe in 1965.

Table A-III-3

RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS

Noble and Activation Gases

Reactor	Shippingport		Yankee		Indian Point I		San Onofre		Conn. Yankee		Ginna	
Location	Pennsylvania		Mass.		New York		California		Connecticut		New York	
Year Critical	1957		1960		1962		1967		1967		1969	
Net Elect. Cap., Mw	60*		175		255		430		575		425	
	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit
1970			17	.26	1700	.03	1500	.28	700	.002	10,000	2.8
1969			4	.062	600	.01	260	.045	190	1	<1	.1
1968	.001	.0025	.68	.008	59.7	.0037	4.83	.00085	3.74	.0039		
1967	.002	.005	2.3	.036	23.4	.0015	4.02	.0024	.021	.00003		
1966	.030	.075	2.4	.035	36.4	.0022						
1965	.032	.08	1.7	.025	33.1	.0020						
1964	.0024	.006	.95	.014	13.2	.00083						
1963	.351	.87	7.4	.11	.0072	4.5×10^{-7}						
1962	.012	.03	21.7	.32								
1961	.103	.26	.00096	.000014								
1960	.029	.073										
1959	.014	.035										

*Modified to 150 Mwe in 1965.

Table A-III-4

RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM PRESSURIZED WATER REACTORS

Halogens and Particulates in Gaseous Effluents

Reactor	Shippingport		Yankee		Indian Point I		San Onofre		Conn. Yankee		Ginna	
Location	Pennsylvania		Massachusetts		New York		California		Connecticut		New York	
Year Critical	1957		1960		1962		1967		1967		1969	
Net. Elect. Cap., Mw	60**		175		255		430		575		425	
	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit	Ci	% of limit
1970			1.8×10^{-6}	4.1×10^{-4}	.075	1	None Detected		.00046	.22	None Detected	
1969			<.0001	.01	.025	.33	<.0001	<.001	<.001	.37	<.0001	<.001
1968	*	<1	*	<1	*	<1	*	<1				
1967	*	<1	*	<1	*	<1	.001	.5				
1966												
1965												
1964												
1963												
1962												
1961												
1960												
1959												

**Modified to 150 Mwe in 1965.

*Negligible.

Appendix III-3

ASSUMPTIONS USED IN ESTIMATING RADIOACTIVE RELEASE RATES

The following parameters were used in the calculation of estimated releases from Oconee Nuclear Station, Units 1, 2 & 3 at 100% power:

Percent fuel leak - 0.25%
Power level - 2,568 MWt per unit
Primary to secondary leakage - 20 gal/day
Steam generator blowdown - zero
Containment purge - 12 times/yr
Decay time: Waste Gas Processing System - 30 days
Reactor Coolant Bleed System - 30 days

1. Liquids

A decontamination factor (D.F.) of 10^4 was assumed for both the waste evaporator and the coolant bleed evaporator and a D.F. of 10 for the demineralizers except for H-3 which we assumed a D.F. of 1 for evaporation-demineralization.

No removal by demineralization was considered for yttrium, molybdenum and cesium. A decontamination factor of 10^3 was used for the evaporation of iodines.

We assumed 255,160 gal/yr processed by the waste disposal system and a 30-day holdup time. It was assumed that 1,060,800 gal/yr processed by the reactor coolant bleed treatment systems.

2. Gases

Twelve (12) containment purge releases annually are assumed. We assumed a 120 gal/day leakage into the containment building and a D.F. of 10 for iodine removal in the charcoal absorbers installed in the purge exhaust system.

Main coolant was assumed to be stripped 12 times per year. Combined fill-hold release time was assumed to yield 30 days decay.

Appendix V-1

ESTIMATION OF INTERNAL RADIATION DOSE TO ORGA ISMS

The internal radiation dose to an organism living in the effluents of the Oconee Nuclear Station was calculated from the following equation:

$$D_i = 1.87 \times 10^7 \, W_i C_i E_i,$$

where

D_i = dose rate due to radionuclide i (millirads/year),

1.87×10^7 = a constant to convert curies per gram of organism to millirad per year,

W_i = the amount of radionuclide (Ci/ml) in water released from Oconee Nuclear Station,

C_i = biological accumulation factor, and

E_i = the effective absorbed energy (MeV) of the specific radionuclide.

The maximum effective absorbed energies (E_i) in man were used in these calculations.[1] Therefore, for small one-celled organisms, the internal dose will tend to be an overestimate, since some of the energy will not be absorbed.

The internal dose for an animal consuming aquatic vegetation was calculated from the following equation:

$$D_i = \frac{1.87 \times 10^7 \, X_i^{eq} \, E_i}{m},$$

where

D_i = dose rate due to radionuclide i (millirad/year),

1.87×10^7 = a constant to convert curies per gram of animal to millirad per year,

X_i^{eq} = body burden or radionuclide i (Ci) at equilibrium in the animal consuming 100 g of aquatic vegetation per day,

E_i = the effective absorbed energy (MeV) of the radionuclide i for a 10-cm-diam cylindrical-shaped animal, and

m = mass of the animal (kg).

The following expression was used to calculate the body burden, X_i^{eq} (Ci), of radionuclide i at equilibrium:

$$X_i^{eq} = 1.4\ T_i W_i C_i g F_i,$$

where

T_i = effective half-time in days of radionuclide i in the animal,

W_i = concentration (Ci/ml) of radionuclide i in water,

C_i = accumulation factor for aquatic vegetation,

g = mass of aquatic vegetation consumed per day (100 g/day), and

F_i = fraction of ingested quantity of radionuclide initially assimilated by the whole body.

REFERENCE FOR APPENDIX V-1

1. International Commission of Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation, ICRP Publ. 2, Pergamon Press, Oxford, 1969.

Appendix XI-1

DETAILS OF COST-BENEFIT ANALYSIS

This Appendix explains the source of data on Table XI-1 and replaces the "remarks" section often necessary on similar tables. Many references are made to "DPC Supp." This is the Duke Power Company Supplement to Environmental Quality Features of Keowee-Toxaway Project, October, 1971. Other references are listed at end of this Appendix.

ECONOMIC IMPACT OF PLANT

POWER

Base Load: A .mes the nameplate rating of each unit, 80% plant factor, and continuous generation. Nameplate rating is from Table 11, DPC Supp.

2658 MW x 0.8 pf x 24 hr/day x 365 day/yr = 18,627,264 MWh/yr
Peaking: Assumes 717,500 Mwh/yr (Table 10, DPC Supp.)

Base Load Costs

Applicant's Proposal: \$38.28/kW/yr (Table 11) x 2,658,000 kW = \$101,748,240/yr.

Alternate #1: \$101,748,240 + \$7,452,800 (Table 10, Note 5) = \$109,201,040/yr.

Alternate #2: Same as Alternate #1.

Alternate #3: \$48.05/kW/yr (Table II) x 2,658,000 kW = \$127,716,900/yr.

Alternate #4: \$127,716,900 + 7,452,800 x 0.87 (heat rate advantage) (Table 11) = \$134,200,836/yr.

Alternate #5: Same as Alternate #4.

Peaking Costs

Applicant's Proposal: \$25,718,000 (Table 10).

Alternate #1: $32,806,000 (Table 10).

Alternate #2: $27,647,000 (Table 10).

Alternate #3: Same as Applicant's Proposal.

Alternate #4: Same as Alternate #1.

Alternate #5: Same as Alternate #2.

GENERATING COST is the sum of the base load and peaking costs noted above.

RESERVE CAPACITY is based on the following table, extracted from a letter from T. A. Phillips (FPC) to Lester Rogers (AEC) dated February 9, 1972:

	Duke Power Co.	Virginia-Carolinas Subregion
Peak Load Forecast - MW	7,502	20,605
Net capability scheduled - MW	8,569	23,123
Reserve - MW	1,067	2,516
- % of peak load	14.2	12.2
Net capability without Cliffside No. 5 - MW	7,979	22,533
Reserve - MW	477	1,928
- % of peak load	6.4	9.4
Net capability without Oconee	7,683	22,237
Reserve - MW	181	1,632
- % of peak load	2.3	7.9
Net capability without Oconee or Cliffside #5	7,093	21,647
Reserve - MW	-409	1,042
- % of peak load	-5.5	5.1
Net capability without Oconee or Surry or Cliffside #5	7,093	20,827
Reserve - MW	-409	222
- % of peak load	-5.5	1.1

The first entry of Net capability (8,569 MW) is interpreted to include Oconee #1, Cliffside #5, Buzzard's Roost and Keowee.

The present capability of the Duke system is assumed to be 7,093 MW (without Cliffside #5 or Oconee). Therefore, projected reserve increase is:

$$\frac{8569 - 7093}{7502} = 19.67\%.$$

The increase without Oconee #1 is: $\frac{(8569 - 7093) - 886}{7502} = 7.85\%$.

Thus the increase attributable to Oconee #1 is: 19.67% - 7.85% = 11.82% ≈ 12%.

ENVIRONMENTAL IMPACT OF PLANT

1. Impact on Water

1.1. CONSUMPTION:

1.1.1. Commercial: Ref. p. 35, DPC Supp; "Based on a value of 0.625¢/1000 gallons, 100 mgd withdrawal from Lake Keowee would have a value of $228,000 per year." However, further up that same page, the value of water is quoted at 0.4¢/1000 gallons. And the possible withdrawals for consumptive purposes by Seneca, Walhalla, Greenville and the Greenville-Pickens Regional Planning Board reflect present withdrawals of 2 mgd and projections totaling 161 mgd to 199 mgd. Both of these projections exceed the minimum daily flow of the watershed. For the purposes of the chart, however, the 100 mgd withdrawal is noted as a cost to the environment in the Applicant's Proposal, Alternates #1, #3, and #4; no appropriate statement can be made for Alternates #2 and #5 at an unknown location.

1.1.2. Power Production: Ref. p. 36, DPC Supp.; "A consumptive loss of 137 mgd (212 cfs) exceeds the recorded minimum daily flow of 152 cfs (Source: USGS) from the entire Keowee River watershed." But independent calculations from the heat rejection model used at Oak Ridge National Laboratory indicate only 50 cfs loss due to evaporation caused by heat rise in the lake. This amounts to 32 mgd. Evaporation and drift loss from cooling towers from the rejection of 17.22×10^9 Btu/hr ≈ 77 cfs (50 mgd), assuming 100% dissipation through evaporation. Drift loss calculations are based on 0.2% maximum guaranteed by the tower manufacturer; this amounts to between 6 and 9 cfs. The total loss of water through evaporation and drift losses in a cooling tower, including loss from auxiliaries, is 79 to 90 cfs, or 51 to 58 mgd. Therefore, power production costs of water to the environment are:

Applicant's Proposal: 32 mgd

Alternate #1: 51-58 mgd

Alternate #2: 51-58 mgd

Alternate #3: 28 mgd (32 mgd x 0.87 heat rate advantage)

Alternate #4: 48-51 mgd (reflects heat rate advantage of fossil fuel)

Alternate #5: 48-51 mgd.

1.2. RADIONUCLIDE CONTAMINATION OF ENVIRONMENT: See Table V-3.

1.2.1. Liquid Discharge: Total ≈ 6 man-rems/yr from liquid effluents.

1.3. NATURAL WATER DRAINAGE: Ref Table 14, DPC Supp.; "26,000 acres." The total area of 26,000 acres was changed from cold water rivers and streams to warm water reservoir. The statement applies to the Applicant's Proposal, Alternates #1, #3, and #4. No statement is made for Alternates #2 and #5.

2. Impact on Air

2.1. CHEMICAL DISCHARGE TO AMBIENT AIR

2.1.1. Air Quality - Chemical: Stack gas analysis is based on data from Kent's, 12 ed., p. 2-29. "W. Va., Kanawha County;" 34.3% volatile material; 55.8% fixed carbon; 5.2 % ash; 0.7% sulfur; 5.6% hydrogen; 76.5% carbon; 1.4% nitrogen; 10.6% oxygen. On p. 45, DPC Supp., "The alternative coal-fired steam electric generating station would have required an average of 6.4 million tons of coal per year." Ref. "Steam," Babcock & Wilcox Co., 1960, p. 28-7; "The dust loading of the flue gas is in the range of 5 to 15% of the ash in the coal, compared with about 80% for a dry-ash pulverized-coal-fired unit."

CO_2 = 6.4 x 0.765 x 44/12 = 17,952,000 tons/yr

SO_2 = 6.4 x 0.07 x 64/32 = 89,600 tons/yr

NO_x = 6.4 x 0.014 x 44/28 = 140,800 tons/yr

Ash = 6.4 x 0.052 = 332,800 tons/yr

Fly ash = 332,800 x 0.8 x 0.05 (assume 95% precip. eff.)

= 13,312 tons/yr

Ash to disposal = 332,800 - 13,312 = 319,488 tons/yr

2.1.1.1.	CO_2	= 17,952,000 tons/yr	Alternates 3 & 5
2.1.1.2.	SO_2	= 89,600 tons/yr	Alternates 3 & 5
2.1.1.3.	NO_x	= 140,800 tons/yr	Alternates 3 & 5
2.1.1.4.	Particulates	= 13,312 Tons/yr	Alternates 3 & 5
2.1.1.5.	Other	= 319,488 tons/yr	Alternates 3 & 5

Stack gas analysis for gas/oil turbines based on data from Kent's, 12 ed., p. 2-48. Texas residuum, C - 84.6%; H - 10.9%; S - 1.6%; O & - 2.9%. Fuel used = 79,000,000 gal/yr (p. 46, DPC Supp.): 79×10^6 gal/yr = 316,824 tons/yr oil.

CO_2 = 316,824 x 0.846 x 44/12 = 982,787 tons/yr

SO_2 = 316,824 x 0.016 x 64/32 = 10,138 tons/yr

NO_x = 316,824 x 0.029 x 44/28 = 14,438 tons/yr

Alternate #1 will have the above numbers for 2.1.1.1., 2., & 3.

Alternate #4 will have:

2.1.1.1. CO_2 = 18,934,787 tons/yr

2.1.1.2. SO_2 = 99,738 tons/yr

2.1.1.3. NO_x = 155,238 tons/yr

2.1.1.4. Particulates = 13,312 tons/yr

2.1.1.5. Other = 319,488 tons/yr

2.2 ENTRAINMENT: Though not specifically mentioned in the DPC Supp., the drift loss of between 6 and 9 cfs would entrain a small amount of water treatment chemicals in the water droplets. (Refer to 1.1.2. for drift loss calculation.) Applies to Applicant's Proposal, Alternates #1, #3, and #4.

2.3 RADIONUCLIDES DISCHARGED TO AMBIENT AIR: See Table V-3, Total ≈ 4 man-rems/yr from gaseous effluents.

2.4 FOGGING and ICING: The possibility of local modifications of weather conditions due to thermal discharge by convection from the lake or to thermal plumes from cooling towers is not discussed. But this possibility exists and some localized fog or ice formation may occur under specific conditions of temperature, humidity and air movement.

3. Temporary Impacts of Construction

3.1. LAND DISTURBANCE: Ref. DPC Supp., p. 4; "...the following alterations were made (for Keowee-Toxaway Project):

430 acres - earthwork and grading for site facilities at Keowee

360 acres - earthwork and grading for site facilities at Jocassee

510 acres - earthwork and grading at Oconee."

Applicant's Proposal: 1300 acres total were graded for the project

Alternate #1: 510 acres are assumed to be required for a like-sized nuclear plant with a gas turbine peaking installation and wet cooling towers also included within the exclusion areas. The map (Figure 2, DPC Supp.) indicates an area which would probably be sufficient for these added structures. This assumes the dams are in place and operating.

Alternate #2: 510 acres is again assumed ample for a similar nuclear plant; no specific size is or can properly be given for the required reservoir for pumped storage peaking operation at a separate location.

Alternate #3: 1300 acres is assumed for the requirements of a coal-fired plant in place of the Proposal. No calculations were made for the required coal pile or ash pond space for a similar plant.

Alternate #4: Same as Alternate #1. It is assumed that the 510 acres will be adequate for the fuel and ash facilities as well as the gas turbine facility.

Alternate #5: Same as Alternate #2.

3.2. AIR QUALITY: Negligible effects would be expected during construction. This environmental consideration is not discussed in DPC Supp.; particulates from excavation and cement plants would be the most important air quality effect.

3.3. WATER QUALITY: A minor amount of siltation would be expected but should be of a temporary nature. Ref. DPC Supp., p. 22; "For years it has been company practice to restore grass and tree cover to such disturbed areas in early stages of construction to reduce erosion and downstream siltation."

3.4. WATER DIVERSION: Not specifically mentioned in DPC Supp., it is obvious that temporary river diversion was necessary for the construction of the Keowee and Jocassee dams. Walleye spawning has ceased in this area and this is probably a "result of excessive turbidity resulting from the construction of the Keowee-Toxaway complex." (Hampton Williams. Fisheries Investigations in Lakes and Streams. District II Annual Report for Period of July 1, 1970 through June 30, 1971. South Carolina Wildlife Resources Department, 1971.) This may be a temporary condition that can be partially corrected by management of water flow through Keowee dam.

In addition to the disruption of the below-the-dam aquatic environment, a total of 26,000 acres were inundated by the two lakes. This converted several miles of river and stream to a lake environment.

3.5. SPOILAGE: Not specifically mentioned in DPC Supp., some spoilage is necessary in order to accommodate the land disturbance mentioned in 3.1. It is assumed that this has been ameliorated by Duke's erosion control practices. (Ref. DPC Supp., p. 22; "For years it has been company practice to restore grass and tree cover to such disturbed areas in early stages of construction to reduce erosion and downstream siltation.")

SOCIETAL IMPACT OF PLANT

1. Operational Fuel Disposition

1.1. FUEL TRANSPORT:

Applicant's Proposal: Ref. p. 45, DPC Supp.; "Nine truck shipments of new fuel will be received in a normal year." In addition, (Ref. p. 21, DPC Supp.) an auxiliary oil-fired boiler used to generate steam during refueling periods will require some oil tank-truck shipments. The oil shipments are recognized but not noted because this fuel is for station operation and does not directly contribute to the generation of electricity.

Alternate #1: Same as Applicant's Proposal plus oil required to fuel the gas turbine peaking generation capacity. Ref. p. 46, DPC Supp.; "When compared to replenishing water power, this would have represented the annual irretrievable consumption of 11.2 billion cubic feet of natural gas or 79 million gallons of fuel oil." Assuming oil as fuel and further assuming incoming shipment in 10,000-gallon railroad tank cars, 7,900 tank cars per year will be required in addition to the nine truck shipments.

Alternate #2: Same as Applicant's Proposal.

Alternate #3: Ref. p. 46, DPC Supp.; "Two trains of 90 cars each would be required every day." This amounts to 65,700 carloads per year.

Alternate #4: Same as Alternate #3 plus Alternate #1 requirement of 7,900 tank cars per year, or a total of 73,600 car loadings per year.

Alternate #5: Same as Alternate #3.

1.2. FUEL STORAGE: This subject is not addressed in DPC Supp.

Applicant's Proposal: Fuel storage is assumed to be within the structures erected for Oconee. No impact on the environment is anticipated for either virgin or spent fuel.

