Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

July 25, 2008

10 CFR 52.80

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

In the Matter of	)	Docket Numbers	52-014 and 52-015
Tennessee Valley Authority	)		

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO ENVIRONMENTAL REPORT REQUEST FOR ADDITIONAL INFORMATION – TERRESTRIAL ECOLOGY

Reference: Letter from Mallecia Hood (NRC) to Ashok S. Bhatnaker (TVA), Request for Additional Information Regarding the Environmental Review of the Combined License Application for Bellefonte Nuclear Plant, Units 3 and 4, dated July 11, 2008 [ML081840493].

This letter provides the Tennessee Valley Authority's (TVA) response to one of the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) items included in the reference letter.

The enclosure to this letter provides the response to one of the NRC requests related to Terrestrial Ecology and includes two attachments addressing the RAI response. The status of the seven NRC RAIs related to Terrestrial Ecology is also provided in the enclosure to this letter.

Attachment 2.4.1-1A provides a copy of TVA's *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, dated March 6, 1973.

Attachment 2.4.1-1B contains pages with **sensitive information** that are extracted from Attachment 2.4.1-1A that **TVA requests to be withheld from disclosure in accordance with 10 CFR 2.390(a)(3).** Table A-8 of the Draft Environmental Statement contains **information related to critical infrastructure and key resources required to be protected from attack and is thus exempted from disclosure in accordance with 10 CFR §2.390(a)(3), and Homeland Security Presidential Directive (HSPD-7) dated December 17, 2003.** Appendix C of the Draft Environmental Statement contains information concerning the nature

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NRO

and location of archaeological resources **exempted from disclosure in accordance with 10 CFR §2.390(a)(3), and 16 U.S.C. § 470hh.**

If you should have any questions, please contact Thomas Spink at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7062, or via email at tespink@tva.gov.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 25th day of July, 2008.

Jack A. Bailey

Jack A. Bailey
Vice President, Nuclear Generation Development
Nuclear Generation Development & Construction

Enclosure
cc: See Pages 4 and 5

Enclosure:

Response to Environmental Report Request for Additional Information – Terrestrial Ecology

Attachment:

2.4.1-1A. Tennessee Valley Authority, *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, March 6, 1973.

2.4.1-1B. WITHHELD INFORMATION, Tennessee Valley Authority, *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, March 6, 1973.

cc (Enclosure and Attachments 2.4.1-1A and 2.4.1-1B):
M. A. Hood, NRC/HQ

cc (w/o Enclosure and Attachments 2.4.1-1A and 2.4.1-1B):
cc: (Enclosures
E. Cummins, Westinghouse
S. P. Frantz, Morgan Lewis
M. W. Gettler, FP&L
R. C. Grumbir, NuStart
P. S. Hastings, NuStart
P. Hinnenkamp, Entergy
M. C. Kray, NuStart
D. Lindgren, Westinghouse
G. D. Miller, PG&N
M. C. Nolan, Westinghouse
N. T. Simms, Westinghouse
G. A. Zinke, NuStart .

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L. Reyes, NRC/RII
J. M. Sebrosky, NRC/HQ
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cc (w/o Enclosure and Attachments 2.4.1-1A and 2.4.1-1B):

G.P. Arent, EQB 1A-WBN
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RESPONSE TO ENVIRONMENTAL REPORT REQUEST FOR ADDITIONAL INFORMATION

TERRESTRIAL ECOLOGY

This enclosure provides the status of the seven requests for additional information (RAI) related to Terrestrial Ecology and provides the BLN response to one of these requests.

Status of Requests for Additional Information Related to Terrestrial Ecology

RAI Number	Date of TVA Response
• 2.4.1-1	This letter – see following pages
• 2.4.1-2	Future – expected submittal by August 4, 2008.
• 2.4.1-3	Future – expected submittal by August 6, 2008.
• 2.4.1-4	Future – expected submittal by August 4, 2008.
• 2.4.1-5	Future – expected submittal by August 6, 2008.
• 2.4.1-6	Future – expected submittal by August 6, 2008.
• 4.3.1-1	Future – expected submittal by August 6, 2008.

NRC Review of the BLN Environmental Report

NRC Environmental Category: TERRESTRIAL ECOLOGY

NRC RAI NUMBER: 2.4.1-1

Provide the document *TVA Draft Environmental Statement, Bellefonte Nuclear Plant. Volume 1 and 2 Docket Nos. 50-438 and 50-439, 6 March 1973*

BLN RESPONSE:

Attachment 2.4.1-1A to this enclosure provides the requested document, TVA's *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, dated March 6, 1973. Attachment 2.4.1-1B provides pages withheld from public disclosure under 10 CFR 2.390(a)(3).

This response is PLANT-SPECIFIC.

ASSOCIATED BLN COL APPLICATION TEXT CHANGES:

None.

ATTACHMENTS:

The following documents are provided as Attachments 2.4.1-1A and 2.4.1.1B:

2.4.1-1A. Tennessee Valley Authority, *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, March 6, 1973.

2.4.1-1B. WITHHELD INFORMATION, Tennessee Valley Authority, *Draft Environmental Statement, Bellefonte Nuclear Plant*, Volumes 1 and 2, March 6, 1973.

ATTACHMENT 2.4.1-1
TENNESSEE VALLEY AUTHORITY
DRAFT ENVIRONMENTAL STATEMENT, BELLEFONTE NUCLEAR PLANT
VOLUMES 1 AND 2
MARCH 6, 1973

Tennessee Valley Authority

Draft Environmental Statement
Bellefonte Nuclear Plant
Volumes 1 and 2

March 6, 1973

TENNESSEE VALLEY AUTHORITY

DRAFT

ENVIRONMENTAL STATEMENT

BELLEFONTE NUCLEAR PLANT

VOLUME 1

254730

SUMMARY SHEET
ENVIRONMENTAL STATEMENT
BELLEFONTE NUCLEAR PLANT

[X] Draft [ ] Final environmental statement prepared by the Tennessee Valley Authority

1. [X] Administrative action [ ] Legislative action

2. This action is the construction and operation of a 2-unit nuclear power plant in Jackson County, Alabama.

3. Construction and operation of the plant is expected to have no significant adverse impact on land use and water use. No significant adverse impact is expected on water quality, fish, or aquatic life resulting from discharges of heated water and treated radioactive, chemical, and sanitary wastes into the Tennessee River. The small quantities of radioactive materials that are released will result in doses within the limits of the Atomic Energy Commission's proposed Appendix I to 10 CFR Part 50. There should be no detectable impact due to these releases. A long-term favorable impact on the economy of the area is expected. Operation of the closed-cycle cooling towers will result in evaporation of water and release of heat into the air. The cooling tower plumes may result in occasional local fog and ice and some visual obstruction. There will be a slight increase in temperature of water returned to the Tennessee River. The small quantities of fish larvae and plankton drawn into the closed cooling system will be destroyed. Construction of the plant will result in some reservoir turbidity. A small amount of land will be converted from agricultural to industrial use. Buildup of construction employees may initially strain the public and private sectors to provide housing, schools, and other services.