Alternate #1: Though not addressed nor calculated, the gas turbine peaking capacity would require an average of 6,583,333 gallons per month. No statement is made in DPC Supp. expressing Duke's normal practice concerning coal or oil reserves. However many power companies regard a 60-day supply as adequate. This means, then, that 13,166,667 gallons' storage capacity would have to be provided for this alternative.

Alternate #2: Same as Applicant's Proposal.

Alternate #3: If the same assumption is made for a coal-fired plant as for the gas turbine (60-day reserve), then storage for 1,067,667 tons of coal would have to be provided. This assumes the 6.4 million tons per year previously documented.

Alternate #4: In addition to the coal storage capacity required for Alternate #3, the approximately 13.2 million gallon oil storage would be required for the gas turbines.

Alternate #5: Same as Alternate #3.

1.3. WASTE PRODUCTS: This category considers waste products directly caused by power generation - i.e., spent fuel from the reactor, ash from the coal-fired alternate - because that constitutes the major insult to the environment. Other waste products are recognized, such as the impact from a sewage plant, solid waste in the form of trash, but they are not stated on the chart.

Applicant's Proposal: Ref. p. 45, DPC Supp.; "Shipment of spent fuel will require an average of 89 shipments annually." This specifically inplies shipment by truck.

Alternate #1: Same as Applicant's Proposal. The fuel assumed (2.1.1, above) is an oil which has no ash content analysis.

Alternate #2: Same as Applicant's Proposal.

Alternate #3: See 2.1.1.5. Other. This refers to ash to be disposed of in the ash pond - 319,488 tons per year.

Alternate #4: Same as Alternate #3; see also Alternate #1, above.

Alternate #5: Same as Alternate #3.

2. Land Use and Property Values

2.1. INDUSTRIAL: "Industrial" in this sense is intended to mean property intended for the basic production of goods or services as opposed to "Commercial" use of the property for distribution or sale or services.

Ref. DPC Supp., Appendix "O", p. 1; "This nuclear station with its initial loads of fuel is estimated to cost $478 million..." Ref. DPC letter to DREP, Jan 19, 1972, p. 5; "...the initial nuclear fuel core of $61,400,000..."

Applicant's Proposal: $478,000,000 - $61,400,000 = $416,600,000.

Alternate #1: Cost of cooling towers, Note 5, Table 10, DPC Supp.; $46,580,000. Combustion Turbines, Table 10, DPC Supp.; $84,180,000 $417,000,000 + $47,000,000 + $84,000,000 = $548,000,000.

Alternate #2: Pumped Storage at a separate location is assumed to cost the same as the two dams at the present site. Ref. DPC Supp., Appendix "O", Section 3, p. 2; "...the Keowee Station cost $56 million..." $417,000,000 + $47,000,000 + $46,000,000 + $105,000,000 = $625,000,000.

Alternate #3: Plant cost/kw is estimated on Table 10 at $119, but rising prices make this estimate too low. The cost of a coal-fired plant is based, therefore, on an estimate of $140/kw. The location of the plant is assumed to be on the existing lakes. 2,658,000 kw X $140/kw = $372,120,000.

Alternate #4: See Alternate #1 for Tower and Combustion Turbine costs. $372,000,000 + $47,000,000 + $84,000,000 = $503,000,000

Alternate #5: See Alternate #2 for Pumped Storage cost. $372,000,000 + $47,000,000 + 56,000,000 + $105,000,000 = $580,000,000.

2.2. COMMERCIAL: Ref. p. 4, DPC Supp.; in the list of alterations to existing conditions," the Applicant made no reference to any commercial structures being removed due to flooding of the lakes or construction of the nuclear station; therefore no loss is assumed. Furthermore, since this statement is true only for the present location, this applies only to Applicant's Proposal, Alternates #1, #3, and #4.

2.3. RESIDENTIAL: Houses displaced because of flooding or the construction of Oconee itself are the only impacts noted here; alternate sites are not evaluated. The numbers apply to the Applicant's Proposal, Alternates #1, #3, and #4.

Ref., p. 41, DPC Supp.; "...Duke purchased and removed 150 houses (12 on farms) appraised at $1,254,000, 57 tenant houses appraised at $122,000 and 120 river houses or mountain cabins appraised at $507,000."

Ref. p. 4, DPC Supp.; "17 houses...were relocated in connection with the developing Oconee site."

The reference on page 41 includes 327 houses, a total of $1,883,000, an average of $5,758.41 per house. Assigning the same value to the 17 houses removed for Oconee, the estimated value of them is 17 x $5,758.41 = $97,892.97. Combining these numbers, there are 344 houses, valued at $1,980,892.97.

Land value has been added by the Keowee-Toxaway Project.

Ref. Table 15, DPC Supp.; "Lake Keowee shoreline land suitable for planned development @ $4000/acre - 7593 acres - $30,372,000.

Lands behind Lake Keowee shoreline land...- $30,000,000"

Totals of above; 19,953 acres; $60,372,000

This amount applies to Applicant's Proposal, Alternates #1, #3, and #4 as a benefit.

2.4. AGRICULTURAL: Loss of agricultural income is noted only for those alternates which have been affected by the lakes, i.e., Applicant's Proposal, Alternates #1, #3, and #4. Ref. DPC Supp., Table 14; "Farm Cash Receipts - 4646 Acres $220,227 Annually"

2.5. FORESTRY: Same restrictions as 2.4, above. Ref. DPC Supp., Table 14; "21,354 acres woodland ... = $152,254 Annually" In addition to the reduction in forest production there was apparently a reduction in the acreage of the White pine-hemlock group. Loss of this evergreen community was increased by clearing for Lake Jocassee.

2.6. RECREATION: Since the value of recreation is unknown except for the proposed area including the two lakes, no appraisal is made for Alternates #2 and #5. Ref. p. 40, DPC Supp. "...the annual expected recreation-days are 4,100,000." This projection by the applicant is based on a permanent recreational population of 5,000 expected by 1985 with 240 visits/yr and a transient recreational population of 36,000 (1985) with 80.64 visits/yr for each transient. This projection is probably optimistic.

The Department of Interior, in commenting on the draft statement, noted that the applicant's estimate of user days was in excess of that estimated in Exhibit R of the application for license from the Federal Power Commission for the Keowee-Toxaway Project. In that application the annual user days for the reservoir was estimated at 93,560 initially, increasing to 292,000 in 2000 and 425,000 by the year 2025.

The difference between the two applications results from the interpretation of what constitutes recreation days. In the FPC application, the value is apparently for the reservoir; in the AEC draft, for the entire project. The true number of recreation days is probably larger than the numbers in the FPC application, but less than the 4,100,000 estimated for 1985 by the applicant.

2.7. NATURAL AREA: The lakes have transformed marginal farm and productive woodland areas into two lakes, altering the land use from woodland to shoreline and aquatic activities. Ref. Appendix "O", DPC Supp.; "...Lake Keowee having a shoreline of 300 miles and 18,435 acres of surface area..." "The lake impounded by Jocassee dam will have a surface area of 7565 acres ... and a shoreline of 75 miles." Total acreage = 26,000; shoreline = 375 miles.

Not only were 26,000 acres covered by water, but several trout water streams were eliminated. (South Carolina Wildlife. John Culler, ed., Winter 14(1) 1967.) Rainbow, brook, and brown trout were residents of the streams in the mountainous regions above Jocassee dam.

This applies to Applicant's Proposal and Alternates #1, #3, and #4.

3. Historical and Archaeological Sites

3.1. ACCESSIBILITY

3.1.1. Historical Sites: Ref. p. 23, DPC Supp.; "Also in the area was a covered bridge known as Chapman Bridge which had significance to the historical societies and to the citizens of the area." The bridge was relocated near Highway 11 in the Keowee-Toxaway State Park.

3.1.2. Archeological Sites: Ref. p. 22-23, DPC Supp.; "...it became apparent ... that the Keowee basin contained significant archaeological remains, including those of the Cherokee and the site of Fort Prince George. ... Duke committed to the University of South Carolina a grant in the amount of $30,000 to finance this [archaeological] survey."

3.2. SETTING OF HISTORICAL SITES: Refer to 3.1.1., above. The setting is changed (cost), but by being relocated it has become "a tourist attraction" (Ref. p. 23, DPC Supp.). Supposedly the bridge has become more accessible (benefit).

4. Community Benefits

4.1. LOCAL TAXES: Ref. DPC Supp., Appendix "O", Section 6, p. 3; " ... local and state taxes on the initial plants are estimated at $16 million annually." This applies to the Applicant's Proposal. This item assumes local and state taxes based on property value; the other alternatives use this $16 million as a base and proportionate amounts based on the property values as noted in line 2.1., above.

Alternate #1: 16 x 548/417 = $21,026,379/yr

Alternate #2: 16 x 625/417 = $23,980,815/yr

Alternate #3: 16 x 372/417 = $14,273,268/yr

Alternate #4: 16 x 503/417 = $19,299,607/yr

Alternate #5: 16 x 580/417 = $22,254,020/yr

4.2. NEW JOBS/INCOME: Ref. Appendix "O", DPC Suppl, Section 5, p. 2; "The first two hydroelectric developments and the initial nuclear generating plant are expected to require a force of about 170 persons as a permanent operating and maintenance staff. ... it is expected that about $1,000,000 would be spent for local supplies and services each year. The estimated annual payroll for these initial developments would be about $1,500,000." This applies to the applicant's Proposal. The alternates would probably be larger because of a larger investment therefore larger maintenance expenditures per year. But these are not predicted here and therefore this number is not derived for the five alternates. They are assumed to be comparable.

Alternate #1: Slightly larger

Alternate #2: Comparable to Proposal

Alternate #3: Larger (Coal and ash handling personnel)

Alternate #4: Larger (Coal and ash handling personnel)

Alternate #5: Larger (Coal and ash handling personnel)

5. <u>Aesthetics</u>

5.1. APPEARANCE

5.1.1. Plant: No discussion of Aesthetics is made, but on page 3, DPC Supp., the Applicant states, "The project lands consist of largely abandoned farm land and wooded tracts which with few exceptions have been periodically cut-over. Duke Power firmly believes that the net overall environmental impact of the Keowee-Toxaway Project is beneficial." The site of the Oconee station is on such second-growth timber area; the impact of the plant itself should, therefore, be minimally disturbing. This should apply in each of the alternatives also.

5.1.2. Transmission Facilities: Ref. p. 53-54, DPC Supp.; "The transmission lines whose construction is necessitated by the additional electric power to be supplied from the Oconee Nuclear Station to Duke's existing grid or system are listed and described as follows: [table from DPC Supp.]

Oconee to -	Wide	Distance	Area
Tiger	150 ft	53 miles	9964 acres
Central	270 ft	9 miles	295 acres
McGuire	200 ft	130 miles	3152 acres
Newport	200 ft	110 miles	2667 acres
North Greenville	200 ft	28 miles	679 acres
TOTAL		330 miles	7757 acres

Ref., Statistical Abstract of the United States, 1970, 91st ed., USDA, Bureau of Census; p. 625 shows 2,862,000 acres in timber, North Carolina; 11,640,000 acres, South Carolina. The states' areas are 48,798 sq mi (NC) and 30,225 sq mi (SC). This yields a ratio of timber-to-total land area of 64.27% for the two states. Using this assumption, the transmission lines will pre-empt 0.6427 x 7757 acres = 4985 acres cleared, converted from timber to low growth with its accompanying impact on the environment and on society. The area to be cleared for transmission lines to alternate sites (Alternates #2, #5) is unknown but should be comparable.

6. Temporary Impacts of Plant Construction

6.1. HOUSING

6.1.1. Residents Relocated: Ref. p. 41, DPC Supp.; "Inundation caused ... 48 farm residents and 780 non-farm residents [to be] relocated." And on page 48; "56 non-farm and eight farm residents were relocated in connection with developing Oconee site." Total residents relocated were 892. This applies to the Applicant's Proposal, Alternates #1, #3, and #4. Alternates #2 and #5 are not calculated for this chart.

6.1.2. Dwelling Units/Value: The permanent impact of the removal and/or relocation of dwelling units is treated 2.3. RESIDENTIAL, above. Temporary quarters for construction personnel are mentioned on page 4 of DPC Supp., but are not detailed either in discussion or on Fig. 2, referred to in the same place. Since this is within the exclusion area it is assumed to have no impact on the area outside the exclusion area.

6.2. SCHOOLS: Ref. DPC Supp., Appendix "O", Section 4, p. 2; The chart contained in the second paragraph illustrates that the average construction force between 1971 and 1973 will total about 1600 men. Based on statistics from the Statistical Abstract of the United States, 1970, 91st ed., USDA, Bureau of Census, p. 38, the average increase in population is about 4300. Assuming that all the work force and their dependents reside in the three-county area (Oconee, Pickens and Transylvania) the population increase would be no more than 3.6%. Further assuming that this population has the same distribution of school-age children as the indigenous population, the average daily attendance of the three-county school systems would increase by no more than 3.6%. This change would be temporary, lasting only until about 1973; at that time there should be a small increase (less than 1%) due to the permanent work force at the project. This small increase applies to the Applicant's Proposal, Alternates #1, #3, #4; temporary increase in ADA for Alternates #2 and #5.

6.3. TRAFFIC: See 6.2., above. The 1600 employment through 1973 will cause some increase in traffic, localized around the Keowee-Toxaway Project. A local traffic increase applies to all alternatives.

6.4. COMMUNITY SERVICES: The increase of 1600 households should cause some increase in the workload of the police and fire protection forces and some increased use of water, power and sewage services. This population increase of 3.6% (see 6.2., above) represents a small but hardly important increase in community services required. (Note: Base for 3-county census; 1972 World Almanac, U. S. Population, by States and Counties, p. 205 and p. 207)

6.5. ECONOMICS - CONSTRUCTION WAGES: Ref. DPC Supp. Appendix "O", Section 4, p. 2; The total construction wages paid are estimated at $163,000,000. This is applicable to the Applicant's Proposal, Alternates #1, #3, and #4. Significant wages (larger than Applicant's Proposal) will be paid for Alternates #2 and #5.

REFERENCES FOR APPENDIX XI-1

1. J. Kenneth Salisbury (ed.), *Kent's Mechanical Engineers' Handbook*, Power volume, 12th ed., John Wiley and Sons, New York, 1965.

2. Babcock and Wilcox Co., *Steam*, 1960.

3. John Culler (ed.), *South Carolina Wildlife*, 14(1) (Winter 1967).

4. U.S. Bureau of the Census, *Statistical Abstract of the United States*, 1970.

5. Hampton Williams, *Fisheries Investigations in Lakes and Streams*, District II Annual Report for July 1, 1970, through June 30, 1971, South Carolina Wildlife Resources Department, 1971.

6. Luman H. Long (ed.), *1972 World Almanac*, paperback ed., pp. 205-207, Newspaper Enterprise Assoc., Inc., New York, 1972.

COMMENTS FROM FEDERAL AND

STATE AGENCIES CONCERNING

THE DRAFT DETAILED STATEMENT

ISSUED DECEMBER 13, 1971

SUMMARY OF AGENCY COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT

The Draft Environmental Statement on the Environmental Considerations by the Atomic Energy Commission, Division of Radiological and Environmental Protection, Related to the Proposed Issuance of an Operating License for the Oconee Nuclear Station was issued on December 13, 1971.

This Draft Statement was sent to a number of Federal, State and local agencies for comment. In the following tabulations, the comments received are abstracted and the action taken by the staff is briefly described.

The discussion of thermal effects of plant operation was rewritten and significantly expanded.

Similarly, opinion was expressed that the data presented on the ecology of the environs, and, in particular, the inventory of biota that might be affected, was not adequate. The corresponding sections of the Draft Statement have been supplemented in the Final Statement.

Other comments referred to dissolved oxygen effects, reduction of radioactive waste impact, and the bases of the cost-benefit analysis. These have been responded to by making substantial revisions in the text. Responding to the comments has resulted in a Revised Statement, over which the staff believes is sufficiently detailed in treatment and broad in scope that the environmental impact of the proposed operation of the Oconee Nuclear Station can be evaluated and that the conclusions reached can be supported.

Federal Agency comments appended and comments addressed include The Environmental Protection Agency; The Department of the Interior; The Department of Commerce; The Federal Power Commission; The Department of Agriculture; The Department of Transportation; The Department of Housing and Urban Development; The Department of Health, Education, and Welfare; The Department of the Army, Corps of Engineers; The Council on Historic Preservation. State Agencies include the Governor of the State of South Carolina; Executive Director of the South Carolina Water Resources Commission; South Carolina Wildlife Resources Department; The Department of Parks, Recreation and Tourism; South Carolina State Commission of Forestry; and Local Agencies, The South Carolina Appalachian Council of Governments.

DEPARTMENT OF THE INTERIOR COMMENTS

[Letter from W. W. Lyons, Deputy Assistant Secretary of the Interior, to L. Manning Muntzing, Director of Regulation, Atomic Energy Commission, dated February 18, 1972] 4

Identification	Comment*	Action taken
Int-1	Need to consider implications of planned 2 additional steam-electric plants that will use the same cooling medium.	Impossible to consider in Final Statement as plans for future plants have not been established. See statement in "Foreword."
Int-2	Since Keowee hydro plant will have 5% plant factor, discharge will be 30 cfs most of the time. This case should be included. [Draft statement, p.13]	Section II and related text have been revised to include 30 cfs case.
Int-3	Analysis of Keowee River water has limited value; need date, location, discharge rate, and whether sample taken under normal conditions. [Draft, p.21]	Further identification of sample is given and additional data included in Section II.E.1.
Int-4	Southern bald eagle is only endangered species which may inhabit the area. [Draft, p.28]	Information included in revised Section II.F.
Int-5	Some species of birds and fish missing. Bureau of Sport Fisheries and Wildlife will furnish faunal list. [Draft, pp.28, 135-141]	Section II.F has been expanded and rewritten. A complete biota list is given in Appendix II-2.
Int-6	Discuss amount and types of hunting and fishing that occurred prior to project and after project operating. [Draft, p.60]	Discussed in revised Sections II.F and V.C.
Int-7	Add column to Table III-6 [Draft, p.60] showing concentrations of chemicals in tailrace during minimum discharge of 30 cfs.	This is included in Table III-14.
Int-8	Studies should be made as soon as possible to assess effects of chemicals, radioactive discharges, heat on aquatic biota in Hartwell and on trout fishery below Hartwell. [Draft, pp.68-79]	Section V.C. has been expanded and rewritten and includes information on these topics.

* In order of appearance in the letter.

Identification	Comment	Action taken
Int-26	Valuation of recreation-day use is inconsistent with that used in FPC license proceeding; visitation figures do not agree. [Draft, p. 113]	See revised Table XI-1 and Appendix XI-1
Int-27	Value of fishery resources is based on costs not recognized by the Federal establishment. [Draft, p. 117, Table X-1]	See revised Table XI-1 and Appendix XI-1
Int-28	Are all costs and benefits included in Table X-1? Do power benefits represent total retail value of power or are operating costs deducted? [Draft, Table X-1]	See revised Table XI-1 and Appendix XI-1

COMMENTS FROM FEDERAL AGENCIES

[Letter from Robert W. Fri, Deputy Administrator, Environmental Protection Agency to L. Manning Muntzing, Director of Regulation, Atomic Energy Commission, dated January 20, 1972]

Identification	Comment	Action taken
EPA-1	Environmental effect of transportation and postulated accidents can be handled on generic basis. EPA would be pleased to cooperate with AEC in this area. [Draft Section VI p.85 to 96]	Plans underway to develop generic treatment with EPA and other agencies.
EPA-2	Gaseous waste will be held for minimum of 20 days. System can retain for 59 days. [Draft p.52, 53, 57]	Restatement of radwaste covers 30-day hold-up which is possible with present system.

Identification	Comment	Action taken
EPA-3	A complete analysis of radiological effects should include estimates of effluents secondary sources (e.g., steam generator leaks and off-site distribution). [Draft pp.52-58, 80-82]	Rewritten radwaste to include such estimates in Section III.D.2a, b, c.
EPA-4	Assuming alarms in effluent streams are used as basis for radwaste release estimates should be presented of actual release before alarms are actuated.	Rewritten radwaste Section III.D.2 emphasizes that alarms are not used for control of releases of liquid and gaseous radwaste. Releases are made after appropriate monitoring.
EPA-5	As much of liquid radioactive as possible should be processed in the evaporator. Demineralizer noted as optional should be used whenever chemical and physical characteristics of evaporator condensate permit treatment. [Draft p.52]	Word optional was incorrect and is deleted in final Figure III-13 of Section III.D.2.
EPA-6	Potential large volume of liquid waste from pump seal should be considered with provisions for collecting, monitoring and treating [Draft p.52]	The radwaste system has been rewritten and includes further identification of sources and treatment, Section III.D.3.
EPA-7	Liquid radwaste sent through buried pipes and released to tailrace of Keowee Dam. Impact of leaks should be addressed. [Draft p.44-56]	Failure of pipe would be a Class 2 accident (Table VI-1). Could not release more activity outside the plant than normal tailrace releases.
EPA-8	Three borated water storage tanks adjacent to reactor buildings should be evaluated for direct radiation and dose contribution. [Draft p.56, Fig.	This is addressed in Section III.D.2a. The 1-mile exclusion area around the plant addresses this problem.

Identification	Comment	Action taken
EPA-9	Duke's supplement, Tables 5 and 6, do not agree with the statement. [Draft p.53, Table III-4]	See Revised Tables III-12, and III-13.
EPA-10	The statement does not contain necessary information to review population exposure estimated. [Draft p.83, Table V-3]	Information presented in Tables V-5 and V-6 in the rewritten section on Radiological Impact, Section V.D.2a & b.
EPA-11	A summary table similar to Table V-3 in the Statement should list individual population exposure and cumulative dose. [Draft, p.83]	This covered in the Final Statement in Figure V-1 and in Section V.D.2.
EPA-12	Table VI-2 seems to imply doses from Class 1.2 and 5.1 accidents will be included under normal releases. Dose should be added.	Dose from any of these accidents, if it occurs, will be of the same order as the dose from routine releases. However, occurrence will be much less frequent.
EPA-13	Major liquid waste pathway to general population is from tailrace of Keowee Dam to municipal water systems on Keowee River. [Draft, p.84, Table V-4]	Presented under Section V.D.2, dispersion of liquid effluents and V.D.3 estimates of radiation dose.
EPA-14	Thermal modeling [Draft p.44 temperature effects]	New Section on thermal effect is presented in Section IIIc and in Appendix III-1.
EPA-15	Thermal and biological effects which will result from the intake and discharge of the Socasse Station not adequately considered.	Thermal effects to biota are considered in Section V.C.R.c and mechanical effects in V.C.2.d.
EPA-16	The area from Oconee's discharge to Keowee Hydro intake in draft is 800 acres and EPA believes is closer to 200 acres. [Draft, p.12]	Treated in greater detail in the thermal effects and thermal Model in Section III.D.1c.

Identification	Comment	Action taken
EPA-17	Temperatures for all calendar months. [Draft p.44]	Presented in Section III.D.1.c with the thermal model description and in Appendix III-1.
EPA-18	Need to know what specific aquatic organisms will be affected. [Draft p.68]	Presented in Section V.C.1.c thermal effects and in Tables V-1, V-2 and V-3.
EPA-19	Potential effects of reproduction and survival fish in Lake Hartwell below the hydroplant. [Draft pp.71 & 74]	Presented in Section V.C.1.c.
EPA-20	Listing of fishery species to be protected in Lake Keowee. [Draft p.140]	Rewritten Section III F and appendix II-2.
EPA-21	Final should outline a commitment to make an inventory of fish species and littoral, benthic and planktonic organisms in Lake Hartwell.	A newly written Section V.C.3 and Appendix II-2.
EPA-22	Gas bubble disease as a potential effect on fish of Lake Keowee. [Not in Draft]	Will be part of monitoring program, Section V.C.3.
EPA-23	Changes related to thermal discharges; dissolved oxygen (D.O.) is potential critical problem during summer and fall. [Draft p.48, 77-78]	Sections III.D.1d under oxygen effect and in Figure III-10 and III-11. Biological Effects Section V.C.1.b.
EPA-24	A brief discussion of leakage or spillage of oil or other hazardous materials and prevention of their reaching water courses should be presented. [Draft p.79]	See Section III.D.3a thru d.

Identification	Comment	Action taken
EPA-25	No estimate of organic pollution load from the pond is given. This water can be chemically treated but Statement doesn't indicate when this will be initiated. [Draft III.D]	Section III.D.3d address this problem.
EPA-26	To determine mortality of aquatic forms that may enter intake. Requires knowledge of distribution fragility and lethal temperatures for each species. [Draft V.C.3]	See Sections V.C.2.b, c, r, d and Appendix II-2.
EPA-27	Information should be provided on proposed disposal procedures for fish removed from the intake screens. [Draft p.39]	The applicant advises that fish trapped on the screens will be buried.
EPA-28	Additional information is required to adequately evaluate the impact of the "small boiler" fired with fuel oil. [Draft p.68]	Boiler is not used when steam from units is available. Use will be most infrequent.
EPA-29	Further consideration should be given to disposal of non-radioactive solid waste generated by this project during construction and operation to ensure that acceptable disposal methods are used. [Draft p.79]	See Section VI.A, B. & C.
EPA-30	A comprehensive monitoring and surveillance program should be developed. [Draft p.68 and Table V-4]	Radiological monitoring is included in Section V.D.5 Thermal monitoring is identified in Section III.D.1.c and biological monitoring is presented in Section V.C.3.

Identification	Comments	Action Taken
EPA-31	A long-term program of biological evaluation should be instituted by Duke Power Company. [Draft p.68-79]	See Section V.C.3.
EPA-32	Comments on cost-benefit analysis. [Draft Section X p. 112 and fold-out table]	See revised Section XI and Appendix XI-1.

[Letter with separate agency comments included, from Sidney R. Galler, Deputy Assistant Secretary for Environmental Affairs, Department of Commerce, to Lester Rogers, Director, Division of Radiological and Environmental Protection, Atomic Energy Commission dated January 14, 1972]

Identification	Comment	Action taken
COM-1	(From Edwin B. Shykind, Bureau of Domestic Commerce) Question with regard to the commodity value (benefit) of energy available from peak power generation, item 32 of Table X-4 and some approximations for federal, state and local tax benefits. [Draft, Table X-4]	Table XI-1.
COM-2	There are at least two areas which may deserve future consideration. Gaseous radioactive waste treatment and release. [Draft p.52]	Rewritten radwaste system in Section III.D.2.
COM-3	Uncertainties associated with thermal effects on biota. (From Robert T. Miki, Deputy Assistant Secretary for Environmental Affairs.)	Rewritten thermal effects section is in Section IIIc, further information in Appendix III-1.

Identi-fication	Comment	Action taken
COM-4	It is inappropriate in Table X-4, column 4 to include "$30,000 to the University of Southern California for Archeological Study" as a benefit. [Draft Table X-4]	Table X-4 has been replaced by Table XI-1 revised.
COM-5	(From Wm. Aron, National Oceanic and Atmospheric Association.) Computation of annual relative concentration of radionuclides at site boundry is a factor 2 higher than that of the applicant. [Draft p.52]	Rewritten radiological impact section in Section V.D.2.
COM-6	Use of annual diffusion rate for computing site boundry doses is inappropriate because waste gas decay tanks and other storage tanks not continuously pruged. [Draft p.5]	Rewritten radiological impact in Section V.D.2.
COM-7	Recommend benthic specimens included in radiological monitoring program. [Draft p.80]	Radiological monitoring is described in V.D.5.
COM-8	From G. P. Cressman, Director of the National Weather Service to W. Aron, NOAA. A more thorough evaluation should be made on the cooling effect along the entire river as more nuclear plants are established.	See the foreword.
COM-9	From Environmental Research Laboratories in a memorandum dated December 23, 1971. This confirms the comments by Aron in COM-2. Radiological impact differs according to their computations by a factor of 2.	Rewritten radiological impact section in Section V.D.2.

Identification	Comment	Action taken
COM-10	From Robert F. Hutton, National Marine Fisheries Service to Wm. Aron.	No adverse comment.

COMMENTS FROM FEDERAL AGENCIES

[Letter from T. A. Phillips, Chief, Bureau of Power. Federal Power Commission to Lester Rogers, Director, Division of Radiological and Environmental Protection, dated January 18, 1972. A following letter commenting on this letter is also appended]

Comment	Action Taken
Comments are in support of need for the Oconee Station.	Addressed in Section I.A., Need for Power.

[Letter from H. L. Strohecker, Department of the Army, Savannah District, Corps of Engineers to Lester Rogers, Director, Division of Radiological and Environmental Protection, Atomic Energy Commission dated January 14, 1972]

Identification	Comment	Action Taken
DA-1	Asks if 3°F increase in Keowee Dam tailrace is seasonal or year-round change.	Rewritten Section III-D.1.c and Appendix III-1 address this question.
DA-2	Asks about future plants.	See the Foreword.
DA-3	Concern over Forestry and Biota in the Keowee-Toxaway Project.	Addressed in Sections II.F, V.C.1 & 2 and in Appendices II-2, II-3, and II-4.

[Letter from W. M. Brickert, Rear Admiral, U. S. Coast Guard, Chief, Office of Marine Environment and Systems, to Lester Rogers, Director, Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission dated January 14, 1972]

- No further comments -

COMMENTS FROM FEDERAL AGENCIES

[Letter from T. C. Byerly, Assistant Director, Science and Education, Department of Agriculture to Lester Rogers, Director, Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission dated January 19, 1972 and letter dated February 18, 1972]

Identification	Comment	Action Taken
Ag-1	Concern by Forest Service over timber, fishing and hunting, in reference to costs. [Draft Table X-4]	Table X-4 is replaced by completely revised Table XI-1 in the Final. See also Appendix II-3, Commercial Forestry Productivity of Oconee and Pickens Counties and nearby counties.
Ag-2	Has commented on erosion control.	Attention to erosion is covered in Section V.C.1. Hunting, fishing and timber production are covered in Section V.C.1.

[Letter from Leo J. Zuber, Assistant Regional Administrator, Community Planning and Management, Department of Housing and Urban Development, to Lester Rogers, Director, Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission dated January 14, 1972]

Identification	Comment	Action Taken
HUD-1	Calls attention to need for design criteria associated with development of the area surrounding the project.	Letters from Pickens and Oconee Counties indicate their willingness to assume this responsibility.

COMMENTS FROM FEDERAL AGENCIES

[Letter from Robert R. Garvey, Jr., Executive Secretary, Advisory Council on Historic Preservation to Lester Rogers, Director, Division of Radiological and Environmental Protection, Atomic Energy Commission, dated January 25, 1972]

Identi-fication	Comment	Action Taken
CHP-1	Final Statement should contain sentence indicating National Register of Historic Places should be consulted. Final Statement should contain evidence of contact with Historic Preservation Officer of the State. [Draft p. 20]	See Section II D.

[Letter from John C. West, Governor, State of South Carolina, to Lester Rogers, Director, Division of Radiological and Environmental Protection, Atomic Energy Commission, dated February 11, 1972]

Identi-fication	Comments	Action Taken
	Asks that Final Statement be comprehensive enough to allow complete evaluation of environmental effects and, therefore, establishment of the necessary monitoring procedures.	The Statement addresses these points.

[Letter from Carnell W. Bennett, Clearhouse Coordinator, South Carolina Appalachian Council of Governments, to R. C. DeYoung, Assistant Director, Pressurized Water Reactors, Division of Reactor Licensing, Atomic Energy Commission dated January 12, 1972 with attached comments from Pickens County Planning and Development Commission; Greenville County Planning Commission; Oconee County Planning Commission]

- No Comment -

COMMENTS FROM STATE AGENCIES

[Letter from Clair P. Guess, Jr., Executive Director, State of South Carolina Water Resources Commission to Lester Rogers, Director, Division of Radiological and Environmental Protection, Atomic Energy Commission, dated January 11, 1972 together with separate comments from other Agencies of this Department]

- No objection to this project -

[Letter from John R. Tiller, State Forester, South Carolina State Commission of Forestry to Mr. C. P. Guess]

- No objection to this project -

[Letter from Maxwell M. Way, Jr., Economist, Department of Parks, Recreation and Tourism to Glenn W. Dures, Civil Engineer, South Carolina Water Resources Commission]

- No comment -

[Letter to C. P. Guess, Executive Director, South Carolina Water Resources Commission from H. J. Webb, Executive Director, South Carolina Control Authority]

Comment

"This agency is in the process of issuing a water quality certificate to the Corps of Engineers as required by the Refuse Act."

COMMENTS FROM FEDERAL AGENCIES

[Letter to Clair P. Guess, Jr., Executive Director, South Carolina Water Resources Commission from James W. Webb, Executive Director, South Carolina Wildlife Resources Department]

Comment	Action Taken
Water level fluctuations are restricted over an unspecified time to a three foot maximum for Lake Keowee and six foot maximum for Lake Jocassee. This will have an effect on fish spawning grounds. The problem of thermal intrusions expected to occur in Hartwell which may affect the heat budget on Lake Keowee.	The thermal model studies presented in Section II.D.c address this question.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

FEB 1 8 1972

Dear Mr. Muntzing:

This is in response to Mr. Rogers' letter of December 13, 1971, requesting our comments on the Atomic Energy Commission's draft detailed statement on the environmental considerations for Oconee Nuclear Station, South Carolina.

The report is the result of substantial coordination by the applicant, AEC, and several other State and Federal agencies. It shows the results of good planning based on analyses of much research and investigations by the applicant alone and by the applicant in cooperation with other organizations. However, in order to be most effective, our comments will generally relate to those areas of the report which we feel are deficient or can be improved.

General

In order for reviewers and decision makers to have a more complete understanding of the cumulative and secondary effects of this proposal, we believe that the applicant's plan to construct two additional steam-electric plants as a part of this project should also be discussed in this environmental statement. We are aware that these plants may have cooling towers or some other type of cooling system; however, since it was the applicant's intention at the time he applied for a license from the Federal Power Commission to use the lakes for these additional plants, we believe your statement should reflect these intentions and their environmental implications.

The minimum flow of 30 cfs should be included in the third paragraph of page 13 since this will usually be the minimum discharge when the Keowee hydroelectric plant is not operating. Since Keowee is expected to operate on a 5% plant factor, this minimum discharge will be the actual discharge most of the time.

The analysis of a sample of Keowee River water, given on page 21, has limited value unless a better description of the conditions is given. The date and location of the sample with respect to the river and discharge rate are needed. Some indication as to the normality of these parameters should be included.

Existing Ecology

The statement that no endangered species inhabit the project area may not be correct. The area may be visited by the southern bald eagle since it is well within the known range of these birds. It is suggested that the following sentence be substituted: "The southern bald eagle is the only endangered species which may inhabit the area."

Several species of birds and fishes are omitted from the faunal lists. As we discussed, the Bureau of Sport Fisheries and Wildlife has agreed to furnish the data necessary to complete the inventory upon your request.

Section II should discuss the amount and type of hunting and fishing which occurred in the area prior to the project and that expected when the project is operating.

Chemical Discharges

Table III-6 lists the types, amounts, and concentrations of chemical wastes from Oconee Nuclear Station. Another column should be added to this table with the concentrations of these chemicals released to the Keowee tailwater during minimum release of 30 cfs. This is particularly important since the discharge from the Keowee hydro plant will be 30 cfs most of the time.

The AEC environmental statement did not show a detailed evaluation of possible environmental effects of chemicals on aquatic biota in Hartwell Reservoir. Since chemical and radioactive discharges as well as some of the waste heat from the Oconee Nuclear Station will be discharged into Hartwell Reservoir, further study is desirable to more adequately assess the environmental impact on this downstream development. The report mentioned that biological data on the Hartwell Reservoir have been requested from Georgia Fish and Game Commission, South Carolina Wildlife Resources Department, and the Army Corps of Engineers. The final environmental statement should also include a discussion of the possible effects on the trout fishery below the Hartwell Dam.

Since Hartwell is several years old, time was available for the applicant to perform inventory and population studies. Consequently, it is recommended that AEC require the applicant to make the necessary studies to allow it to assess the effects on the aquatic life in this portion of Hartwell Reservoir as rapidly as possible.

Thermal Effects

The waste heat load when all three units are operating is expected to give Keowee Lake a homogenous thermal condition in August which is several months prior to the normal fall turnover for lakes in this region. The probable effects of this early homogenous condition on the aquatic life should be analyzed. The taking of the cooling water from the hypolimnion and discharging the effluent into the epilimnion along with the pumped storage condition will cause a more homogenous condition year round by the mixing action.

When the Keowee hydroelectric plant and the Oconee nuclear-fueled steam-electric plant are both generating under normal operating conditions the temperature of the tailrace water will be raised about 3°F according to the environmental statement; however, the temperature of the tailrace water will probably be raised more than 3°F when the Oconee Nuclear Station is operating at full load and the Keowee hydro plant is operating at less than full load. The steps the licensee would take to keep within the State standards should be listed along with an analysis of this greatly fluctuating discharge and temperature changes on the aquatic life in the upper end of Hartwell Reserovir and in Lake Keowee.

The Keowee River from the Keowee hydro plant to Hartwell Reservoir and the upper reaches of Hartwell Reservoir are expected to receive periodic surges, approximately 11 feet above normal, of warmed water for about 5 percent of the time. A specialized community of organisms is expected to develop in this area according to AEC's environmental statement. The expected types of organisms which would develop in this area should be evaluated. Pages 71 through 78 cite results of many studies on aquatic life under varying conditions. This general background data appears sufficient to allow the applicant to make an evaluation of the probable effects the discharges will have on the aquatic biota in the upper reaches of the Hartwell Reservoir. However, caution should be exercised in the use of laboratory data, such as given in Table V-1, as a basis for determining temperature effects on certain species of aquatic life. Factors such as acclimation to a particular temperature, rate of temperature changes, and the ability of the aquatic life to avoid undesirable environments are sometimes not included in laboratory data.

The applicant has used data from Lake Norman and the Marshall steam-electric plant as a base to project many of the impacts it anticipates in Lake Keowee as a result of the operations of the Oconee nuclear plant. We do not question this since it may well be the best basis from which to make such an assessment; however, we do think it important for the reviewer to be aware of the differences in the two systems. These differences seem to amplify the need for sufficient monitoring to record the actual effects of the first unit on the lake and its environment as a basis for projecting the effects of the other two units. A comparison of the two systems is given below.