4. Base-loaded coal-fired and nuclear-fueled units were considered to meet the 1979-80 winter peak load. Nuclear units were selected due to the significant environmental advantages and lower costs. Due to similar power supply situations faced by other utilities, the purchase of power in the quantities needed was not a realistic alternative.

5. Federal agencies to review are:

   - Advisory Council on Historical Preservation
   - Appalachian Regional Commission
   - Atomic Energy Commission
   - Council on Environmental Quality
   - Environmental Protection Agency
   - Federal Power Commission
   - Department of Agriculture
   - Department of Commerce
   - Department of Defense
   - Department of Health, Education and Welfare
   - Department of Housing and Urban Development
   - Department of the Interior
   - Department of Transportation

   State, regional, and local agencies to review are:

   - Alabama Development Office
   - Top of Alabama Regional Council of Governments

6. The draft statement was sent to the Council on Environmental Quality and made available to the public on March 6, 1973.

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1.0 INTRODUCTION

TVA is a corporate agency of the United States created by the Tennessee Valley Authority Act of 1933 (48 Stat. 58, as amended, 16 U.S.C. §§ 831-831dd (1970)). In addition to its programs of flood control, navigation, and regional development, TVA operates a power system supplying the power requirements for an area of approximately 80,000 square miles containing about 6 million people. Except for direct service by TVA to certain industrial customers and Federal installations with large or unusual power requirements, TVA power is supplied to the ultimate consumer by 160 municipalities and rural electric cooperatives which purchase their power requirements from TVA. TVA is interconnected at 26 points with neighboring utility systems.

The TVA generating system consists of 29 hydro generating plants and 11 fossil-fueled steam generating plants now in operation. In addition, power from Corps of Engineers' dams in the Cumberland River basin and dams owned by the Aluminum Company of America on Tennessee River tributaries is made available to TVA under long-term contracts. Figure 1.0-1 shows the location of TVA's present generating facilities and those under construction. The approximate area served by municipal and cooperative distributors of TVA power is also shown.

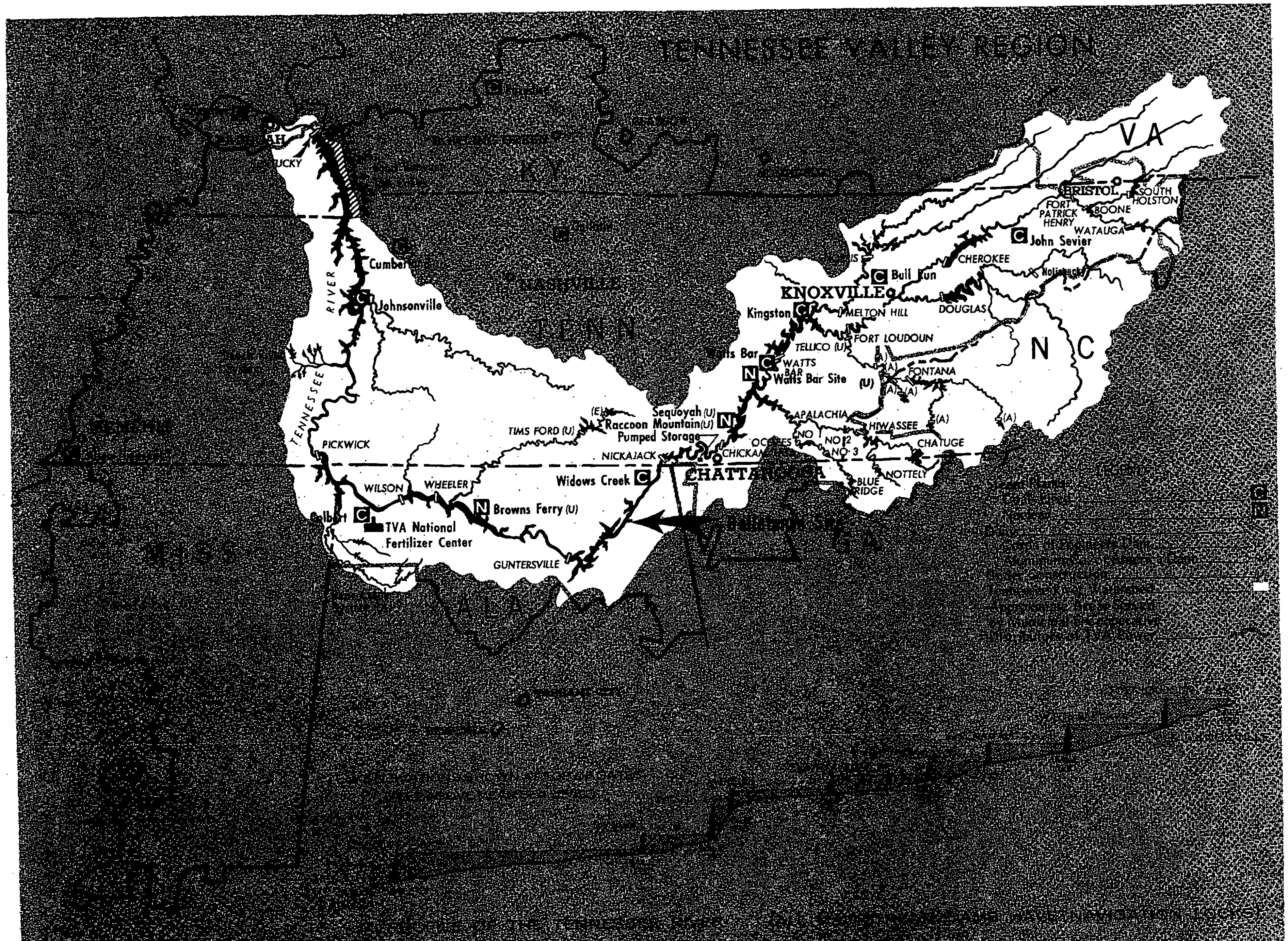
Power loads on the TVA system have doubled in the past 10 years and are expected to continue to increase in the future. In order to keep pace with the growing demand, it has been necessary to add substantial capacity to the generating and transmission system on a regular basis. The present system capacity is shown in Table 1.3-1.

This plant is proposed to satisfy in part TVA's obligation to supply an ample amount of electricity to the area which TVA serves. An application to construct and operate the plant will be filed with the Atomic Energy Commission (AEC). The decision by TVA to locate the plant at the Bellefonte site will be made considering the results of this environmental review. After extensive review of the preliminary safety analysis report and other documents by the AEC regulatory staff and the independent Advisory Committee on Reactor Safeguards and after a public hearing before an Atomic Safety and Licensing Board, AEC is expected to grant a construction permit sometime in calendar year 1974. Construction will start soon thereafter. The final safety analysis report will be submitted to AEC at a later date, along with a request for authorization to operate both units of the plant at the designed power level. Under the current schedule, TVA expects to begin to load the nuclear fuel for unit 1 in March 1979. Full power operation of unit 1 is expected in September 1979; unit 2 is expected to go into operation in June 1980.

As a Federal agency, TVA is subject to the requirements of the National Environmental Policy Act of 1969 (NEPA) which became effective on January 1, 1970. In carrying out its responsibilities under the TVA Act, TVA follows a policy designed to develop and enhance a quality environment. As a result of this policy, TVA has long considered environmental matters in its decision making. Offices and divisions within TVA employ personnel with a wide diversity of experience and academic training which enables TVA to utilize a systematic, interdisciplinary approach to insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making as required by NEPA. This statement on the environmental considerations relating to the Bellefonte Nuclear Plant is being sent to state and Federal agencies for review and comment pursuant to that Act as implemented by guidelines issued by the Council on Environmental Quality (CEQ) and Office of Management and Budget Circular A-95.

It should be noted that although the two units will begin operation at different times, this environmental statement considers the plant as operating with both units, in order to accurately assess the impact of the plant on the environment, and so that consideration of the cumulative effects of the plant can be assured.

The remainder of this statement provides a baseline inventory of environmental information and covers the environmental considerations set out in Section 102(2)(C) of NEPA, as implemented by the CEQ and AEC guidelines.


TENNESSEE VALLEY REGION
VA
BRISTOL
SOUTH HOLSTON
FORT PATRICK HENRY
BOONE
WATAUGA
John Sevier
CHEROKEE
Bull Run
KNOXVILLE
Kingston
MELTON HILL
DOUGLAS
TELLICO (U)
FORT LOUDOUN
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WATTS BAR
Watts Bar
Watts Bar Site
(U)
FONTANA
(A)
Sequoyah (U)
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Pumped Storage
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APALACHIA
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NO 3
NOTTELY
BLUE RIDGE
NICKAJACK
CHATTANOOGA
Widows Creek
Cumberland
Johnsonville
RIVER
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1.1 <u>General Information</u> - This section provides a basic knowledge of the existing environment and the important characteristics and values of the Bellefonte site as it now exists in order to establish a basis for consideration of the environmental impact of the facility.

1. <u>Location of the facility</u> - The proposed site is located on a tract of land consisting of approximately 1,500 acres on a peninsula at Tennessee River mile (TRM) 392 on the west shore of Guntersville Lake about 7 miles east-northeast of Scottsboro, Alabama. The site lies on the southeast side of Browns Valley which separates Sand Mountain on the southeast from the rest of the Cumberland Plateau on the northwest. The proximity of the site to local towns, rivers, and state boundaries is indicated on the vicinity map, figure 1.1-1.

2. <u>Physical characteristics of the facility</u> - The plant will have the following principal structures on the site: two reactor containment buildings, turbine building, auxiliary building, service building, condenser circulating water pumping station, two diesel generator buildings, river intake pumping station, natural draft cooling towers, transformer yard, 500-kV and 161-kV switchyards, and sewage treatment facilities. Figure 1.1-2 shows the preliminary arrangement of these facilities. This arrangement may change as design of the plant progresses.

The two reactor containment buildings each house a pressurized water reactor designed and manufactured by Babcock & Wilcox. The 2-unit plant will have a total electrical generator nameplate rating of 2,664 megawatts. Nuclear fuel is contained inside each reactor pressure vessel. The fuel is in sealed metal tubes and consists of slightly enriched uranium dioxide pellets. The fission process in the fuel produces heat. Water serves as both the moderator of the fission process and the coolant. The primary coolant water is pumped through the reactor from below the fuel and is heated by contact with the fuel element tubes. The reactor power is controlled by control rods, lumped burnable poison rods, and neutron-absorbing boric acid solution. The heated coolant flows in two closed-loop circuits through tubes in steam generators and then is pumped back into the reactor. In each steam generator a separate body of water flows in contact with the outside surfaces of the tubes and absorbs heat from the reactor coolant, producing steam to power the turbine generator. The electrical power thus produced by the turbine generators is fed through the switchyard and transmission line connections into the TVA system to meet system power requirements.

The principal ways in which the plant will interact with the environment, discussed later in detail, are:

1. Releases of minute quantities of radioactivity to the air and water;
2. Release of minor quantities of heat to Guntersville Lake and major quantities of heat and water vapor to the atmosphere; and
3. Change in land use from farming to industrial.