	Lake Norman Marshall Plant	Lake Keowee Oconee Plant
Total waste heat, Equivalent MW	2,640	4,950
Mean fresh water discharge into lake, cfs	2,670	1,140 (675 in Little River)
Cooling water discharge, cfs	1,200 (max. 2,300)	4,733
Lake surface area, sq. mi.	50.7	29
Potential recirculation distance, mi.	4	2
Temperature rise in plant, °F	28	17.6

Dissolved oxygen

Although the use of the water for cooling purposes will not likely result in the release of a significant amount of oxygen from the water, the effects of discharging this water with a dissolved oxygen content below that in the receiving water of the epilimnion could be significant. A great deal of this oxygen-deficient water will also be discharged into the Hartwell Reservoir.

Mechanical Damge to Aquatic Organisms

Mechanical damge to aquatic organisms will undoubtedly occur at the Oconee Station but more mechanical damage to aquatic life will likely occur at the hydroelectric plants as a result of the large amount of water involved and high intake and discharge velocities. It is probable that even more fish and aquatic life will be drawn into the turbines of the Keowee hydroelectric plant as a result of being attracted to the warmed water near the Oconee steam-electric plant. Some assessment of the probable effects the operation of Oconee will have on intensifying these damages by the hydroelectric plants seems in order.

Monitoring

It is not possible to determine accurately the depth and configuration of the epilimnetic and hypolimnetic layers without actual data; consequently, an adequate monitoring system must be established as soon as possible and operational before the first unit goes into operation to obtain this information. This data would also serve as a basis for estimating the effects of the operation of Units 2 and 3 of this plant and future steam-electric plants using the lakes as the medium of waste heat dissipation.

The predicted concentrations of chemicals in water released to Hartwell Reservoir are given in Table III-6. We agree with AEC's statement that the concentrations of these chemicals should be determined from studies at operating conditions. In fact, AEC should require that chemical, thermal, and biological monitoring similar to the radioactive monitoring program given in Table V-4 be performed to the extent necessary to adequately assess the impacts resulting from the operation of the Oconee plant. The locations of stations, frequency and type of data required should be given. We are aware of the water quality monitoring stations shown in Figures 15 and 16 of the applicant's report, but a description of the type and frequency of this monitoring is omitted.

Radiological impact on fish and wildlife is not discussed in Section V. The statement should include such a discussion. Since benthic animals tend to accumulate some compounds, they should be sampled in the monitoring survey to insure that safe levels are not exceeded.

Outdoor Recreation and Fish and Wildlife Habitat

A more complete description of the planned 155-acre recreation complex and a map showing the location of the proposed access points, recreation areas, and residential developments would be useful to the reviewer.

Section IV, Environmental Impact of Site Preparation and Plant Construction, should contain a description of the loss of wildlife and stream fish habitat on the fish and wildlife resources and the environment.

The impact of the managed project areas such as the wildlife management lands and the timber management lands on wildlife resources should be evaluated.

that appropriate numerical descriptive terms are no less quantifying than dollars and are often more meaningful when dealing with the environment.

Since the applicant may decide at a later date to seek permission to construct additional plants which would use the lakes as a cooling medium, the environmental effects of the potential future plants should also be evaluated as part of the ultimate development.

Many of the dollar benefits are incorrectly derived. On-site fishing, hunting, and other recreational benefits are usually developed and computed for Federal projects in accordance with Supplement No. 1 to Senate Document 97 ("Policies, Standard, snd Procedures in the Formulation, Evaluation, and Review of Plants for Use and Development of Water and Related Land Resources"). Although badly out of date, this sets out a schedule of administrative unit-day values which are multiplied by projected man-days of recreation expected to be generated as a result of project construction and operation over the life of the project. Gross expenditures of recreationists have been abandoned as a valid measure of the net value of recreational activities for evaluating Federal water projects. They have not been used in the past decade on the basis that they are properly classified as associated costs of securing such benefits.

The applicant's estimation of 4,100,000 recreation day usage of the Oconee project area has been utilized in the derivation of recreation benefits. The Recreation Development Plan, Exhibit R, included as part of the Federal Power Commission license for this project, contains an estimate of initial and ultimate use. The Keowee Reservoir annual user days is estimated at 93,560 initially, increasing to 292,000 by the year 2000, and to 425,000 by the year 2025. Recreation land areas and facility development proposed by the license is based on this projected level of use.

We find that there is a wide discrepancy between the visitation figures used as part of the FPC license proceedings and those now contained in this document. There appears to be a lack of clear understanding of the definitions used in this analysis and no meaningful determinations can be made as to the acceptability of the recreation values used. We believe these differences should be resolved.

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The value of the fishery resources is incorrectly estimated. This value is based on a report, "Monetary Values of Fish" by the Southern Division of the American Fisheries Society. Essentially, this report uses fish replacement costs from hatcheries as value. Its stated purpose is to establish a basis for asking monetary compensation for episodic events of fish kills resulting from pollution or contamination of waters. It has never been used in the Federal establishment for the purpose of evaluating the long-term impact of water resource development projects. We suggest that the fishing resources be evaluated in terms other than dollars.

We believe that the investment cost of $639,000,000 would be more appropriate in the cost column. If the intention of AEC is to indicate benefits due to the investment, it appears that some of these values could be used. However, many, if not all, of these benefits are already itemized.

It is difficult to determine if all costs and benefits are included in Table X-4, "Benefit-Cost Comparison for Oconee Nuclear Power Station Alternatives," or if the costs or benefits are given as net values. For instance, do the power benefits of $102,000,000 and $26,000,000 represent the total retail value of power, or is it the total retail value, less the operating costs?

We hope these comments will be useful to you in the preparation of the revised environmental statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. L. Manning Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF THE ADMINISTRATOR

JAN 20 1972

Mr. Manning Muntzing
Director of Regulation
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muntzing:

We have reviewed the draft environmental statement for the Oconee Nuclear Station, Unit 1, and are pleased to provide you with the enclosed comments. Our review was prepared in accordance with the requirements placed on Federal agencies by the National Environmental Policy Act of 1969.

We found that additional information is needed to evaluate fully the environmental impact of this station. We are particularly interested in more comprehensive data on thermal modeling and biological effects. A review of the final statement containing information requested in our comments will permit us to complete our evaluation of Oconee Station.

It is requested that the Atomic Energy Commission consider the attached comments as general guidance suggesting the breadth and depth of coverage needed in future draft impact statements.

We will be pleased to discuss any of our comments with you and to assist in preparing a conceptual framework to aid in developing the requested information in a timely manner.

Sincerely yours,

Robert W. Fri
Deputy Administrator

Enclosure

ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

January 1972

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

EPA D-AEC-06018-19

Oconee Nuclear Station, Unit 1

TABLE OF CONTENTS

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Oconee Nuclear Station, Unit 1, prepared by the U.S. Atomic Energy Commission and issued on December 13, 1971. Following are our major conclusions:

1. Additional information in three areas is needed to more fully assess the thermal environmental impact; detailed mathematical modeling of expected thermal regimes, definition of present and projected biota, and detailed plans for monitoring physical and biological parameters.

2. The applicant should use good management with respect to reducing radioactive discharges to the lowest level practicable whenever possible.

3. The dose levels arising from all sources of radiation exposure not considered in the statement should be estimated. These estimates should be combined with similar information for the sources considered in the statement and summarized for both the individual and cumulative populations.

4. Two issues are identified which should be resolved on a generic basis: transportation and accidents. Further elucidation of these issues in an adequate manner will limit the requirement to deal with these issues in subsequent impact statements.

5. Detailed monitoring and surveillance systems, particularly those for municipal water systems, will be a condition to EPA's concurrence on the Section 13 Permit.

RADIOLOGICAL ASPECTS

The Atomic Energy Commission has proposed numerical guidelines for light water cooled power reactor plants designed to keep radioactivity in effluents as low as practicable. EPA accepts this concept as a reasonable approach in minimizing the environmental effects associated with the operation of nuclear power plants.

The review of the Oconee impact statement surfaced two general issues: transportation and accidents. The operation of the plant should not be delayed while these issues are being addressed.

With respect to transportation the statement contains an analysis which leads to the conclusion that there will be no undue hazard to the public or adverse environmental effect from transportation accidents. Further details on the methods of analysis would be helpful. We recognize that since evaluation of potential environmental effects of transporting fuel and radioactive wastes is a requirement common to all nuclear power stations it is probably best handled on a generic basis. We would be pleased to cooperate with the AEC in this area.

The analyses of the environmental impact of postulated accidents presented in the statement is predicated on the standard accident assumptions and guidance issued by the AEC as a proposed amendment to Appendix D of 10 CFR Part 50 on December 1, 1971. This guidance is applicable to all nuclear power plants and should be handled on a generic basis. EPA comments on the proposed amendment were transmitted to the Commission by letter dated January 13, 1972.

The statement indicates that the gaseous waste will be held up for a minimum of twenty days. The gaseous waste treatment system, however, has the capability to retain radioactive gaseous waste for up to fifty-nine days. The applicant should use good management practices with respect to reducing radioactive discharges to the lowest level practicable whenever possible.

Based on a field study conducted by EPA at the Yankee Nuclear Power Station, and preliminary data from a similar study at the Connecticut Yankee plant, the gaseous waste treatment system may not constitute the major source of gaseous effluent from a pressurized water reactor (PWR). Other sources, including vents from the auxiliary building, reactor building containment air, and the main condenser air ejectors (which remove from the secondary system any radioactive gases which have leaked through the steam generators), will probably be the major contributors. A complete analysis of the radiological effects should include an estimate of the effluents from these secondary sources and their off-site dose contribution. Such an analysis may indicate that effluents from these other sources may need additional treatment. For example, it may be advisable to route the auxiliary building ventilation system exhaust and the gases from the condenser air ejector through a filter system similar to that used in the reactor building containment purge system.

The statement makes frequent mention of the monitoring of effluent streams by the use of alarms. In the event of excess radioactivity, these alarms notify operators who then shut off the appropriate discharge pathways. Estimates of the amount of activity that will escape before the alarms are activated, as well as the amount escaping before shutoff occurs, should be presented.

The description of the proposed liquid waste system indicates that it may be bypassed and the waste discharged directly to the environment after monitoring. Such direct discharge should be kept to a minimum. As much of the liquid radioactive wastes as possible should be processed by the evaporator. The demineralizer, which is noted as being optional, should be used whenever the chemical and physical characteristics of the evaporator condensate permit treatment.

At the previously mentioned field study at the Yankee Nuclear Power Station, it was noted that about 12% of the secondary system volume was lost through leakage each day, primarily at major pump seals. The only apparent provisions made for handling this leakage at the Oconee plant will be the routing of the auxiliary building floor drains to the low activity waste tanks. This potentially large volume of liquid waste should be explicitly considered and provisions made for collecting, monitoring, and treating.

The liquid radioactive waste will be sent through a buried pipe and discharged into the tailrace of the Keowee Dam. The waste may contain radioactive materials which are significantly above the concentration limits contained in 10CFR Part 20. It is conceivable that the liquid waste could leak from this pipe or escape as a result of a gross pipe failue. The environmental impact of such events should be addressed. In particular, it should be determined where the leakage from this pipe will flow in the event of a break anywhere along the length of the pipe (Oconee intake canal, Oconee discharge area, Lake Keowee, Keowee tailrace, or other ground water sources). The methods used to detect possible leakage should be described.

It was learned from the Yankee study that liquid storage tanks, located outside the buildings, may contribute the largest source of radiation exposure to persons in the plant vicinity. The three large borated water storage tanks located adjacent to the Oconee reactor buildings should be evaluated for possible direct radiation, and the dose contribution included in the estimate of annual average doses.

The statement provides a summary of anticipated radionuclides to be released from the Oconee station. A number of radionuclides found to be discharged from the Yankee plant are not included in this summary. Anticipated releases of ^{3}H, ^{14}C, and ^{41}Ar in gaseous form and ^{14}C, ^{51}Cr, and ^{55}Fe in liquid form should be evaluated.

The Duke supplement, in Tables 5 and 6, presents anticipated radionuclide releases which do not agree with those in the statement. The supplement addressed the specific case of the Oconee waste treatment systems while the statement refers to experience with other PWRs. The specific information in the supplement is of considerably more value than the information on similar plants in the statement. An adequate evaluation of the environmental impact of any reactor plant requires specific effluent data.

Dose Assessment

The statement does not contain the necessary information required to review the given population exposure estimates. The bases for these estimates (e.g., the assumed radionuclide content of the water) should be included. The dose contribution from the secondary sources previously discussed must be estimated and added to the doses from the primary gaseous waste treatment system. Contradictory estimates of the population dose from liquid effluents are given in the statement--100 man-rem/year (Table X-4) versus 12 man-rem/year (page 81). A summary table, similar to Table V-3 in the statement, should be presented listing the individual population exposures from all pathways including air, water ingestion, direct radiation, and the various food chains, such as milk and fish, as well as the cumulative dose.

The statement, in Table VI-2, seems to imply that the doses from Class 1, 2, and 5.1 accidents will be included under normal releases. If this is to be done, these doses should be included in the summary table referred to above.

The major liquid waste pathway to the general population is from the Keowee tailrace to the municipal water systems located on the Keowee River (Clemson-Pendleton) and on the Hartwell Reservoir (Anderson). Best estimates of the expected radioactive discharges and the minimum dilution flow lead to the conclusion that a minimal dose will be delivered to members of the public who obtain their drinking water from these sources.

THERMAL MODELING

EPA has several concerns with the modeling studies to predict the pattern of thermal discharges which were presented in the draft environmental statement and the Duke Power Company supplement. These concerns are outlined below, and specific information is requested to allow a more complete evaluation of the expected thermal effect.

Discrepancies exist between the statement and the supplement regarding information on flow and temperature. Temperature rise is presented in the statement at 17.6°F; however, the supplement notes temperature rises of 17.2, 19.6, and 25.7°F (not including flow or heat load of auxiliary cooling systems) as a function of flow rate and season. The supplement quotes discharge flows of 3027, 3969, and 4530 cfs as a function of seasons (not including flow of auxiliary cooling systems), while the statement indicates a maximum flow of 4733 cfs which includes auxiliary cooling flows. Comparisons of heat load calculated from information presented in the supplement do not agree with the value of 16.9×10^9 btu/hr presented in the statement as a maximum rate. It is not evident whether this value includes auxiliary cooling, fuel pool cooling and other inplant sources of heat. These discrepancies should be clarified and maximum flow rates and heat loads provided.

The discussion of the thermal effects arising from the operation of the Oconee Station in the supplement is based on average values for stream flow and meteorology. The resulting calculations therefore provide only predictions of the monthly average, median-year conditions; these constitute an inadequate basis for assessing the effects of thermal discharges on aquatic biota and defining stress conditions.

The supplement bases its thermal analysis on the assumption that the Oconee plant will operate with an annual load factor of 90 percent We question the validity of this assumption. Peak power demands and system economics will probably dictate that the plant be operated at nearly full power during the summer months. Under these conditions, with a cooling water flow of 4733 cfs, the total useable volume of Lake Keowee might be pumped through the plant in about 3 months if the lake were full, or in 1 1/2 to 2 months with the lake at the maximum drawdown level.

Although Lakes Norman and Keowee are quite similar, projection of mixing zone acreages in the manner presented is subject to considerable error. The T*/To* versus A/Q projection method does not take meteorology, windspeed, and physical parameters of the lake into consideration in estimating normal as well as critical areas required. The curve used in the projection (made available to EPA, Region IV, but not presented in the supplement) shows considerable scatter, attributable to the above inadequacies, which subjects projections to significant possible error. Projections of "critical" mixing zone areas by this method is further limited since actual critical-year lake temperatures and elevation, inflow, meteorology, etc., are not duplicated in the January 1971 surveys. Projection of fall critical mixing zone areas from the ratio of winter normal to winter critical areas is questionable since nearly isothermal conditions exist during the winter (but not during the fall) which would allow a greater degree of mixing. While the analysis may predict an order-of-magnitude agreement, the thermally affected areas could be significantly larger than predicted on the basis of windspeed only.

Thermal and biological effects which will result from the intake and discharge of the Jocassee station are not adequately considered. Since the Jocassee intake/discharge, the Keowee Dam skimmer weir, and the Oconee discharge are all at nearly the same elevation, their interaction will tend to completely mix the upper 35 to 45 feet of Lake Keowee (in the Keowee arm of the lake, if not in the whole reservoir). This mixing will reduce surface transfer of heat to the atmosphere and increase the retention of heat in the lake. It should be noted that the volume of Lake Keowee between elevations 755 and 800 feet is about 616,000 acre-feet, which is approximately 65 percent of the volume.

Both the statement and the supplement refer to an April 1966 report by Velz and Associates. Additional reports published by Edinger and Geyer in June 1965 entitled "Heat Exchange in the Environment" and by Brady, Graves, and Geyer in November 1969, entitled "Surface Heat Exchange at Power Plant Cooling Lakes" appear to provide predictive capabilities which might be utilized to improve the Velz model. The Velz report does not provide sufficient information to define the mixing zone size and temperature during critical spawning periods.

Prediction of thermal discharges from Keowee Station to Lake Hartwell is based on the T*/To* versus A/Q analysis and is subject to the discrepancies and errors previously mentioned. In addition, projections under critical meteorology, streamflow, and drawdown were not presented to determine compliance with South Carolina Water Quality Standards. The area from Oconee's discharge to the Keowee Hydro intake is noted on Page 12 of the statement as 800 acres; however, our calculations indicate that this area is more nearly 200 acres.

In order to satisfy the above concerns and allow reviewers of this project to assess and comment on the thermal effects and associated biological impact of the proposed operation of Oconee station on Lakes Keowee and Hartwell, additional thermal modeling information is required. We understand that Duke Power Company has developed a computer model of the thermal discharge for their Marshall Steam Station on Lake Norman, which was verified by thermal imagery and field surveys, and that this model could be capable of predicting areas of expected isotherms in Lake Keowee. Duke Power Company has been requested, in connection with EPA's review of the Refuse Act discharge permit application, to provide the following information: (This information should be presented in the final environmental statement.)

A. Temperatures for all calendar months. (Oconee thermal discharge should correspond to the maximum annual demand curve expected during the life of the plant). These data should include the following specific information for both the average monthly and twenty-year recurrent monthly meteorology, streamflow, and drawdown conditions.

1. Average discharge temperature for each month.
2. Maximum daily average discharge temperature during each month.
3. Maximum instantaneous discharge temperature during each month.
4. Monthly average equilibrium and ambient surface temperature during each month.
5. Maximum daily average equilibrium and ambient surface temperatures during each month.

B. Acreages and percent of total surface acreage corresponding to items A-1 and A-2 above for both the average and twenty-year recurrent cases in 5° F increments (i.e., 85°F, 80°F, 75° F,etc.) to within 3°F of the ambient surface temperature. A minimum of three points is required for each condition. Maps delineating largest summer and winter mixing zone acreages for each condition should be included.

C. Vertical temperature profiles corresponding to a distance of about 3,000 feet from the discharge point (where the depth is at least 100 feet) and at the skimmer wall for item A-1 under both average and twenty-year recurrent cases.

D. Table of areas and volumes in 5-foot increments between elevations 800 and 755 for Lake Keowee.

E. Maximum discharge temperatures to Lake Hartwell from Keowee Station and expected ambient Hartwell temperatures, for conditions A-1 and A-2 under both average and twenty-year recurrent cases.

F. Mixing zone incremental acreages to within 3°F of ambient temperature associated with temperatures and discharge hydraulics for conditions in E above (see B above for information format). Maps of Lake Hartwell delineating largest summer and winter mixing zone acreages should be provided for each condition.

G. Assumptions used in developing information in sections A through F above (excluding D) should be provided.

The statement, on page 44, describes the direct discharge of heated condenser cooling water into Lake Hartwell, in the event of a reactor shutdown following a loss of electrical power. In order to adequately assess the impact of this action, specific information, such as flow rates, discharge temperatures, and affected areas, are necessary and should appear in the final statement.

BIOLOGICAL EFFECTS

The previous section described the analyses that will be necessary to improve our understanding of the temperature changes that will occur as a result of the plant's discharges. Water temperature is an important regulator of natural processes in the aquatic environment. In order to get an objective and representative picture of how a body of water will react to a thermal discharge, it is necessary to know not only what pattern of temperature changes will result but also what specific aquatic organisms will be affected.

The environmental statement lacks the biological information necessary to adequately analyze the plant's direct or indirect impact on aquatic organisms. A good deal of the needed information is in fact called for in the AEC's Guidelines, for instance: identification of primary aquatic and terrestrial species; analysis of changes in water quality and temperature;analysis of effects of discharges of nutrients and chemicals; diagrams indicating trophic levels, life cycles of biota, flows and movements of energy, pollutants and organisms.

Since the impoundments are quite new (Jocassee is still filling), little information is available on the characteristics of the aquatic biota. There were no data available on the phytoplankton, emergent or floating macrophytes, zooplankton, aquatic invertebrates, reptiles, amphibians, and other organisms. The statement further indicated that:

"A detailed evaluation of possible effects on the aquatic biota is not possible at this time since the information available related to preliminary fish surveys conducted in late August of 1969. Information on littoral, benthic, and planktonic organisms is not available at this time for Lake Keowee and Hartwell Reservoir. Hence, the following comments are of a general nature and should be considered as preliminary review of possible problem areas."

Adequate analysis of environmental effects requires a comprehensive investigation of the particular aquatic environment and the problem areas expected. Problem areas which need to be analyzed immediately include the potential effects on the reproduction and survival of fish in Lake Hartwell below the hydro plant as a result of increased temperatures and rapid fluctuations in temperature, and the impact of heated water on the success of reproduction and survival of fish spawning in shallow areas in the discharge zone of Keowee.

In order to enable reviewers of the project to assess the impact which operation of the Oconee station will have on the aquatic ecology of the area, the following information should be developed:

1. A listing of fishery species to be protected in Lake Keowee should be developed immediately and agreement to this list should be reached by the South Carolina Wildlife Resources Department, the Bureau of Sport Fisheries and Wildlife, and EPA. EPA will cooperate fully in developing this list.

2. The final statement should outline a commitment to make an inventory of fish species and littoral, benthic and

planktonic organisms in Lake Hartwell and describe associated thermal and hydraulic (i.e. Keowee Hydro station) effects. Although it will take at least a year to develop this information, the inventory should be initiated immediately in order to establish baseline conditions prior to thermal effects from Oconee station.

The impact statement indicated that an in-depth systematic inventory will be done on Lake Keowee and the surrounding environs. EPA agrees with this statement and suggests that the study cover those requirements outlined in Section V, paragraph C of AEC's guidelines.

Based on studies at Lake Norman, it has come to our attention that gas bubble disease in fish is a potential problem associated with power operations at Lake Keowee. The probability of this occurrence and its effects on fish in Lake Keowee should be assessed in the final environmental statement.

In addition to concern about the impact of temperature changes related to thermal discharges, dissolved oxygen (D.O.) is potentially a critical problem during the summer and fall. Virtually anaerobic, hypolimnetic water will be discharged to the surface of Lake Keowee. The statement on page 77 states: "Measurements of the effects on the D.O. in a receiving lake due to withdrawal of hypolimnetic waters to serve as condenser coolant have been made in a lake in North Carolina.(29) During the colder seasons (November through March) the average decrease in dissolved oxygen, from intake to discharge, was less than 1.0 ppm at the immediate site of the discharge. During the warmer months (May through September) the concentration of dissolved oxygen in the intake water was lower than that of the average lake area due to the hypolimnetic withdrawal. The discharge concentration decreased to an average (1969-1970) of 5.2 ppm in May, 1.0 ppm in July and 0.7 ppm in September (surface and 10-foot depth measurements were averaged)." At the same time, however, the statement indicated dissolved oxygen values in Lake Norman, downstream from the Marshall Steam Generation Station, do not reach background levels for a distance of 4.8 miles.

In order to permit evaluation of the impact of plant operations on dissolved oxygen concentrations in Lake Keowee, the following information has been requested by EPA from Duke Power Company and will be provided as soon as possible:

1. Maximum acreages in which daily average surface dissolved oxygen concentration is expected to be less than 5 mg/l and/or the minimum daily concentration is expected to be less than 4 mg/l. Incremental acreages in one mg/l increments from zero to 5 mg/l should be provided.

2. Maximum and average depths to which reduced dissolved oxygen concentrations in the incremental acreages noted in Item 1 can be expected.

3. Under conditions when discharge temperatures are less than reservoir surface temperatures and density interflows are expected to occur, information comparable to Items 1 and 2, as well as expected depth of interflow below the surface.

The above information should be presented in the final statement for average conditions of meteorology, streamflow, and drawdown, and for twenty-year recurrent conditions producing maximum retention in lower depths of the lake.

NON-RADIOACTIVE WASTES AND OTHER TECHNICAL COMMENTS

Handling and treatment of chemical waste, as presented in the statement and supporting reports, generally appears adequate. No mention is made, however, of the disposal of sludges or suspended solids from the treatment of potable water or the treatment of detergents and ammonia wastes. Removal of solids from all waste streams should be provided by diversion to the holding pond or by other methods. Treatment of detergent and ammonia wastes should be provided by discharge to the sanitary sewage treatment plant or by providing equivalent secondary treatment rather than discharging them directly to Hartwell Reservoir as indicated in Table III-6 of the statement.

Oils, chromium, hydrazine, acids, bases, and other solid and liquid hazardous materials will be stored and used on site during construction and operation of the plant. A brief discussion of the storage and control methods which will be used, as well as proposed procedures to prevent the contents of a ruptured tank or accidental leakage or spillage of oil or other hazardous materials from reaching surface watercourses, should be presented.

The spent brines from the regeneration of ion exchangers and the backwash water from these units are to be retained in a holding pond where particulate matter will settle. No estimate of the organic pollution load from this pond is given. The statement indicates that this water can be chemically treated, but does not indicate under what conditions treatment will be initiated.

The statement (page 78) describes the problems associated with screen clogging resulting from winter kills of threadfin shad trapped in the intake canal, which has occurred at other stations. Information should be provided on proposed disposal procedures for fish removed from the intake screens.

We are in general agreement with the proposed design and operation of the intake structure. It appears adequate to prevent adult fish from being swept into the condensers and pumps. Even small organisms will be kept out to some degree by the skimmer wall. There is no way to keep the planktonic organisms less than 3/8 inch out of the pumps, so these will no doubt be swept through. The extent or significance of damage cannot be ascertained at this time from the [illegible] of knowledge available. To determine the mortality of these forms requires knowledge of distribution, fragility, and lethal temperatures for each species.

The amount of sanitary waste is estimated to be 5,100 gal/day. For the indicated labor force of 210 men, this amounts to 24 gal/man-day, which is reasonable. The 5,100 gal/day figure is not reasonable if construction employees are included. There will be a large number on the site with about 500 remaining as late as 1974. Also no estimate is made of the number of visitors to the site.

Additional information is required to adequately evaluate the impact of the "small boiler" fired with fuel oil discussed on page 68 of the statement. This information should include the size of the boiler, frequency of use, purpose, and quantities and types of fuel used.

Further consideration should be given to disposal of non-radioactive solid waste generated by this project during construction and operation to ensure that acceptable disposal methods are used.

MONITORING AND SURVEILLANCE

A comprehensive monitoring and surveillance program should be developed for the environment affected by Oconee station. EPA will be pleased to work with Federal and State agencies in developing general guidelines which can be used by the applicant in preparing a comprehensive plan.

The following specific areas should be considered in developing the Oconee monitoring and surveillance plan:

1. Radioactivity monitoring of the municipal water systems which draw water from the Keowee River and Lake Hartwell. The program should be designed to enable emergency protective action to be taken.

2. Radioactive effluent monitoring. This sampling and analysis program should include specific analysis for those radionuclides which are the major dose contributors.

3. Water temperature monitoring. Several continuous monitoring stations, in addition to those currently proposed, will be required to document compliance with the South Carolina water quality standards.

4. Dissolved oxygen monitoring. This is necessary to ensure that receiving waters remain within applicable standards.

5. Biological monitoring. The development of this plan will depend on established base-line biological data and demonstrated needs as determined by information generated by other elements of the monitoring system.

The monitoring plan developed by Duke Power will be evaluated by EPA. The requirement to provide the needed data will be a condition to EPA's concurrence on the Section 13 Permit.

A long-term program of biological evaluation, at least equivalent to that done for Lake Norman, should be developed and instituted by Duke Power Company. EPA is prepared to work with Duke in defining this program. The area evaluated should include all of Lake Keowee, the affected areas of Lake Hartwell, and one or more similar unaffected areas of Lake Hartwell, and Lake Jocassee in the vicinity of the pumped storage hydroelectric facilities. Special attention should be given to the following areas:

1. The extent of use of the headwaters of Hartwell below the hydroelectric plant for reproduction of shad, white bass, and walleye before and after operation of the facility;

2. Temperature regime during March, April, and May of the shallow overbank areas in the portion of the reservoir being affected by the heated discharge and the success of reproduction and survival of centrarchids in these same areas; and

3. Impact of plankton entrainment in the cooling waters on the ecology of Lake Keowee.

COST BENEFIT ANALYSIS

The quantification of the damage to the environment is a relatively new science. The accuracy with which the environmental costs can be assessed from these data and then converted into monetary units is limited. Therefore, any analysis must include judgment factors.

EPA takes issue with the values assigned to several of the benefits and the omission of certain costs. These include additional environmental costs from thermal effects and transmission line rights-of-way, and consideration of accident probabilities. We have attempted to conservatively factor these considerations into the cost/benefit balance.

The following items have either been omitted or are inadequately considered in the statement:

1. Potential Thermal Effects

The treatment of thermal effects in Lake Keowee is inadequate. Accordingly, we believe some of the potential recreational fishing benefits in this lake will not be realized. Additional information would be required from the applicant before this benefit could be fully justified.

By virtue of the proximity of the condenser outlet to the Keowee dam, it is likely that the South Carolina discharge limits, a temperature differential of 3°F, may be approached or even exceeded. Furthermore, under some conditions, the heated water from the condenser will be discharged directly into the tailrace of the Keowee dam. These thermal discharges may interfere with the spawning of certain species in the upper arm of the Hartwell Reservoir. It is unlikely that these thermal discharges will affect more than one spawning arm of the Hartwell Reservoir.

It is unlikely that thermal effects would be felt beyond the confines of Lake Keowee and Hartwell Reservoir. The downstream Savannah River contains several impoundments, the ecology has already been significantly perturbed, and it is not a spawning region.

It appears that the Jocassee impoundment has destroyed a portion of a valuable and endangered resource in the Southeast, namely portions of some of the finest wild, primitive mountain trout streams left in North and South Carolina, including (among others) Horsepasture River, Thompson River, and Whitewater River. The statement and the supplement include the fishery in the impounded Jocassee as a benefit to the project after subtracting out the value of the acreage of stream lost to impoundment, as though the two fisheries were of equal value. In actuality, on a per-acre basis, the lake fishery has only a fraction of the value of the primitive stream fishery for trout. Although the project has gone beyond the point at which this fishery loss can be avoided, the final statement should recognize this as an adverse impact. Some of the trout water impounded is in North Carolina. The North Carolina

Wildlife Resource Commission is not listed as having been contacted in regard to the project. The views of this agency should be reflected in the final statement.

2. Transmission line costs

No consideration is given in the cost/benefit summary as to the cost due to environmental impact of the power transmission lines or the transmission line right-of-ways, although limited consideration of this matter is presented in the text.

We are aware that the applicant has a good record with respect to erosion control, consideration of game, and intelligent routing to minimize aesthetic impact. Presumably, the transmission line right-of-ways will not affect the productive farm land. However, since the analysis does not consider the impact, we assume the destruction of farm land and woodland in the 3900 acres preempted, and an annual cost of approximately $75,000 is involved (using the applicant estimates for the value of farm land and woodland in the area).

The preponderance of "statements" in Table X-4 makes an objective evaluation very difficult. For example, the consumptive loss of water can be quantified, as well as several of the items denoted "negligible". A greater attempt should have been made to quantify effects.

The dollar value benefit of drinking water was obtained by using the cost of purchasing water from the Hartwell Reservoir. A superior method would have been to use the differential costs to Seneca, Walhalla, and Greenville between Lake Keowee water and alternative supplies.

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

55

50-269

January 14, 1972

RECEIVED JAN 19 1972 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of December 13, 1971. We have reviewed the draft detailed statement on the environmental considerations for the Ocenee Nuclear Station, Unit #1 of the Duke Power Company.

In order to give you the full benefit of the Department's analysis, I am enclosing the review comments from the Bureau of Domestic Commerce, the Office of the Assistant Secretary for Economic Affairs and the National Oceanic and Atmospheric Administration.

We hope this information will be helpful.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosures (10 pages), 3 sets

December 29, 1971

MEMORANDUM FOR Sidney Galler

From: Edwin B. Shykind EBS

Received 1-14-72

Subject: Comments on Draft Detailed Statement on Environmental Considerations for Oconee Nuclear Station, Unit #1 of Duke Power Company

The need for the electric power to be furnished to this area by the Oconee Plant is corroborated by FPC reports entered in previous statements (p. 45, detailed statement). The reserve power margins for the power pool of which the applicant is a member would be less than 9% in 1973 if the proposed units were not built and operated as planned.

Review of the economic data in this draft detailed statement indicates coverage of the major areas. The economic benefits accruing as a result of the nuclear plant are the electric energy itself with a market value in excess of $100 million, and an annual income benefit of approximately $3 million for the present site.

There appears to be a question with regard to the commodity value (benefit) of the energy available from peak power generation, item 32 of Table X-4. The applicant's supplement indicates (in Table 10) that the annual costs of peaking capacity and energy for the alternative closed-cycle pumped-storage is approximately $17 million. The Table X-4 figure is $26 million with an asterisk indicating that expansion capacity is included. This asterisk is also applied to the Keowee-Toxaway project (subsystem #1) where the approximately $26 million in both Tables X-4 and Table 10 is identical. Either the asterisk does not apply to the pumped storage hydro peaking (subsystem #1), or perhaps the $17 million figure applies for the pumped-storage-at-separate-location subsystem.

The $3 million annual income is composed of approximately $1.7 million for direct operating employee payroll and approximately $1.28 million of secondary income contributions due to tourist-industry generated local increases. The $1.7 million income is stated by the AEC draft detailed statement

(p. 116) to be for 210 operating employees while the figure stated in item 42, Table X-4 is 450 employees. This 450 employee figure appears to be estimated construction employees on the Keowee-Toxaway project in July of 1974 according to the applicants supplement, p. 33.

Table X-4 also contains some approximations for Federal, state and local tax benefits. These figures may or may not include amounts for the real property tax (the text indicates these amounts have not yet been reported). If available, the amounts for these taxes should be included. Environmental effects have been quantified to a larger degree than has historically been true resulting in a better data base from which to form a balanced judgement during review.

There are at least two areas which may deserve future consideration. The areas of concern are those of gaseous radioactive waste treatment and thermal effects (on both fish life and heat capacity) of the facility. The problems relative to gaseous radioactive waste treatment and release can best be resolved by the AEC and EPA. The uncertainties associated with the thermal effects on aquatic biota (especially fish life) and the future heat capacity losses of the water resources possibly could be given some additional consideration as further information becomesavailable from the applicant.

In general, the benefits stated by the applicant appear to considerably outweigh the undesirable environmental aspects for this particular nuclear station. The areas cited above would not be considered particularly major in their impact and conceivably should be adequately resolved without extended effort.

Washington, D.C. 20230

January 11, 1972

Received w/... 1-14-72

MEMORANDUM TO Dr. Sidney R. Galler
Deputy Assistant Secretary for Environmental Affairs

FROM: Robert T. Miki, Senior Economist RTM
Office of the Assistant Secretary for Economic Affairs

SUBJECT: Duke Power Company: Oconee Nuclear Station, Unit 1

I have reviewed the environmental report relating to the proposed issuance of an operating license to the Duke Power Company for the Oconee Nuclear Station, Unit 1, and focused particularly on the cost-benefit analysis contained in the report. I have no major substantive comments on the analysis that was made. It is inappropriate in Table X-4, column 4 to include "$30,000 to University Southern California for archeological study" as a benefit.

National Oceanic and Atmospheric Administration
Rockville, Md. 20852

Date : January 12, 1972

To : Dr. S. R. Galler

From : Dr. William Aron

1-14-72

Subject: Comments on Draft Detailed Environmental Statement Oconee Nuclear Station

NOAA is pleased to transmit the attached comments from the National Weather Service, the Environmental Research Laboratories and the National Marine Fisheries Service.

In summary:

1. Increased incidence of steam fog arising from plant operation should be limited to areas within a few miles of the reservoir receiving the heat load.

2. Our computation of average annual relative concentration of radionuclides at the site boundary is a factor of 2 higher than that of the applicant (we were obliged to consult the Final Safety Analysis Report in order to make this comparison).

3. The use of an average annual diffusion rate for computing site boundary doses is inappropriate, since the waste gas decay tanks and other storage tanks are only intermittently, not continuously purged.

4. In order to round out the radiological monitoring program, we recommend that benthic specimens such as insect larvae and fish eggs be included.

Enclosure

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland 20910

60

W112x2

Subject: Oconee Nuclear Station Environmental Statement

To: Dr. William Aron, CE

RECEIVED JAN 11 1971

The National Weather Service has reviewed the AEC environmental statement on the Oconee Nuclear Station.

The only environmental impact from a meteorological point of view is the potential increase in steam fog which would result from the warmer reservoir and river waters created by the plant's water discharge from its heat dissipation system. However, we concur with the AEC opinion that this inadvertent impact will be limited to areas within a few miles of the reservoirs.

Perhaps as more nuclear plants are established along and near this watershed, a more thorough evaluation should be made on the cumulative effect this warming could have along the entire river.

George P. Cressman
Director, National Weather Service

Regulatory File Cy.