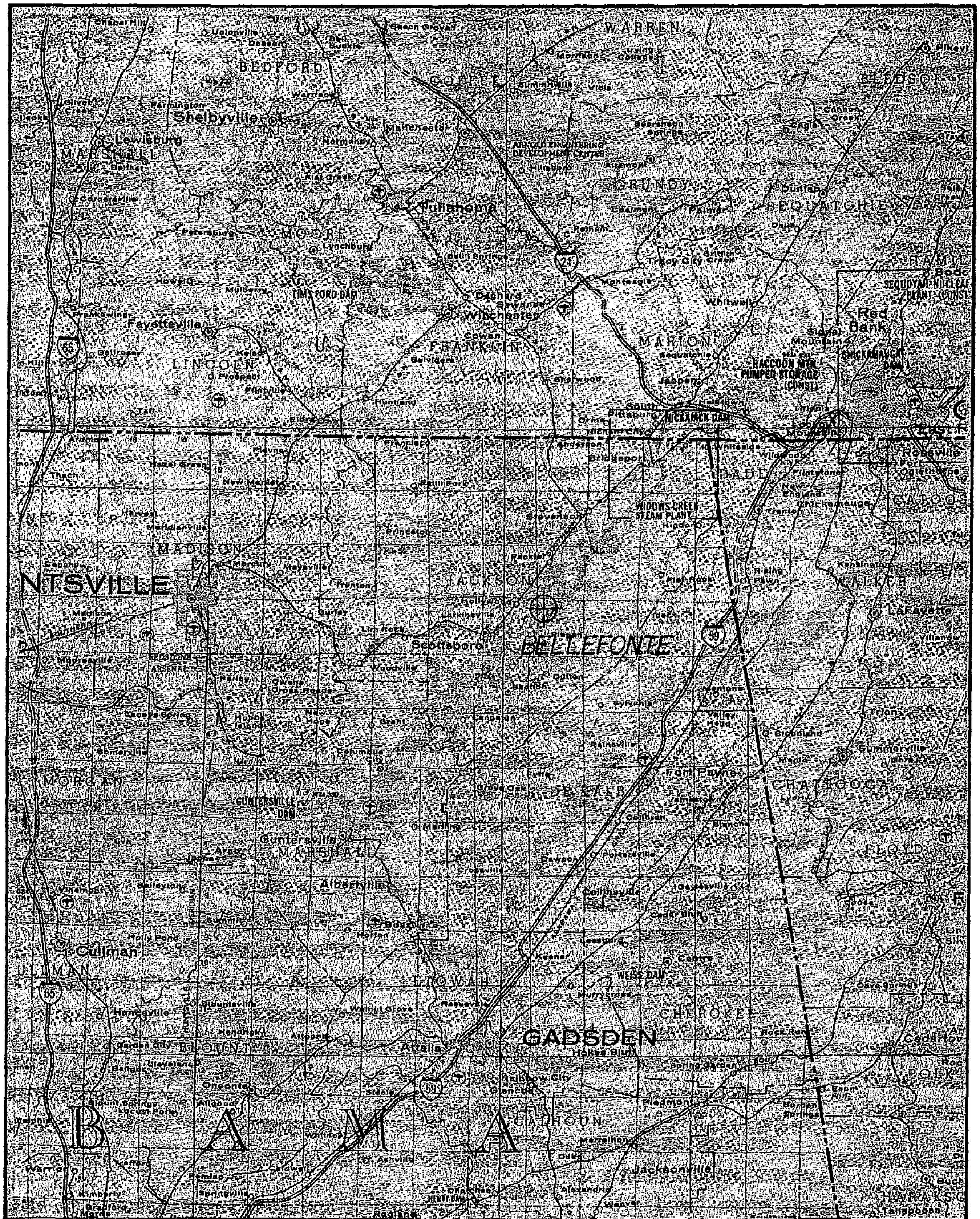


Figure 1.1-1

BELLEFONTE VICINITY MAP

(Site location - 85° 55' 35.6" W, 34° 42' 31.8"N)

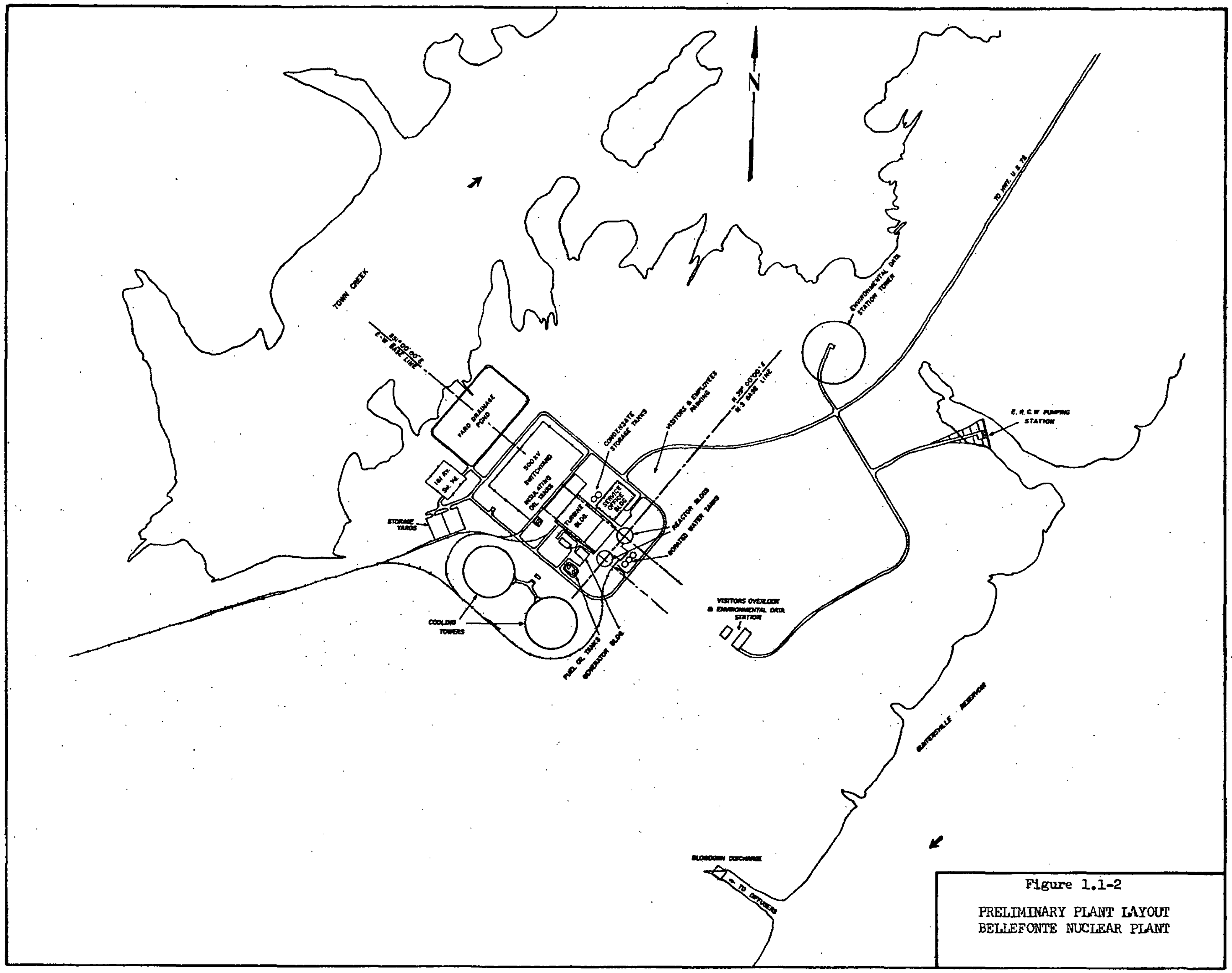


Figure 1.1-2

PRELIMINARY PLANT LAYOUT
BELLEFONTE NUCLEAR PLANT

1.2 Environment in the Area - The following summary description provides a baseline inventory of the important characteristics of the region.

1. History - The Bellefonte site is in Jackson County, Alabama. Located in the northeastern corner of the state, Jackson County is bounded by the Tennessee State Line, the Georgia State Line, and by DeKalb, Marshall, and Madison Counties. The county was created by an Act of the State Legislature on December 13, 1819. It was named for General Andrew Jackson, hero of the Creek Indian War and seventh President of the United States. Upon the formation of the county, Santa Cave was the temporary county seat but in 1821 Bellefonte was chosen. In 1850 the county seat was removed to Scottsboro, where it has remained.[1]

2. Topography - The Bellefonte site is a moderately wooded area with steep hills on the eastern portion of the tract. The plant will be located west of these hills. On the site, the land rises from the water surface (normal maximum level elevation 595 feet above mean sea level) to a hill crest approximately 800 feet above mean sea level. Across the river, the west escarpment of Sand Mountain rises to approximately 1,400 feet above mean sea level. The general topographic features of the site and nearby areas are shown on Figure A-3 (Appendix A).

3. Geology - The site lies on the southeast side of Browns Valley, which separates Sand Mountain on the southeast from the rest of the Cumberland Plateau to the northwest. Browns Valley in Alabama and its northeastward extension in Tennessee - Sequatchie Valley - were formed as the result of erosion of an anticlinal structure which

extends for over 150 miles from Blount Springs, Alabama, northeastward to Crab Orchard, Tennessee. The rock strata exposed by the anticline range from Cambro-Ordovician dolomite in the core up through Ordovician limestone; Silurian limestone, shale, and sandstone; Mississippian limestone and shale; to Pennsylvanian sandstone and shale on Sand Mountain and the Cumberland Plateau. The major portion of the site is in Section 7, Tier 4 South, Range 7 East.