Received w/Ltr Dated 1-14-72

Comments on

Draft Detailed Statement on the Environmental Considerations
for the Oconee Nuclear Station, Unit 1, Duke Power Company
by U.S. Atomic Energy Commission
Dated December 13, 1971

Prepared by

Air Resources Environmental Laboratory
National Oceanic and Atmospheric Administration
December 23, 1971

Although some onsite meteorological data are presented in the latest Draft Statement, no details are given on where (what levels above the ground), for how long, and how the data are categorized. Furthermore, no explanation is given on how these data were used to compute the radiological doses presented in Tables V-3 and VI-2. Apparently, it is assumed that the Final Safety Analysis Report (FSAR) with its various amendments and supplements are available to reviewers. Fortuitously, the Oconee FSAR was available to this NOAA Laboratory as part of its review responsibilities for the AEC, Division of Reactor Licensing. Comments on the FSAR were sent to the AEC on July 29, 1970 and a copy transmitted to the Deputy Ass't. Sec'y. for Environmental Affairs, Dept. of Commerce on March 2, 1971 in response to the first AEC Detailed Statement dated February 3, 1971. Our conclusion in these comments on the FSAR was that sufficiently detailed and appropriate meteorological data had been developed and presented by the applicant that enabled us to compute relative atmospheric diffusion rates for various release periods including a year. Our computation of the average annual relative concentration at the site boundary was a factor of two higher than that of the applicant. However, we reiterate our comments dated 10/29/71 on the first Detailed Statement, namely, that if the radioactive releases are intermittent (like once a month) and at preferred times of day, the use of an annual average diffusion rate is inappropriate. It is stated in Revision No. 1 to the Supplemental Environmental Report for Oconee that "the Reactor Building purge is an intermittent release as is the release of the waste gas decay tanks." The latest Draft Detailed Statement states on page 57 that "the reactor containment is periodically purged . . . and vented to the atmosphere", and that the waste gases from the reactor coolant liquids "are continually collected, compressed, and stored in tanks for radioactive decay."

At [illegible] point, we are not confident that an annual average diffusion rate is appropriate in this case.

We have confined our comments to the meteorological aspects of atmospheric transport and diffusion and have not treated other areas of NOAA expertise such as hydrology, seismology, and weather modification effects.

National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Washington, D.C. 20235

F34

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Regulatory File Cy.

EE - Dr. William Aron, Director
Office of Ecology and Environmental Conservation

Robert F. Hutton
Associate Director for Resource Management

Received w/Ltr Dated 1-14-72

Oconee Nuclear Station, Unit: Review of Draft Environmental Impact Statement by the National Marine Fisheries Service

The Atomic Energy Commission's draft environmental impact statement on the Oconee Nuclear Power Plant has been reviewed by National Marine Fisheries Service as requested in your memo of December 17, 1971. We offer the following comments for your consideration:

(1) NMFS commented on the previous draft EIS (comments forwarded December 10, 1971).

(2) The Oconee plant is located far inland; therefore, the operation of the power plant probably will not adversely affect marine, estuarine, or anadromous organisms or their habitat, or existing or potential commercial fisheries.

(3) The radiological monitoring program appears to be adequate except for the omission of benthic animals, which should be sampled to insure that the entire ecosystem is monitored adequately.

Attachment

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

National Marine Fisheries Service
144 First Avenue South
St. Petersburg, Florida 33701

Date: November 23, 1971

Reply to Attn of: FSE21

Subject: AEC Environmental Impact Statements - Oconee Nuclear Station project

To: Acting Associate Director for Resource Management F34
NMFS
Washington, D. C.

Regulatory File Cy.
Received w/Ltr Dated 1-14-72

As requested in your memorandum dated November 15, 1971, we have reviewed subject Environmental Impact Statement.

It appears that the applicant has given adequate consideration to protection and even enhancement of the environment. However, we do have reservations regarding the monitoring programs. There is no specific mention that the recommendations for a minimum radiological monitoring program, drawn up by the NMFS Atlantic Coastal Fisheries Center (see attachment), will be adhered to. This assurance should be provided by the applicant.

We also share the concern expressed by BSF&W in their October 26, 1971 comments, namely, (1) the applicant provide adequate assurance that facilities to cool the project effluent and otherwise mitigate its pollutional effects to levels that will not cause significant damage to fish and other aquatic life in Keowee Reservoir, the Keowee River, and Hartwell Reservoir can and will be incorporated in the project if demonstrable need occurs; (2) facilities to prevent significant loss of fish and other aquatic organisms by entrapment or entrainment in the cooling water system can and will be incorporated in the project if the need is demonstrated; and (3) the location, design, construction methods, and impact of transmission lines on aquatic resources be identified, and means provided to correct any resultant damage.

There is another problem which may arise during project operation that should be considered and corrective measures provided for. Should an emergency shutdown of plant operations occur during winter months, what will be the effects on aquatic (including benthic) organisms that have been conditioned to unseasonably warmer temperatures? Extensive damage could result with abrupt disruption of an artifically warm environment.

R. T. WHITELEATHER
Regional Director

Attachment

Date: October 12, 1971

Mid-Atlantic Coastal Fisheries Research Center
Beaufort, North Carolina 28516

Reply to Attn of: F15

65

Subject: Environmental Impact - 19 Nuclear Power Plants

File 097

To: Division of River Basin Studies
Bureau of Sport Fisheries and Wildlife
U.S. Department of the Interior
Washington, DC 20240
Attn: Paul Berg

1-14-72

This confirms the information related to you in our phone conversation of October 12, 1971.

The following recommendations for a minimum radiological environmental monitoring program applies to all nuclear power plants ~~and~~ fuel re-processing plants.

I. Frequency of surveys
   A. Pre-operational-- at least one
   B. Post start-up-- one every six months during operation

II. Sampling stations (minimum- 3)
   A. Within 500 feet of effluent discharge point
   B. Down-current, within 1 mile from discharge point
   C. Up-current from discharge point (control)

III. Type of samples, each station
   A. Water
   B. Sediment
   C. Benthic animals (examples: ~~clams, oysters, scallops, crayfish, lobsters, crabs, copepods~~, insect larvae, fish eggs)
   D. Plants (~~examples: kelp, rockweed, marsh grasses~~)
   E. Fish, including herbivores and carnivores
   F. Waterfowl, if applicable
   G. Other animals feeding upon aquatic life, as deemed necessary

IV. Type of analyses
   A. Gross beta
   B. Gross gamma
   C. Identify nuclides when either of above is significant
   D. Gamma scan
   E. Report results as radioactivity per gram wet weight

John Baptist
JOHN P. BAPTIST
Fishery Biologist

1871 1971 A Century of Fish Conservation

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO: **66**

January 13, 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of December 13, 1971, requesting the comments of the Federal Power Commission on the AEC Draft Detailed Statement on the Environmental Considerations Related to the Issuance of an Operating License to the Duke Power Company for the Oconee Nuclear Station, Unit No. 1.

By letter dated August 20, 1970, the Federal Power Commission transmitted comments to the AEC relative to the environmental statement on the Oconee Nuclear Power Plant, Units No. 1, No. 2, and No. 3. These comments are reflected in the AEC draft statement issued December 13, 1971, which correctly describes power system load growth patterns and related characteristics of the area. Therefore, the following comments are directed toward an analysis of the load, power resources, and reserve margin situation as it may obtain during the forthcoming 1972 summer peak period on the Applicant's system and the systems of the Virginia-Carolina Subregion of the Southeastern Electric Reliability Council which includes the Applicant. This is a most important time in the overall expected life of the generating unit (some 35 years) because it represents a significant part of the potential new capacity which is sorely needed to meet projected 1972 summer demands.

Because of delays encountered in meeting scheduled commercial operation dates for several large new generating units, and if further delays transpire in the next five months, the concerned electric utility systems in this area may be faced with considerably less than their desired generating capacity reserve margins with the consequent possible threat to the adequacy and reliability of bulk power supply during this period. All three of the Oconee units have suffered some delay. With particular regard to the subject Unit No. 1, very recent information indicates that the earliest operating date is now June 1972. Mechanical problems with a main reactor coolant pump will make it impossible to meet the earlier expected initial operation date of March 1972. Earlier this unit was expected to have achieved criticality in December 1971. The Surry No. 1 nuclear unit (820 MW) of the Virginia Electric and Power

Company is also delayed and the Company hopes to have it in operation by June 1972. The H. B. Robinson No. 2 unit (700 MW) suffered several months of delay because of mechanical problems, but it is now operating. Currently these plants are all subject to a continuing evaluation of certain environmental aspects.

1972 Summer Peak Load Period

	Duke Power Co.	Virginia-Carolina Subregion
Without Oconee No. 1		
Net Capability - Megawatts	7,093 2/	22,237 3/
Load Responsibility - Megawatts	7,502 1/	20,605 4/
Reserve Margin - Megawatts	-409	1,632
Reserve Margin - Percent of Load Responsibility	-5.5	7.9
With Oconee No. 1 (886 MW)		
Net Capability - Megawatts	7,979	23,123 3/
Load Responsibility - Megawatts	7,502 1/	20,605 4/
Reserve Margin - Megawatts	477	2,518
Reserve Margin - Percent of Load Responsibility	6.4	12.2
Percent of Reserve Represented by Oconee No. 1	185.7	35.2

1/ System load plus net of firm receipts and deliveries (7,516-14).
2/ December 31, 1970, capability of 6,744 megawatts plus 1971 additions of Keowee (140 MW) and Buzzard's Roost (209 MW).
3/ Includes Robinson No. 2 (700 MW), Surry No. 1 (820 MW), Cliffside No. 5 (590 MW fossil), Sutton No. 3 (420 MW fossil).
4/ System load plus net of firm receipts and deliveries (20,980-375).

The foregoing tabulation indicates the importance of the timely and continued operation of the Oconee No. 1 unit to the adequacy and reliability of the concerned systems. The reserve margins are required to provide for loss of capacity due to forced outages of or scheduled maintenance of generating capacity, occurrence of loads higher than those forecast, operating margins required to fulfill obligations to participants in the interconnected systems, and operating margins to provide for flexibility in the allocation of load to generating resources

Mr. Lester Rogers

because of abnormal bulk power system conditions. Also, the Applicant's installed hydroelectric capacity of approximately 1,000 megawatts included in its generating resources will at times be subject to less than full output under varying seasonal conditions. These considerations indicate that, if the forecast peak load is reached in the summer of 1972, the Applicant must have all of its generating resources, including Oconee No. 1, in operation if it is to satisfy its demand. Without the Oconee No. 1 unit in operation at the time of its peak demand, the Applicant is deficient by 409 megawatts in meeting its demand and must rely upon the resources of the other subregion members. In this event, and under similar peak load conditions throughout the subregion, the subregion's reserves are reduced to 1,632 megawatts, or 7.9 percent of its load responsibility. Since this 1,632 megawatts includes not only the full operation of all now operating generation resources including the Robinson No. 2 nuclear unit, but also the Surry No. 1 nuclear unit (820 MW), Cliffside No. 5 fossil fired unit (590 MW), and the Sutton No. 3 fossil fired unit (420 MW) not yet in operation, it is reasonable to conclude that the timely operation of the Oconee No. 1 unit will make a substantial contribution to the adequacy and reliability of the affected systems.

Very truly yours,

T. A. Phillips
T. A. Phillips
Chief, Bureau of Power

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

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IN REPLY REFER TO:

PWR-ER

50-269

FEB 9 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

It has come to my attention that an inconsistency was inadvertently included in the tabulation on page 2 of my letter to you dated January 13, 1972, regarding the projected capacity-load-reserve margin situation that may obtain on the Duke Power Company system with and without the capacity expected from the Oconee No. 1 nuclear fueled unit.

The Cliffside No. 5, 590 megawatt, fossil fueled unit of the Duke Power Company was included in the net capability of the Virginia-Carolina Subregion, but not in the net capability of the Duke Power Company. Initial information had indicated that this unit was scheduled for commercial operation in April 1972, and thus would aid in meeting the 1972 summer peak load. Subsequent information indicated that the commercial operation of this unit in time for the 1972 summer peak was unlikely, and it was therefore not included in the net capability of the Duke Power Company. Please subtract this 590 megawatts of capacity from the net capability of the Virginia-Carolina Subregion for this period. This reduces the projected subregion reserves to 1,042 megawatts (5.1 percent) without Oconee No. 1 and to 1,928 megawatts (9.4 percent) with Oconee No. 1. This makes the impact of the absence of the Oconee No. 1 unit on the reserve margin situation of the subregion even greater than initially indicated.

Since the January 13, 1972 date of my letter, a further note of concern has been observed. There is increasing likelihood that the Surry No. 1 unit of the Virginia Electric and Power Company will not be in commercial operation at the time of the 1972 summer peak. If this should be the case, the subregion's reserve margin would be further reduced to 222 megawatts without Oconee No. 1 and to 1,108 megawatts with Oconee No. 1.

Very truly yours,

Stewart P. Green

for T. A. Phillips
Chief, Bureau of Power

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

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FEB 1 8 1972

50-269

Mr. Lester Rogers
Director, Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, DC 20545

Dear Mr. Rogers:

This refers to our letter of January 19, 1972, transmitting the U. S. Department of Agriculture comments on the Duke Power Company's Oconee Nuclear Station, Unit 1. Comments on this station from the Forest Service are enclosed.

Sincerely,

T. C. Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Attachment

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

2-18-72

The major impact on the forest resources discussed in this project has already occurred, e.g., clearing and innundation of 26,000 acres. The statement is very complete and thorough concerning most resources affected. Although benefits are shown for hunting, fishing, and other forms of recreation, costs or losses are not shown (unless they are included in the 7.8 million under land use). To be truly objective, expected future returns for timber, hunting, fishing, and other land and water uses on land to be innundated should be shown as "costs".

We are happy to see that some of the Duke Power Company land will be converted to forestry. As you know, change in land use often results in sedimentation, so adequate plans to control erosion should be considered.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

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January 19, 1972

50-269

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

We have reviewed the draft environmental statement for Oconee Nuclear Station Unit 1 of Duke Power Company and comments from the Agricultural Research Service are attached. Forest Service has not yet completed its review of this statement. They will send whatever comments they may have to you direct at a later date.

Sincerely,

T. C. Byerly

T. C. BYERLY
Assistant Director
Science and Education

Attachment

The Agricultural Research Service has reviewed the Draft Detailed Environmental Statement on the Oconee Nuclear Station, Unit 1, Duke Power Company. There is no indication that construction of this facility would have any adverse effect on the agriculture of the area.

Conversion of 26,000 acres from a terrestial to an aquatic environment will undoubtedly have some impact on the ecology of the area. If properly managed, no serious detrimental effects should result. Care should be exercised during construction of residences and roads in the circumferential areas following completion of the project to minimize undue erosion hazards.

Potential hazards to aquatic biota by thermal discharges is acknowledged. Benefits derived from the construction of this facility far outweigh any of these minor hazards which may materialize.

In general, there appears to be no potential hazards to soil and water resources of the area indicated in this statement. The Agricultural Research Service, therefore, does not object to the proposed plans for the Oconee Nuclear Station, Unit 1, as submitted.

DEPARTMENT OF THE ARMY
SAVANNAH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 889
SAVANNAH, GEORGIA 31402

74

50-269

IN REPLY REFER TO
SASGN

14 January 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D.C. 20545

RECEIVED JAN 18 1972

Dear Mr. Rogers:

Reference is made to your letter of 13 December 1971 with inclosed Draft Detailed Statement on the Environmental Considerations for Oconee Nuclear Station, Unit 1 (Docket No. 50-269), Duke Power Company, Oconee County, South Carolina.

Our review of the referenced material indicates no conflict with planned Corps of Engineers projects in the upper Savannah River Basin. We have no Flood Plain Information studies in this area, and none are planned in the near future.

Application has been received from Duke Power Company for three discharges into Hartwell Lake and Lake Keowee under Section 13 of the Rivers and Harbors Act of 1899.

Attention is directed to page 49, first paragraph. It is not clear whether the expected 3°F increase in the Keowee Dam tailrace water temperature is a seasonal or year-round change, nor is it clear how the predicted 3°F change was calculated.

It is of vital concern to the Corps of Engineers that the temperature of water released from Keowee Lake into Hartwell Lake be carefully and continuously monitored in order to maintain the existing temperature balance and minimize adverse effects on existing ecosystems. The possibility of future nuclear stations within the Keowee-Toxaway Project area would also be important in this connection.

Page 117, third paragraph, indicates a managed forestry program to be instituted in the project area. Some mention should be made of the relative value to wildlife of the managed forestry areas as compared with the habitat value of these areas as they existed before the project was begun.

SASGN
Mr. Lester Rogers

14 January 1972

We would like to receive results of the licensee's current studies of the biota and water quality of the project area.

An early response to the questions concerning the quality of releases into Hartwell Lake would be appreciated.

Sincerely yours,

HOWARD L. STROHECKER
Colonel, Corps of Engineers
District Engineer

Copy furnished:
Mr. Timothy Atkeson, General Counsel
Council on Environmental Quality
Executive Office of the President
722 Jackson Place, N.W.
Washington, D.C. 20506

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
PEACHTREE SEVENTH BUILDING, ATLANTA, GEORGIA 30323

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January 14, 1972

REGION IV

RECEIVED
JAN 18 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

50-269

IN REPLY REFER TO:
4ME

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

We have reviewed the draft Environmental Statement and related papers on the Oconee Nuclear Power Station, Unit 1, of the Duke Power Company (Docket No. 50-269) which you transmitted by letter dated December 13, 1971, to Mr. Edward H. Baxter, Regional Administrator.

These reviews reveal that there is no objection by this Department in those areas of concern or special expertise in which HUD has an interest relative to the Oconee Nuclear Station, Unit 1.

However, there is ancillary comment to proposed future recreational and residential development in the Keowee Lake area. The element of possible subdivision development adjacent to the lake was not clearly defined. Extreme care should be taken to establish good design criteria and development controls for this type of development. Any plans and proposals should be coordinated with the areawide planning agency for that region of South Carolina. Similarly, designated design criteria and development control should be exercised in providing for recreational uses and its allied commercial activities.

Historically, a majority of lakeside development has left much to be desired in terms of long term utility. Therefore, the necessity of establishing model development control relative to residential, commercial and related development would be essential to protect and enhance the Keowee-Toxaway environment.

We return herewith a copy of the documentation surplus to our needs.

Sincerely,

Joe C. Behrens
for Leo J. Zuber
Acting Assistant Regional Administrator
Community Planning and Management

Enclosure

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
WASHINGTON, D.C. 20201

50-269

OFFICE OF THE SECRETARY

78

RECEIVED
FEB 8 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

Mr. Lester Rogers
Director
Division of Radiological and
Environmental Protection
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of December 13, 1971, wherein you requested comments on the draft environmental impact statement for the Oconee Nuclear Station Unit 1.

This Department has reviewed the health aspects of the above project as presented in the documents submitted. This proposed nuclear generating station does not appear to represent a hazard to public health and safety. Moreover, it appears that any delay in such construction and operation could result in power shortages with consequences prejudicial to the public health.

Final documentation concerning this station should include information on actions to be initiated in the event of an accident including notification of and participation with cognizant State and local authorities. It should also describe arrangements for the exchange of information and coordination with such authorities on routine environmental surveillance activities.

The opportunity to review the draft environmental impact statement is appreciated.

Sincerely yours,

Merlin K. DuVal M.D.

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

50-26

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (WS/83)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

77

SA 0306

14 JAN 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of 13 December 1971 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning the draft detailed statement on the environmental considerations for the Oconee Nuclear Station, Unit No. 1, of the Duke Power Company, South Carolina.

Reference is made to our letter of 24 March 1971 addressed to Mr. Harold L. Price, Director of Regulation, AEC, regarding this Department's previous review of the Oconee Station.

The concerned operating administrations and staff of the Department of Transportation have reviewed the additional material and the draft detailed statement on the environmental considerations of the Oconee Station and no further comments are offered.

The opportunity for the Department of Transportation to review this report is appreciated.

Sincerely,

W. M. BENKERT
Rear Admiral, U. S. Coast Guard
Chief, Office of Marine Environment
and Systems

50-269

80

State of South Carolina

JOHN C. WEST
GOVERNOR

OFFICE OF THE GOVERNOR
COLUMBIA 29211

February 11, 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

I have reviewed the comments made by Federal agencies on the draft Environmental Impact Statement of the Oconee Nuclear Power Station, Unit 1. I was especially interested in the comments of the Corps of Engineers, the Department of Commerce, and the Environmental Protection Agency and am sure that these recommendations and requests for more comprehensive data will be included in the final statement.

It is my desire to maintain a balanced economic growth for South Carolina and, at the same time, insure the quality of the environment. The final Environmental Impact Statement must be comprehensive enough to allow for the complete evaluation of the environmental effects and, therefore, the establishment of the necessary monitoring procedures.

Sincerely,

John C. West

/jf

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S.C.
P. O. Box 11,188
Capitol Station 29211

79

RECEIVED
MAR 22 1972
Mail Section

March 20, 1972

50 - 269

Mr. Lester Rogers, Director
Division of Radiological &
Environmental Protection
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

Thank you for your information on the Draft Detailed Statement on the Environmental Considerations for the Oconee Nuclear Station, Unit 1, Docket 50-269, issued on December 13, 1971, as well as the Detailed Statement issued on February 3, 1971.

Duke Power Company has been most cooperative, but this project was initiated before pertinent federal legislation was enacted, and only limited opportunity was given for protection of historic or archeological sites, or for investigation of possible adverse effects within the area impounded.

Although, so far as is known, no one on a state level has discussed with Duke Power Company the historic value of lands surrounding the lakes, it is our understanding that the Pendleton District Historical & Recreational Commission is working with Duke in the moving of a historic house in the area. We also understand, through the Pendleton Commission, that Duke is protecting an old Presbyterian Church and has moved other endangered cemeteries. It is our assumption, therefore, that nothing on the peripheral lands of this project is currently endangered.

Thank you for your cooperation.

Sincerely,

Christie Z. Fant
for
Charles E. Lee
State Liaison Officer for
Historic Preservation

CEL/pn

State of South Carolina
Water Resources Commission

81

JAN 26 1972

Clair P. Guess, Jr.
Executive Director

January 24, 1972

50-269

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
United States Atomic Energy Commission
Washington, D. C. 29545

Dear Mr. Rogers:

Reference is made to a letter with enclosures dated January 11, 1972, to your office from Mr. Clair P. Guess, Jr., Executive Director, South Carolina Water Resources Commission. That letter and enclosures were assigned docket numbers 50-269, 50-270, and 50-287. During the period from January 18 through January 21, 1972, we received additional comments from State agencies on the Draft Enfironmental Statement relating to the application by Duke Power Company for an operating permit for Oconee 1. For your information, I have attached copies of these comments.

Sincerely yours,

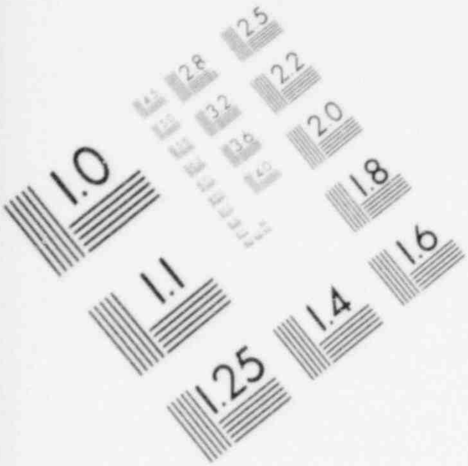
Glenn W. Dukes

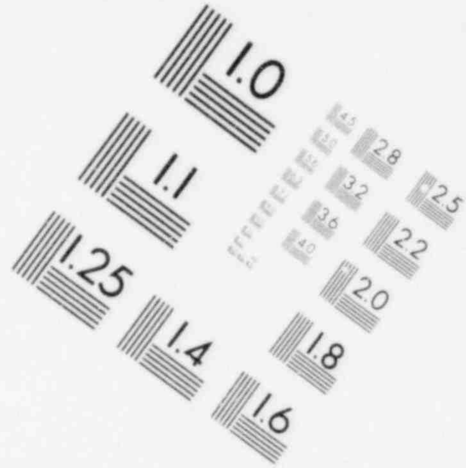
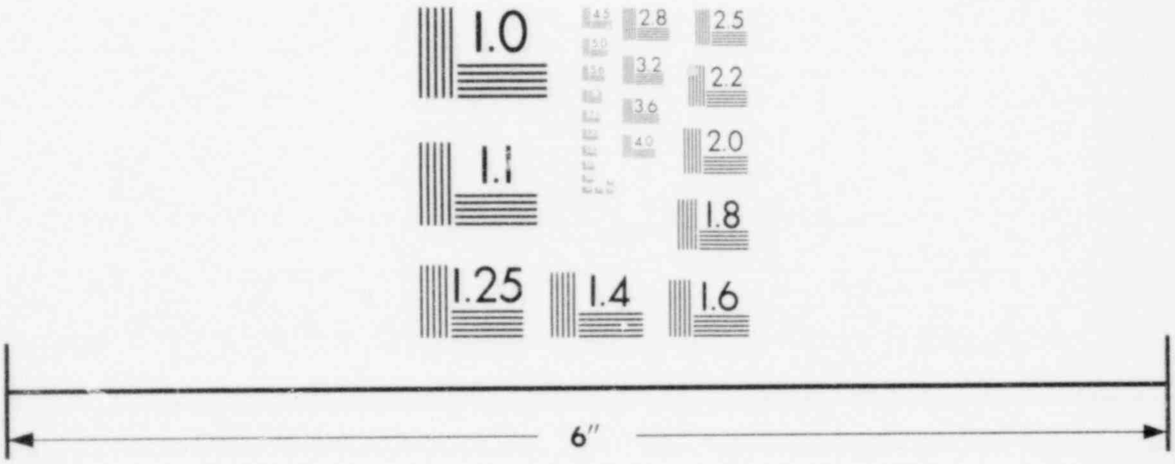
Glenn W. Dukes
Water Resources Engineer

GWD:fw
Enclosures

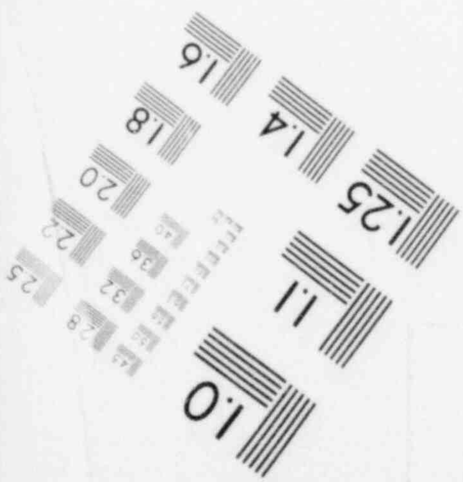
2414 Bull Street / Columbia, South Carolina 29201 / (803) 758-2514

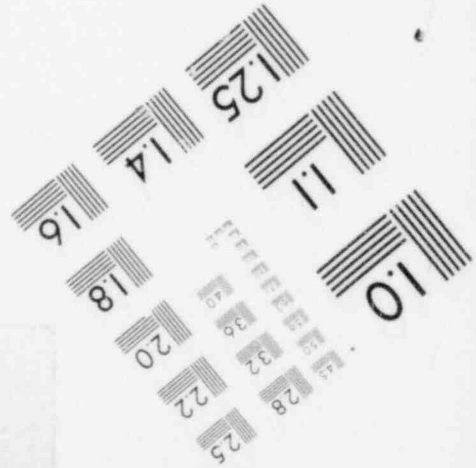
IMAGE EVALUATION TEST TARGET (MT-3)

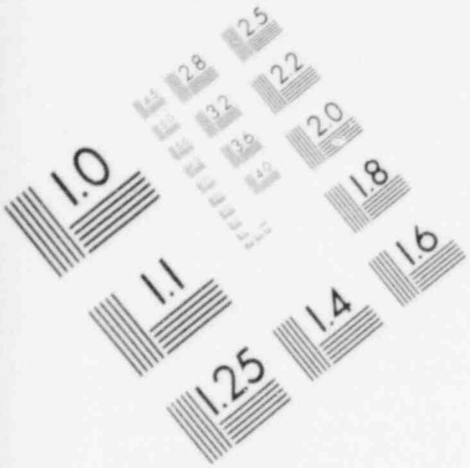




MICROCOPY RESOLUTION TEST CHART







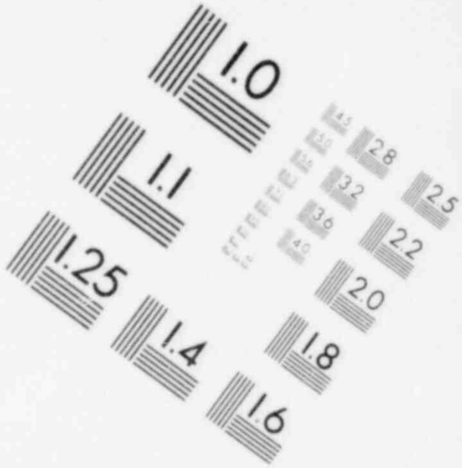
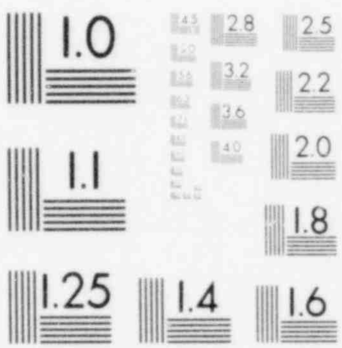


IMAGE EVALUATION
TEST TARGET (MT-3)



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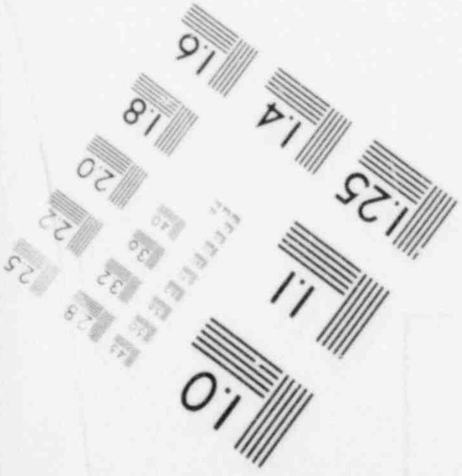
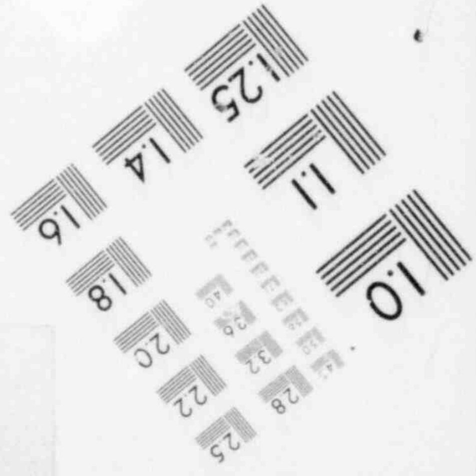
MICROCOPY RESOLUTION TEST CHART





AGENCIES ASKED FOR COMMENTS

Dr. Kenneth E. Aycock
State Health Officer
State Board of Health
2600 Bull Street
Columbia, S. C. 29201

Mr. Bob Hickman, Director
Department of Parks, Recreation
and Tourism
P. O. Box 1358
Columbia, South Carolina 29202

Mr. John R. Tiller
State Forester
State Commission of Forestry
P. O. Box 287
Columbia, South Carolina 29202

Mr. S. N. Pearman
Chief Highway Commissioner
S. C. State Highway Department
1100 Senate Street, P. O. Box 191
Columbia, South Carolina 29202

Mr. J. Bonner Manly, Director
S. C. State Development Board
Hampton Building
P. O. Box 927
Columbia, South Carolina 29202

Mr. James W. Webb, Executive Director
S. C. Wildlife Resources Department
1015 Main Street
Columbia, South Carolina 29202

Dr. Hubert J. Webb, Executive Director
S. C. Pollution Control Authority
Owen Building, 1321 Lady Street
P. O. Box 11628
Columbia, South Carolina 29211

JAN 21 197.

83

South Carolina Pollution Control Authority

HUBERT J. WEBB, PH.D.
EXECUTIVE DIRECTOR
OWEN BUILDING
1321 LADY STREET P. O. BOX 11628
Columbia, South Carolina 29211

AREA CODE 803
TELEPHONE: 758-2915

Received w/ 1-24-72

50-269

RECEIVED JAN 26 1972 U.S. ATOMIC ENERGY COMMISSION Mail Section

January 20, 1972

Mr. Clair P. Guess, Jr.
Executive Director
S. C. Water Resources Commission
2414 Bull Street
Columbia, South Carolina

Dear Mr. Guess:

We have reviewed the environmental impact statement prepared on the Oconee Nuclear Station being built by Duke Power Company on the Keowee Reservoir. There is no information presented in this document which is in conflict with that presented to us at an earlier date. This agency issued a construction permit for this particular installation on November 19, 1970. This permit provided for the discharge of 3,040 million gallons of water per day. Data presented at that time indicated that this discharge will meet the requirements of the laws of this State.

Based on the information previously presented to this agency as well as that in the impact statement, this agency is of the opinion that there will be no contravention of the air pollution laws of this State.

It is recognized that this project does modify the environment in the area involved, and that there has been a long time commitment of resources for the purpose indicated. The report discusses these considerations fully and frankly, all of the modifications and commitments have, however, been in keeping with those laws which are administered by this agency. We do not, therefore, enter any objections to this project at this time. The emission of air contaminants from an operation of this type will be less than that from

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fossil fuel plants. The volume of solid waste (fly ash) will be negligible from this plant. There will, however, be a small volume of radioactive waste that must be disposed of.

This agency is in the process of issuing a water quality certificate to the Corps of Engineers as required by the Refuse Act. We anticipate no problems in this respect.

Yours very truly,

H. J. Webb
Executive Director

HJW/dkw

South Carolina State Commission of Forestry

JOHN R. TILLER
STATE FORESTER

P. O. BOX 287
COLUMBIA, S. C. 29202

January 3, 1972

Mr. Clair P. Guess, Executive Director
S. C. Water Resources Commission
2414 Bull St.
Columbia, S. C. 29201

Dear Clair:

The major impact of the Keowee-Toxaway Power Project on the forest resources of South Carolina resulted from the conversion of 26,000 acres from woodland to lakes. This has already occurred. Some additional land will be diverted from timber production for transmission line rights of way, intensive recreation use, and residential purposes. Some of this conversion would occur whether or not this particular project was constructed.

It is expected that the remaining woodland acres will be managed by the company with multiple use as the objective. Duke Power Company has for a number of years practiced good forest management on their forest lands in South Carolina. Timber production, wildlife habitat protection, watershed protection, recreation and other multiple use considerations should be a part of the overall land use planning and result in no additional adverse impact on the forest resources of the area.

The Forestry Commission has no objection to this project. We believe there will be no additional adverse environmental or ecological impact to the forest resources except that which has already occurred when the 26,000 acres were diverted from forest land to lakes.

The description of the forest resource impact is covered on page 69, item 2 - Terrestrial Impact. The impact discussed on these pages appear to be normal and unavoidable.

Very truly yours,

John R. Tiller
State Forester

JRT:mbs

JAN 18 1972 Received ... 1-24-72

PRT

50-269 86

January 17, 1972

Mr. Glenn W. Dukes
Civil Engineer
S. C. Water Resources Commission
2414 Bull Street
Columbia, S. C. 29201

Dear Mr. Dukes:

The Department of Parks, Recreation and Tourism does not have the scientific expertise available to make a meaningful statement on the environmental impact submission of Duke Power Company for the Oconee Nuclear Station, Unit One.

Sincerely,

Maxwell M. Way, Jr.
Economist

MMWJr:kld

South Carolina Department of Parks, Recreation & Tourism — Box 1358, Columbia, South Carolina 29202

State of South Carolina
Water Resources Commission

Clair P. Guess, Jr.
Executive Director

January 11, 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
United States Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

The South Carolina Water Resources Commission is the clearinghouse for State Governmental agency comments on Atomic Energy Commission's environmental statements. Upon receipt of the Atomic Energy Commission's draft environmental statement relating to the application by Duke Power Company for an operating permit for Oconee Nuclear Station Unit 1, copies were furnished to interested State agencies for review and comment. A list of those agencies is attached. Those agencies wishing to comment were asked to have their comments in the Water Resources Commission's office on or before January 10, 1972. Attached to this letter are agency comments.

The Staff of the Water Resources Commission has reviewed the draft environmental statement and is of the opinion that operating the Oconee Nuclear Station Unit 1 will have less adverse environmental effects than its alternatives. Therefore, the Commission urges the granting of an operating permit.

Sincerely,

Clair P. Guess, Jr.
Executive Director

CPGJr:fw
Enclosures

cc: Mr. Bill Lee

2414 Bull Street / Columbia, South Carolina 29201 / (803) 758-2514

1-24-72 JAN 21 1972

88

South Carolina

WILDLIFE RESOURCES DEPARTMENT

POST OFFICE BOX 167 COLUMBIA, SOUTH CAROLINA 29202

• JAMES W. WEBB
EXECUTIVE DIRECTOR

• PAT RYAN
DIRECTOR, DIVISION
OF GAME AND
FRESHWATER FISHERIES

• DR. JAMES A. TIMMERMAN, JR.
DIRECTOR, DIVISION
MARINE RESOURCES

January 20, 1972

50-269

Mr. Clair P. Guess, Jr.
Executive Director
Water Resources Commission
2414 Bull Street
Columbia, South Carolina 29201

Dear Mr. Guess:

Reference Mr. Glenn Dukes' letter of December 17, 1971, and the attached Draft of the Detailed Statement of the Environmental Considerations by the U. S. Atomic Energy Commission Related to the Proposed Issuance of an Operating License for Duke Power Company for its Oconee Nuclear Station, Unit 1.

The subject report has been reviewed by this Department and this review indicates that much of the information within the document has been presented or discussed in earlier reports or hearings in which this Department was given an opportunity to comment.

There are several points within the proposed operating procedures which this Department does wish to comment on. The first of these relates to water level fluctuations as found on page 38 of the subject report. This states that these fluctuations are restricted over an unspecified time to a three feet maximum for Lake Keowee and six feet maximum for Lake Jocassee. Earlier in a letter by Mr. William S. Lee, it was stated that the maximum daily fluctuations of two and four feet may be experienced. The point which I wish to raise at this time is that the more important species of fish which will inhabit these bodies of water use the edge of the impoundment for spawning, which is usually four feet or less in depth. Therefore, such fluctuations could have severe detrimental effects on the fishery resources in both reservoirs. It would be hoped that some procedures may worked out between the Power Company and this Department to insure more stable water levels during the spawning periods.