Included as Figures 1.2-1 to Figure 1.2-4 are the regional tectonic map, regional geologic map, geologic and tectonic map of the plant area, and geologic map of the plant site.

Structures at the Bellefonte site would be founded on Chickamauga limestone of Middle Ordovician Age. The limestone of the Chickamauga strata occur along the entire length of the eastern side of the anticlinal valley and along most of the western side. At the site the strike of the strata is N 40°E and the dip is 17° southeast. The Chickamauga is slightly over 1,400 feet thick in the area and is overlain by approximately 150 feet of limestone, shale, and sandstone of the Silurian Red Mountain Formation and is underlain by several thousand feet of Cambro-Ordovician Knox dolomite.

Exploration and construction activities at the site will not destroy outcrop areas of significant geologic value. In fact, cores from exploratory drilling and exposures in foundation excavations will allow detailed geologic studies to be made in an area that otherwise contains few bedrock exposures. Representatives of the Alabama and Tennessee Geological Surveys have studied cores from the preliminary exploratory drilling and will be advised when additional material is available for further study.

No mineral deposits are being worked in the area. Studies of potential iron ore deposits in the Guntersville Reservoir area included investigation of the Red Mountain Formation at Sublett Ferry in the southwest corner of the site area. Detailed stratigraphic measurements of 150 feet of the formation disclosed no commercially mineable iron ore. The Red Mountain Formation is the host rock for iron ore in the Birmingham District where the formation is 300-500 feet thick and contains beds of ore up to 15 feet thick. In the Browns Valley area, the formation is much thinner and has no distinct iron ore beds. Instead, streaks of ferruginous sandy limestone occur intermittently throughout the section, but nowhere do these have high enough iron content or sufficient thickness to be commercially productive.

There is no indicated potential for any oil and gas production in the area. The latest information furnished by the Alabama Geological Survey indicates that only two exploratory holes have been drilled in Jackson County, both in 1913.[2] One was near Stevenson and the other near Bridgeport. Both were nonproductive.

4. Seismology - The site lies within the borders of the Southern Appalachian seismotectonic province. Figure 1.2-5 locates the nearest faults in the region.

The nearest local quake with a Modified Mercalli intensity of V was centered 5 miles west of the site. The nearest known epicenter of a damaging quake (MM VII) was approximately 50 miles south of the site. The maximum intensity felt at the site from the latter quake was probably no higher than MM IV. Accelerations at the site from a recurrence of these shocks would be far less than the assumed seismic event: a MM VIII shock, centered at the site, with an acceleration of 0.18g. The seismic history of the Bellefonte area is similar to that presented for the Sequoyah Nuclear Plant.[3]

5. Climatology and meteorology - The site is located in a temperate latitude about 250 miles north of the Gulf of Mexico. The area is dominated in winter and spring by alternating cool dry continental air from the north and warm moist maritime air from the south. During this period, migratory cyclonic disturbances cause frequent precipitation and moderate wind. Storms, including tornadoes, reach severest intensity in March and April.

In summer and fall the migratory systems are less frequent and less intense, and the area is generally dominated by the western portion of the Azores-Bermuda anticyclonic circulation. In the fall extensive periods of weak wind and stable atmospheric conditions most likely occur and result in the least favorable atmospheric dispersion conditions. Days of high air pollution potential that would likely affect the area should number about 6 days annually.

Tornadoes in the area generally move northeastward up the valley and cover an average surface path 5 miles long and 150 yards wide. However, the probability of a tornado occuring at the site is extremely low, about once in 15,000 years. Severe windstorms may occur several times a year, with wind speeds reaching 45 mi/h and on occasion exceeding 75 mi/h. High wind may accompany moderate-to-strong cold frontal passages 30 to 40 times a year with maximum frequency in March and April. Strong wind may accompany thunderstorms about 60 times a year with maximum frequency in July.

Average monthly temperatures in the area range from about 43°F in January to about 79°F in July. The maximum annual temperature range, from 109°F in July to -16°F in February, is 125°F. Detailed temperature data for Scottsboro, Alabama are shown in Table 1.2-1.

Approximately 60 percent of the annual average precipitation of about 56 inches, in the plant site area results from migratory cyclonic disturbances from late November through April (Table 1.2-2). Snowfall data is in Table 1.2-3.

No records of the frequency and intensity of fogs are available for the Bellefonte site area. However, Chattanooga records (Table 1.2-4) indicate that heavy fogs (visibility equal or less than 1/4 mile) occur on 36 days annually with a maximum of 6 days in October and a minimum of 2 days from February through July.

Wind patterns in the area should be similar to those near the Widows Creek Steam Plant about 15 miles northeast of the site where data have been collected since 1964. Both plant sites have similar physiographic features. At Widows Creek the mean wind throughout the lower 600 to 800 feet is markedly bimodal (Figure 1.2-6) with northeasterly (NNE-NE) downvalley wind occurring about 22 percent of the time and southwesterly (SSW-SW) upvalley wind occuring about 24 percent of the time. About 70 percent of the downvalley wind is between 1 and 3 mi/h and occurs most frequently in September.
One year of monitoring data at the Bellefonte site shows calm conditions occurring about 15 percent of the time and wind speeds, 1 to 3 mi/h, occurring about 58 percent of the time. This excessive frequency of weak wind conditions is due in part to the higher starting threshold (2 to 3 mi/h) of the older model wind speed sensor which has operated

since 1964 at the Widows Creek power plant meteorological facility relative to that sensor at the temporary meteorological facility (starting threshold of 0.6 mph).

Wind patterns on Sand Mountain tend to reflect the regional windflow, which is quite dissimilar to that in the lower valley. The directional frequency pattern on Sand Mountain (Figure 1.2-7) shows a rather uniform distribution, with somewhat higher frequencies of southeasterly, southwesterly, and northwesterly winds. Average wind speeds are about 2 to 3 mi/h higher than those in the valley.

Because of the limited record of data from the temporary meteorological facility near the Bellefonte plant site, an extrapolated evaluation of the atmospheric dispersion conditions in the form of a joint frequency distribution of wind direction, wind speed, and stability was developed. The evaluation was based primarily on the (1) comparative wind direction and wind speed data from the Widows Creek Steam Plant and the Sequoyah Nuclear Plant, (2) temperature gradient data from the Sequoyah Nuclear Plant - adjusted to the Bellefonte plant site, and (3) stability percentage of occurrence (Pasquill classes A through G) at the Sequoyah Nuclear Plant - adjusted to the Bellefonte plant site (Table 1.2-5).

A breakdown of the estimated occurrence of the individual stability categories, A through G, with respect to wind direction and wind speed is shown in Tables 1.2-6 through 1.2-12. Most significant is the percent occurrence of the 0-3.4 mph wind speed range for the F and G categories which are usually identified with the most adverse onsite atmospheric dispersion conditions. The respective values are about 26 and 11 percent.

The principal effect of the valley-ridge terrain features on the atmospheric dispersion of effluent releases is one of confinement within the valley, particularly during weak and stable upvalley (southwesterly) and downvalley (northeasterly) flow. Also, with the relatively flat and undulating valley floor, there should be minimal discontinuity of the low-level windflow from terrain roughness and irregularity.

The temporary meteorological facility began operation May 12, 1972, at a site about 2 miles north-northeast of the Bellefonte plant site and at or near plant grade. The facility consists of a 130-foot steel tower with an instrument building near the tower base. The data, processed by a pulse-o-matic automatic data logging system, consist of (1) wind speed and wind direction at 130 feet, and (2) temperature at 33 feet (10 meters) and 130 feet. In early 1973 additional wind direction, wind speed, temperature and dew point sensors will be installed.

On October 3, 1972, another temporary meteorological facility began operation on the immediate plant site. This facility, having continuous analog recording of wind direction and wind speed at 33 feet, was installed to obtain further data on the onsite low-level wind conditions.

Well in advance of fuel loading and in ample time to collect adequate data for preparing a precise evaluation of the onsite dispersion conditions, the permanent meteorological facility will become operational. The facility will be located on the immediate plant site and will consist of a 300-foot steel tower with instrument building (environmental data station). The data collected and processed by a high speed digital computer system will include (1) wind direction and wind speed at 33 and 300 feet; (2) atmospheric turbulence (sigma-y and sigma-z) at 33 and 300 feet; (3) temperature and dew point at 4, 33, 150, and 300 feet; and (4) solar radiation, total radiation, atmospheric pressure, and rainfall at 4 feet.

Also, plans are now being made to conduct special field studies before plant construction to identify the representative onsite atmospheric dispersion conditions or, more specifically, to develop reliable diffusion parameters for estimating maximum ground-level concentrations attributable to postulated accident and/or normal effluent releases.

6. Hydrology and water quality -

(1) Ground water - Ground water at the site is derived principally from precipitation, which has averaged about 56 inches per year.

There is no distinct aquifer in the Chickamauga limestone at the Bellefonte site. The majority of the ground water flow moves through the residual soil overlying rock paralleling the topographic surface. Only minor amounts of water penetrate small fractures and cracks in the argillaceous limestone. Observation of water levels in exploratory holes indicates a piezeometric surface slightly above the top of bedrock which slopes with the topography toward the Town Creek embayment of Guntersville Lake north of the site area. Ground water will flow from the site to Town Creek embayment and reservoir. Drilling of more than 80 exploratory holes in the site area has disclosed no indication of major solution channels in the Chickamauga limestone. Pressure testing of these holes has shown them to be tight with no acceptance of water up to pressures of 50 lb/in^2.

(2) <u>Surface water</u> - Surface water is derived from precipitation remaining after losses. It can be generally classified as local surface runoff or streamflow.

(a) <u>Reservoir description</u> - The site is located 43 miles upstream of Guntersville Dam. At normal pool elevation of 595 feet, the reservoir is 75.7 miles long with an area of 67,900 acres, a volume of 900,000 acre-feet, a shoreline length of 959 miles, and a width which ranges from 900 feet to 2.5 miles. At the site it is about 3,400 feet wide, with depths ranging up to 30 feet at normal pool elevation. Navigation is provided by maintaining a minimum channel depth of 11 feet. Flow is in a general southwesterly direction.

(b) <u>Streamflow</u> - Records maintained at South Pittsburg, Tennessee, and Hales Bar Dam for the period 1931 through 1970 show an average discharge of 35,300 ft^3/s at South Pittsburg. The flow at Bellefonte would be about 3 percent greater. During the summer months (May-October) the flow averages 27,100 ft^3/s and during the winter months (November-April), averages 44,200 ft^3/s.

Channel velocities at the plant site average 1.1 feet per second under normal winter flow conditions and 0.6 foot per second under normal summer conditions. Reversals of flow into the embayments occur as a result of water management practices.

(c) Water quality - A detailed water quality study of Guntersville Reservoir was made during the 12-month period from May 1963 through April 1964.[4] This study included an assessment of both the quality conditions and the uses of Guntersville Reservoir waters. The locations of points where water quality data were collected are shown in Figure 1.2-8.

Results of the bacteriological sampling indicate that the 30 miles of the reservoir upstream from the mouth of Mud Creek (about 2 miles upstream from the Bellefonte Plant site) was seriously polluted by the discharge of untreated or partially treated wastes to the Tennessee River at Chattanooga. This section of Guntersville Reservoir was judged unsatisfactory for swimming and other water-contact recreation. Recent improvements in waste treatment facilities at Chattanooga have greatly reduced the discharge of untreated sewage to the Tennessee River. The results of bacteriological studies made during the recreational season of 1971 and 1972 show that the waters of the Tennessee River downstream from the old Hales Bar Dam (TRM 431.1) are now suitable for water-contact recreation.

The sanitary-chemical and mineral quality of Guntersville Reservoir water was found to be high quality. The water is soft to moderately hard and low in organic content, iron, and manganese. The mineral quality of the water is satisfactory for almost any municipal or industrial use. The bacteriological, sanitary-chemical, and mineral quality data collected during 1963-1964 at Tennessee River mile 385.9 (about 6 miles downstream from the plant site) are shown in Table 1.2-13.

The radiological quality of water was determined by samples collected from two stations at approximately monthly intervals over the one-year survey period. A three-point composited sample (surface, mid-depth, and near the bottom) from Tennessee River mile 350.4, and a surface sample from Tennessee River mile 385.9, were analyzed to determine alpha and beta radioactivities. The results of these analyses are shown in Table 1.2-14. Alpha-particulate activities ranged from 0 to 2 picocuries per liter while beta activity ranged from 7 to 33 picocuries per liter.

(d) Water temperature and dissolved oxygen - The water temperature and dissolved oxygen profiles observed in Guntersville Reservoir in 1963-1964 during typical spring, summer, fall, and winter months are shown in Figure 1.2-9.

Near river mile 380 mild thermal stratification developed during the warmer months, associated with diminishing DO concentrations in the lower levels of the reservoir. Downstream from mile 380 thermal stratification and DO deficits in the lower levels usually became more pronounced. Depressed DO concentrations at the lower elevations in Guntersville Reservoir were attributed principally to (1) inflow of water from Hales Bar Reservoir that was low in DO, (2) poor vertical mixing in the downstream end of the pool of the warmer surface water and the cooler water near the bottom, and (3) decomposing plankton and other organic material that settle in the downstream end of the pool from the well-aerated surface layers into the cooler waters below.

Since 1960, TVA has been monitoring, on a weekly basis, the water temperatures and dissolved oxygen concentrations in the releases from its hydro projects. The water temperature and DO concentrations of the releases from Hales Bar and Guntersville Dams during calendar years 1963 and 1964 are shown in Figure 1.2-10. These data show that during the summer, water leaving Guntersville Dam was slightly warmer and contained slightly more DO than when it passed through Hales Bar Dam. The addition of unit number 8 at Widows Creek Steam Plant (TRM 408) in 1965 and the closure of Nickajack Dam (replaced Hales Bar Dam located about six miles upstream) in 1967 probably resulted in water temperatures in Guntersville Reservoir slightly warmer than those observed in 1963-1964, although no data are available to document this. The water temperatures of the releases from Nickajack and Guntersville Dams are summarized in Table 1.2-15.