The referenced report is the first acknowledgment made that thermal intrusions are expected to occur in Hartwell (See page 49). This would appear to be a structural change which may have significant effects on the heat budget on Lake Keowee especially if large amounts of heated effluents are syphoned off to Hartwell, it is regretted that greater opportunity was not provided to fully evaluate this situation.

This Department appreciates the opportunity of reviewing this draft and making the above comments.

Very truly yours,

James W. Webb

JAMES W. WEBB
Executive Director

RAS/pal

CC: Dr. James A. Timmerman, Jr.
Mr. Pat Ryan
Mr. J C. Fuller
Mr. E B. Latimer
Honora ıle Clyde A. Eltzroth
DRBS, Raleigh, North Carolina

south carolina appalachian council of governments

(803) 268-2431
11 REGENCY HILLS DRIVE • DRAWER 6668 • GREENVILLE, SOUTH CAROLINA 29606

50-269

90

January 12, 1972

RECEIVED
JAN 13 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory Mail Section

Mr. R. C. De Young, Assistant Director
Pressurized Water Reactors Division
of Reactor Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Young:

This letter is to inform you that the Duke Power Company's application for a license to operate the Oconee Nuclear Station Unit 1 was mailed for review on December 30, 1971 to Mayors, Councilmen, Legislative Delegations, and County Planning Directors in Anderson, Oconee, and Pickens Counties.

Please note attached comments which have been received at this time. This Office has no adverse comments relative to this project.

Sincerely,

CW Bennett

Carnell W. Bennett
Clearinghouse Coordinator

CB:ld

Attachments

ERNEST COOLER
EXECUTIVE DIRECTOR
P. O. BOX 37
PICKENS, S. C.
TELEPHONE 878-2244

Received w/... 1-12-72

PICKENS COUNTY
PLANNING & DEVELOPMENT COMMISSION

91

January 4, 1972

50-269

Mr. Chris Trabookis, Planning Director
S.C. Appalachian Council of Governments
11 Regency Hills Drive
Drawer 6668
Greenville, South Carolina 29606

Dear Chris:

Information regarding Duke Power Company's Application for a License to operate the Oconee Nuclear Station Unit 1, has been received by this office. We wish to make no comments with regard to this project at the present time.

Sincerely,

Ernie

Ernest W. Cooler

EWC/vh

RECEIVED
JAN 13 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

JAN 6 1972

GREENVILLE COUNTY PLANNING COMMISSION

18 Thompson St. • Greenville, South Carolina 29601

92

Received 1-12-72

50-269

January 5, 1972

Mr. Christopher G. Trabcokis
Planning Director
South Carolina Appalachian Council
of Governments
Drawer 6668
Greenville, South Carolina 29606

Dear Chris:

Re: A-95 Review of Duke Power Company's Application for a License to Operate the Oconee Nuclear Station Unit 1

The planning staff has reviewed Duke Power Company's application for a license to operate the Oconee Nuclear Station Unit 1.

We have no comments on this application.

Very truly yours,

Coleman

J. Coleman Shouse
Director of Planning

JCS:bo

JAN 13 RECD

OCONEE COUNTY PLANNING COMMISSION

South Carolina

1-12-72

Drawer 188 • Walhalla, South Carolina 29691
Telephone (803) 638-2604

93

January 12, 1972

50-269

RECEIVED JAN 13 1972 U.S. ATOMIC ENERGY COMMISSION Regulatory Mail Section

Mr. Chris Trabookis, Planning Director
S. C. Appalachian Council of Governments
P. O. Box 6668
Greenville, South Carolina 29606

Dear Chris:

Reference your memorandum, Subject: Duke Power Company's Application for a License to Operate the Oconee Nuclear Station Unit 1, I wish to comment as follows:

We, the Planning Commission, speaking for the County of Oconee, heartily and enthusiastically support the construction and operation of this fine facility, and are extremely pleased with the environmental quality features of the Keowee-Toxaway project.

We encourage in every way the issuance of this application and offer our full assistance to the applicant.

Sincerely,

C. Dick Plyler
Director

CDP/lwd

SUMMARY AND CONCLUSIONS

1. This is the Final Detailed Environmental Statement by the U. S. Atomic Energy Commission, Division of Radiological and Environmental Protection, related to the proposed issuance of an operating license to the Duke Power Company for the operation of Unit 1 at the Oconee Nuclear Station in the State of South Carolina, county of Oconee, near the city of Seneca. This statement will also serve for future consideration of operating licenses for Units 2 and 3.

2. The Oconee Nuclear Station will have three units, each with a pressurized water reactor having an electrical output of about 922 megawatts (of which 36 megawatts will be used within the plant) and a waste heat generation of about 1650 megawatts. Although the present action is concerned with the proposed issuance of a license to operate one unit, this Statement considers the environmental impact of the simultaneous operation of all three units. The Oconee Station is integrated into the applicant's Keowee-Toxaway Project in an arrangement that provides water for condenser cooling as well as hydroelectric power (140 megawatts total) for peaking purposes. The Project at present consists of Lake Keowee (impounded by the Keowee Dam) and its completed hydroelectric station, the Oconee Nuclear Station with one unit completed and two units in an advanced stage of construction, and Lake Jocassee with its 610-megawatt pumped-storage facility (which is also under construction).

3. The environmental impact, including adverse and beneficial environmental effects, of the Oconee Nuclear Station is as follows:

    - Reassignment of use of about 2000 acres of land for the Station and its exclusion area and withdrawal of some marginal agricultural production;

    - Flooding of 26,000 acres of wooded and farm land to form Lake Keowee and Lake Jocassee, and conversion of much of the remainder of the applicant's land acquired for the Project (157,000 acres total) to forestry and wildlife management programs;

    - Removal of about 340 residences and relocation of almost 900 residents from the land used by the Project;

- Withdrawal of a maximum of 4733 cubic feet per second (three units of the Station) of water from near the bottom of Lake Keowee, elevation of the temperature of the water (in which aquatic biota may be entrained) by about 18°F in passage through the condenser-cooling systems, and discharge of the water nearer the lake surface at 95 to 100°F during the late summer months;

- Reduction of the oxygen concentration in the surface waters near the plant discharge during periods of the year when the plant is withdrawing oxygen-deficient water from the hypolimnion and discharging it to the surface:

- Conversion of 7,800 acres of farm land and forest to transmission line right-of-way;

- Discharges of small quantities of chemicals (that are not expected to produce discernible effects) into the headwaters of the Hartwell Reservoir via the tailrace of the Keowee hydroelectric station;

- Discharges of small quantities of radioactive gaseous and liquid wastes to the environment;

- Creation of a very low probability risk of accidental radiation exposure to nearby residents;

- Addition of electrical energy generating capacity needed to support the economic growth of the area served by the applicant's power network;

- Creation of an area that may become attractive for residences;

- Creation of a recreational lake area, including a visitors' center and associated tourist amenities; and

- Stimulation of the local economy through taxes, direct employment, tourism.

4. The following alternatives were considered:

   - Purchase of power from outside sources;

   - Location of the Station at other sites;

- Adoption of once-through cooling using the flowing stream at this site;
- Use of fossil fuel with once-through cooling and pumped-storage hydroelectric peaking;
- Use of fossil fuel with evaporative cooling towers and gas-turbine peaking;
- Use of fossil fuel with evaporative cooling towers and pumped-storage hydroelectric peaking at a separate location;
- Use of nuclear fuel with evaporative cooling towers and gas-turbine peaking;
- Use of nuclear fuel with evaporative cooling towers and pumped storage hydroelectric peaking.

5. The following Federal, State and local agencies submitted comments on the Draft Detailed Environmental Statement issued December 13, 1971:

   Council on Historic Preservation
   Department of Transportation
   Department of Commerce
   Health, Education and Welfare
   Department of the Army, Corps of Engineers
   Federal Power Commission
   Department of the Interior
   Department of Agriculture
   Department of Housing and Urban Development
   Environmental Protection Agency
   Office of the Governor of South Carolina
   State Water Resources Commission, South Carolina
   State Commission of Forestry, South Carolina
   Department of Parks, Recreation and Tourism, South Carolina
   Pollution Control Authority, South Carolina
   Wildlife Resources Department, South Carolina
   Appalachian Council of Governments, South Carolina

   The texts of all comments received are appended to this Final Environmental Statement. Identification of where the Draft Statement was revised in response to the comments is tabulated in an appendix.

6. The conclusion is that the benefits to be derived from operation of the Oconee Nuclear Station outweigh the adverse effects identified in this Statement. On the basis of the evaluation and analysis set forth in this Final Statement, and after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, it is concluded that from the standpoint of environmental effects the action called for is the issuance of a license to operate Unit 1 of the Oconee Nuclear Station providing the applicant takes the following additional action:

   (1) Accumulate information required to establish baselines for the evaluation of thermal, chemical and radiological effects of station operation on terrestrial biota and aquatic biota in Lakes Keowee, Hartwell and Jocassee.

   (2) Develop and implement a comprehensive monitoring program that will permit surveillance during plant operation of thermal, chemical, and radiological effects on terrestrial biota and on aquatic biota in Lakes Keowee, Hartwell, and Jocassee.

   (3) Monitor concentrations of chemical discharges into Hartwell Reservoir.

   (4) Monitor the temperature of the condenser cooling discharges into Lake Keowee.

7. The date that this Final Environmental Statement is being made available to the public, to the Council on Environmental Quality, and to the other agencies noted in Item 5 above is March 24 1972.

Benefit-Cost Comparison for Oconee Nuclear P

PRIMARY IMPACT and POPULATION or RESOURCE AFFECTED	UNIT of MEASURE	NUCLEAR FUELED STEAM-ELECTRIC POWER GENERATION				
		APPLICANT'S PROPOSAL With Pumped Storage Hydro Peaking and Impounded Lake Once-Through Cooling		ALTERNATE #1 With Wet Cooling Towers and Gas Turbine Peaking		ALTERN… With Wet Cooli… Pumped Storage at …
		COST	BENEFIT	COST	BENEFIT	COST
ECONOMIC IMPACT of PLANT						
Power Benefits — Base Load	$/yr - Mwh/yr	$102,000,000	18,600,000	$109,000,000	18,600,000	$109,000,000
Power Benefits — Peaking	$/yr - Mwh/yr	$26,000,000	717,500	$33,000,000	717,500	$28,000,000
Generating Cost (Σ Base Load + Peaking Costs)	$/yr	$128,000,000		$142,000,000		$137,000,000
Reserve Capacity	% Increase System reserve		12%		12%	
Summary of Economic Impacts						
ENVIRONMENTAL IMPACT of PLANT						
1. Impact on Water						
1.1 CONSUMPTION — 1.1.1. Commercial	mgd	100		100		
1.1 CONSUMPTION — 1.1.2. Power Production	mgd	32		51 - 58		51 - 58
1.2 RADIONUCLIDE CONTAMINATION of ENVIRONMENT — 1.2.1. Liquid Discharge	Man-rems/yr	6		6		6
1.2 RADIONUCLIDE CONTAMINATION of ENVIRONMENT — 1.2.2. Solid Waste Discharge	Man-rems/yr					
1.3. NATURAL WATER DRAINAGE	Statement	Cold river	Warm lake	Cold river	Warm lake	
2. Impact on Air						
2.1 CHEMICAL DISCHARGE to AMBIENT AIR — 2.1.1. Air Quality - Chemical — 2.1.1.1. CO_2	tons/yr	Negligible		982,787		Negligible
2.1.1.2. SO_2	tons/yr			10,138		
2.1.1.3. NO_x	tons/yr			14,438		
2.1.1.4. Particulates	tons/yr					
2.1.1.5. Other	tons/yr					
2.2. ENTRAINMENT	Statement			Water treat. chem. released		Water treat. chem. released
2.3. RADIONUCLIDES DISCHARGED to AMBIENT AIR	Man-rems/yr	4		4		4
2.4. FOGGING and ICING	Statement	May occur under certain atmospheric conditions		May occur under certain atmospheric conditions		May occur under certain atmospheric conditions
3. Temporary Impacts of Construction						
3.1. LAND DISTURBANCE	Statement	1300 acres		1300 acres		510 acres
3.2. AIR QUALITY	Statement	Negligible		Negligible		Negligible
3.3. WATER QUALITY	Statement	Minor siltation		Negligible		Negligible
3.4. WATER DIVERSION	Statement	Walleye spawning disrupted		Walleye spawning disrupted		Negligible
3.5. SPOILAGE	Statement	Negligible		Negligible		Negligible
Summary of Environmental Impacts						
SOCIETAL IMPACT of PLANT						
1. Operational Fuel Disposition						
1.1. FUEL TRANSPORT	Statement	9 Truck Shipments/yr		9 Trucks; 7,900 Cars/yr		9 Truck Shipments/yr
1.2. FUEL STORAGE	Statement	No impact		13,200,000 gallons		No impact
1.3. WASTE PRODUCTS	Statement	89 Truck Shipments/yr		89 Truck Shipments / yr		89 Truck Shipments/yr
2. Land Use and Property Values						
2.1. INDUSTRIAL	$ Investment	$417,000,000	Increased property value	$548,000,000	Increased property value	$625,000,000
2.2. COMMERCIAL	$ + Statement	No loss by flooding		No loss by flooding		
2.3. RESIDENTIAL	$ + Statement	344 Houses; $1,981,000	$60,000,000	344 Houses; $1,981,000	$60,000,000	
2.4. AGRICULTURAL	Area - $/yr	4,646 Ac - $220,000/yr		4,646 Ac - $220,000/yr		
2.5. FORESTRY	Area - $/yr	21,354 Ac - $152,000/yr		21,354 Ac - $152,000/yr		
2.6. RECREATION	Recreation Days		4,100,000		4,100,000	
2.7. NATURAL AREA	Statement	26,000 acres flooded	26,000 acres fishery created	26,000 acres flooded	26,000 acres fishery created	
3. Historical and Archaeological Sites						
3.1. ACCESSIBILITY — 3.1.1. Historical Sites	Statement	Covered Bridge site flooded		Covered bridge site flooded		
3.1. ACCESSIBILITY — 3.1.2. Archaeological Sites	Statement	Fort Prince George, Cherokee	Sites surveyed	Fort Prince George, Cherokee	Sites surveyed	
3.2. SETTING of HISTORICAL SITES	Statement	Settings flooded	Bridge more accessible	Settings flooded	Bridge more accessible	
4. Community Benefits						
4.1. LOCAL TAXES	$/yr		$16,000,000/yr		$21,000,000/yr	
4.2. NEW JOBS/INCOME	No/$-yr		170/$2,500,000/yr		Slightly Larger	
5. Aesthetics						
5.1. APPEARANCE — 5.1.1. Plant	Statement	Disturbs natural setting		Disturbs natural setting		Disturbs natural setting
5.1. APPEARANCE — 5.1.2. Transmission Facilities	Statement	5000 acres timber cleared		5000 acres timber cleared		
6. Temporary Impacts of Plant Construction						
6.1. HOUSING — 6.1.1. Residents Relocated	No.	892		892		Not Estimated
6.1. HOUSING — 6.1.2. Dwelling Units/Value	No./$	See Appendix X-1		See Appendix X-1		Not Estimated
6.2. SCHOOLS	Chg in Attendance	<3.6% ADA increase		<3.6% ADA increase		Temporary Increase
6.3. TRAFFIC	Statement	Small Increase		Small Increase		Small Increase
6.4. COMMUNITY SERVICES	Statement	Small Increase		Small Increase		Small Increase
6.5. ECONOMICS - CONSTRUCTION WAGES	Total $		$163,000,000		$163,000,000	
Summary of Societal Impacts						

ower Station Alternatives, TABLE XI-1

...TE #2 ...g Towers and ...Separate Location		COAL FUELED STEAM-ELECTRIC POWER GENERATION					
		ALTERNATE #3 With Pumped Storage Hydro Peaking and Impounded Lake Once-Through Cooling		ALTERNATE #4 With Wet Cooling Towers and Gas Turbine Peaking		ALTERNATE #5 With Wet Cooling Towers and Pumped Storage at Separate Location	
BENEFIT		COST	BENEFIT	COST	BENEFIT	COST	BENEFIT
18,600,000		$128,000,000	18,600,000	$134,000,000	18,600,000	$134,000,000	18,600,000
717,500		$26,000,000	717,500	$33,000,000	717,500	$28,000,000	717,500
		$154,000,000		$167,000,000		$162,000,000	
12%			12%		12%		12%
	1.1.1.	100		100			
	1.1.2.	28		48 - 51		48 - 51	
	1.2.1.						
	1.2.2.						
	1.3.	Cold river	Warm lake	Cold river	Warm lake		
	2.1.1.1.	17,952,000		18,934,787		17,952,000	
	2.1.1.2.	85,600		99,738		85,600	
	2.1.1.3.	140,800		155,238		140,800	
	2.1.1.4.	13,312		13,312		13,312	
	2.1.1.5.	319,488(ash)		319,488(ash)		319,488(ash)	
	2.2			Water treat. chem. released		Water treat. chem. released	
	2.3.						
	2.4.	May occur under certain atmospheric conditions		May occur under certain atmospheric conditions		May occur under certain atmospheric conditions	
	3.1.	1300 acres		1300 acres		510 acres	
	3.2.	Negligible		Negligible		Negligible	
	3.3.	Minor siltation		Negligible		Negligible	
	3.4.	Walleye spawning disrupted		Walleye spawning disrupted			
	3.5.	Negligible		Negligible		Negligible	
	1.1.	65,700 Cars/yr		73,600 Cars/yr		65,700 Cars/yr	
	1.2.	1,100,000 tons		+13,200,000 gal		1,100,000 tons	
	1.3.	319,000 tons/yr		319,000 tons/yr		319,000 tons/yr	
Increased property value	2.1.	$372,000,000	Increased property value	$503,000,000	Increased property value	$580,000,000	Increased property value
	2.2.	No loss by flooding		No loss by flooding			
	2.3.	344 Houses: $1,981,000	$60,000,000	344 Houses: $1,981,000	$60,000,000		
	2.4.	4,646 Ac - $220,000/yr		4,646 Ac - $220,000/yr			
	2.5.	21,354 Ac - $152,000/yr		21,354 Ac - $152,000/yr			
	2.6.		4,100,000		4,100,000		
	2.7.	26,000 acres flooded	26,000 acres fishery created	26,000 acres flooded	26,000 acres fishery created		
	3.1.1.	Covered bridge site flooded		Covered bridge site flooded			
	3.1.2.	Fort Prince George, Cherokee	Sites surveyed	Fort Prince George, Cherokee	Sites surveyed		
	3.2.	Settings flooded	Bridge more accessible	Settings flooded	Bridge more accessible		
$24,000,000/yr	4.1.		$14,000,000/yr		$19,000,000/yr		$22,000,000/yr
Comparable to Proposal	4.2.		Larger		Larger		Larger
	5.1.1.	Disturbs natural setting		Disturbs natural setting		Disturbs natural setting	
	5.1.2.	5000 acres timber cleared		5000 acres timber cleared			
	6.1.1.	892		892		Not Estimated	
	6.1.2.	See Appendix X-1		See Appendix X-1		Not Estimated	
	6.2.	<3.6% ADA increase		<3.6% ADA increase		Temporary increase	
	6.3.	Small increase		Small increase		Small increase	
	6.4.	Small increase		Small increase		Small increase	
Significant	6.5.		$163,000,000		$163,000,000		Significant