(3) Water use - From its head near Knoxville to Kentucky Dam near its mouth, the Tennessee River is a series of highly controlled multi-purpose reservoirs. This chain of reservoirs provides flood control, navigation, generation of electric power, sport and commericial fishing, industrial and public water supply, recreation and waste disposal.

Water use in the area is not limited to reservoir water, since several public and private water supplies are taken from ground water sources. These withdrawals are small compared with reservoir uses.

There are seven public water supplies taken from Guntersville Reservoir and its tributary embayments. The nearest downstream supplies are Scottsboro and the Sand Mountain Water Authority, 6.2 and 9.9 miles below the site. Thirteen public ground water supplies are within a 20-mile radius of the site (Figure 1.2-11). The ground water supply nearest the site is 3.4 miles west at Hollywood, serving 485 people. In addition, two public water supplies (Bridgeport and Arab, Alabama) use both surface waters of Guntersville Reservoir and ground waters as their source of supply.

There are four industrial water supplies taken from Guntersville Reservoir and its tributary embayments. Only one of these, the TVA Widows Creek Steam Plant, is within 20 miles of the site. The nearest downstream industrial water supply intake is for the Monsanto synthetic fiber plant at TRM 365 (27 miles downstream). Water from this supply is also used for potable water within the plant. All other industries in the vicinity of the site purchase their process and potable water from public systems. Detailed information on public and industrial water use is in Table 1.2-16.

7. Land Use - For many years, relative isolation due to the topography associated with the Cumberland Plateau has kept the towns within the Sequatchie Valley and its extension into North Alabama from the mainstream of industrialization and urbanization occurring in the Great Valley (Chattanooga and Gadsden) and on the Highland Rim (Tullahoma and Huntsville). However, in recent years several urban-industrial nodes have been developing along the Guntersville Reservoir within the Sequatchie Valley extension (Guntersville, Scottsboro, Stevenson, Bridgeport, and South Pittsburg). Better road access, ample labor and

available waterfront sites have all contributed to the gradual extension of urban-industrial development into the valley. Scottsboro, about 7 miles west-southwest of the site, is the nearest and most important emerging center with a 1970 population of 9,324.

Surrounding these urban-industrial nodes in the river bottomland are extensive agricultural areas. On the Cumberland Plateau to the east, very low-density residential development is scattered among farms specializing in high-value cultivated crops. To the west the plateau is more suitable for forestry and forest related activities and has been primarily so utilized.

The 1971 land use in the site area is shown in Figure A-1 (Appendix A). A more complete description of current local land use is provided in Appendix A. Summary discussions of land use categories are given below.

(1) Industrial operations - Several manufacturing plants are located in and around Scottsboro. The two most important are Revere Copper and Brass Corporation and Goodyear Tire and Rubber Company. Revere is located on a peninusla south of Scottsboro, while Goodyear is on a part of a large tract on the southwest edge of the city.

(2) Farming - Jackson County, according to the 1969 Census of Agriculture, had about 44 percent of its land area in farms. The average size of the 2,044 farms was 145 acres, with only 85 being 200 acres or larger. Farm sales were derived principally from livestock, poultry, and their products, with the major farm sales area being poultry and poultry products (about 34.8 percent gross farm sales). Gross sales were about $13.9 million for an average of about $6,800 per farm.

(3) <u>Transportation</u> - U.S. Highway 72, connecting Chattanooga, Tennessee, and Huntsville, Alabama, passes about two miles to the northwest of the proposed site. The Alabama State Highway Department is improving U.S. 72 from Huntsville eastward to the Tennessee line to a four-lane divided highway with unlimited access. Interstate Highway 59 is approximately twenty miles to the southeast of the site. The Southern Railway line between Chattanooga and Huntsville passes about three miles northwest of the site. Barge traffic on Guntersville Reservoir is discussed below.

(4) <u>Recreation</u> - Guntersville Reservoir is especially attractive for water-based recreation. With an average annual use level of over 5 million visits, it ranks second in popularity among all TVA reservoirs. Reservoir use is concentrated primarily in the 7-month period from April through October, within which an estimated 85 percent of the annual use occurs.

Recreation developments on the reservoir include a state park, 3 county parks, 5 municipal parks, 3 wildlife management areas, 26 public access areas, 28 commercial docks or resorts, and several private group camps and club sites. TVA and the State of Alabama plan to augment the system of public access areas on the reservoir, and several of the public parks will be expanded over the next few years. Sand Mountain, an attractive wooded ridgeline, parallels the east shore of the reservoir.

Away from Guntersville Reservoir a variety of recreational attractions exist within a 60-mile radius of the Bellefonte site. Included within this area are all or parts of several Federal or private reservoirs, a portion of the Chattahoochee National Forest, the Wheeler National Wildlife Refuge, Russell Cave National Monument, several state parks and forests, and several commercial recreation attractions.

(5) Wildlife areas - Several wildlife management areas are located in the vicinity of the site. Three, primarily for waterfowl, are located on North Sauty Creek, Mud Creek, and Crow Creek embayments. An upland game area, Skyline Game Management Area, is about thirteen miles north of the site. During hunting seasons, these areas add to recreational activity by attracting hunters.

(6) Population distribution - Jackson County is sparsely settled with a 1970 population of 39,202. Net population growth in the county between 1960 and 1970 totaled 2,521, for a 6.9 percent increase. Scottsboro, the county seat, is the largest city in the area with a 1970 population of 9,324. The remainder of the population is scattered among farms, rural nonfarm residences, and small towns of less than 3,000 people. Figures 1.2-12 and 1.2-13 show the 1970 population distributions within 10 miles and 50 miles respectively of the site. Figures 1.2-14 and 1.2-15 show projected year 2020 population distributions within 10 miles and 50 miles, respectively, of the site.

Population within 60 miles totals 1,313,515. Slightly over 50 percent is in towns with more than 2,500 people and two-thirds of this is located in the three metropolitan areas of Huntsville, Chattanooga, and Gadsden.

(7) Waterways -

(a) Navigation use - For the years 1971 and 1972, barge and recreational use of the Tennessee River both upstream at Nickajack Lock and downstream at Guntersville Lock are given below:

		Guntersville Lock	Nickajack Lock
Tons	1971	4,955,888	2,808,638
	1972	4,057,000	2,526,000
Number of Barges	1971	7,227	4,701
	1972	6,009	5,253
Number of Tows	1971	1,158	1,057
	1972	1,011	1,261
Number of Recreational Craft	1971	3,127	1,098
	1972	3,847	1,427

The apparent inconsistency between the tonnage and number of barges and tows for the Nickajack Lock results from a change in the composition of the tows traversing this particular lock.

(b) Growth - Total tonnage for the Tennessee River in 1970 was 25.5 million tons and in 1971 was 27.7 million tons. Estimates indicate that Tennessee River traffic will experience an average growth rate of about 4.8 percent annually to 1980, when it will reach about 40.5 million tons.

(8) Forestry - A TVA field survey conducted in September 1972 showed that 57 percent of the area around the proposed Bellefonte Nuclear Plant is forested. Average growing stock is 870 cubic feet of merchantable timber per acre with 24 percent softwoods and 76 percent hardwoods. The sawtimber volume is 2,010 board feet per acre, 32 percent of which is softwoods. Current wood volumes on the site are below the averages of 950 cubic feet and 2,670 board feet for Jackson County, Alabama and 900 cubic feet and 3,230 board feet for the entire Tennessee River Valley.

A field survey conducted in 1962 indicated that of the land in Jackson County 60.8 percent was forested, 34.7 percent was nonforested, and 4.5 percent was covered by water. Volume of growing stock was 319.4 million cubic feet, with 93 percent hardwoods and 7 percent softwoods.

(9) Government reservations and installations - The Tennessee Valley Authority's Nickajack Dam, Guntersville Dam, and Widows Creek Steam Plant and the Department of the Interior's Russell Cave National Monument are the only government installations in the general area of the plant. Redstone Arsenal near Huntsville, Alabama, is located approximately 40 miles west of the site.

8. Ecological surveys - The plant site and adjacent waters have been examined and assessed. No rare or endangered species are known or expected to be threatened on the Bellefonte site. Collected data, species lists, sampling areas and procedures, charts, and other detailed information appear in Appendix B. Appendix B has four subsections, B1 through B4, discussed in the paragraphs below.

(1) Fish and aquatic macrophytes - The most current surveys of the fishery resource of Guntersville Reservoir and of the vicinity of the proposed plant site were conducted in 1971 and 1972 and are detailed in Appendix B1. The two surveys yielded 50 species among 27 genera belonging to 14 families of fish. Comparison of the reservoir-wide 1971 survey with recent results from other TVA lower mainstream reservoirs indicates that Guntersville ranks first in numerical standing stock of harvestable sport species and fourth in commercial species.

In the 1972 site survey, the Mud Creek and Town Creek embayments contained greater percentages of young-of-the-year fish than did the mainstream cove; the majority of these in the embayments were game species, primarily centrarchids. Other sampling operations yielded essentially similar information in terms of species importance.

The aquatic habitat in the vicinity of the plant site supports a diverse piscine fauna dominated by three families: Centrarchidae, Clupeidae and Scianidae. Embayments support large numbers of young game fish; the mainstream supports rough and forage species and adult game species. The most important game species identified in the creel census were white crappie, bluegill, redear sunfish and largemouth bass. Cove-rotenone and meter-net data indicate that all four species are utilizing this area as a reproductive and nursery area. Important commercial species of Guntersville Reservoir as identified in a 1971 survey were catfish, buffalo, carp and drum; these species appeared in the collections of the 1972 biological survey, but the role of the embayments with regard to these is not clear. Forage species, primarily gizzard shad, but with substantial numbers of cyprinids contributing, were found in all areas.

A series of rooted aquatic macrophytes periodically appear at the interface between water and land and out into deeper water. These plants develop in relation to site contours and light penetration. They grade from emergent, to floating leaved, to totally submerged. A preliminary survey of the species found is shown in Table 1.2-17.

Three invading aquatic species identified are Eurasian watermilfoil (Myriophyllum spicatum), Asiatic clams (Corbicula manilensis) and the freshwater shrimp (Palaemonetes kadiakensis), each of which is colonizing extensive areas of Guntersville Reservoir.

(2) Mammals, birds, herptiles, and rare and endangered animal species - Appendix B2 provides the ecological survey for mammals, birds and herptiles. Also included is a listing of rare and endangered animal species which could possibly inhabit the area. Summary discussion of these items is provided below.

(a) Mammals - A qualitative assessment of the Bellefonte site mammal populations was made based on a comprehensive vegetative analysis (Appendix B3) of the area, knowledge of past land use practices, a review of a list of mammals found on Wheeler National Wildlife Refuge and Burt's A Field Guide to the Mammals, 1952. Species known to occur at Wheeler Refuge and those whose distributional limits include the plant site area are listed in Appendix B2.

There are several of the larger mammals represented on the Bellefonte site such as the white-tailed deer, gray fox and cottontail rabbit. In addition, because of the habitat variety afforded by different plant associations occurring in small intermixed areas, there are expected to be moderate to large populations of a large variety of small mammals.

(b) Birds - The list of birds given in Appendix B2 is a composite listing of species which likely nest and winter in the Bellefonte area and those that migrate through Jackson County.

The good mixture of forest and open vegetative types and large degree of openness within forest types available at Bellefonte provides an abundance of niches favoring a diverse bird population.

A species commonly seen on large TVA reservoirs is the Osprey, or Fish Hawk. This bird is not listed as rare or endangered by the Department of the Interior at the present time, but is rapidly decreasing in numbers and may well be placed on the list of threatened species within the next few years. Ospreys have been known to nest on channel marker buoys in Watts Bar, Chickamauga, and other TVA mainstream reservoirs.

The Prothonotary Warbler is conspicuously present in late spring and early summer, breeding in the littoral areas in hollow willows and other tree species. Also, numerous Great Blue Herons and Green Herons use the area.

The Wood Duck is the only waterfowl species which nests frequently in the vicinity of the Bellefonte site. The close proximity of state and federal waterfowl management areas, however, attracts a large number of ducks and geese during the winter months. These birds fly considerable distances in their daily feeding excursions and frequent the waters adjacent to the site. The abundance of aquatic and riparian vegetation in and around the shallow waters of the Bellefonte peninsula serve as natural attractants to waterfowl. These plants are listed and rated for cover and food values in Appendix B2.

The State of Alabama operates four different waterfowl management areas in the vicinity of the plant site (North Sauty, Mud Creek, Crow Creek, and Raccoon Creek). The Mud Creek Waterfowl Management Area is operated on TVA land leased to the State of Alabama and is nearest the site. Virtually all development and hunting activity within the Mud Creek Area is more than four miles north of the proposed plant site.

(c) Herptiles - There are no published accounts dealing specifically with the reptiles and amphibians of Jackson County. An account by Penn (1940) provided an annotated list of species and subspecies collected in Mentone, DeKalb County, and vicinity, and this was used for many years as a source of reference to the herpetology of northeastern Alabama. Within recent years, field crews from Auburn University have made a number of trips to Jackson County for the purpose of making comprehensive collections of reptiles and amphibians. Most of the specimens obtained have been placed in the Auburn University Museum. A total of 81 species, representing 20 families, are thought to occur in Jackson County. The wide variety of habitats found on the proposed plant site doubtless harbor diverse herptile populations (See Appendix B2).

(d) Rare and endangered animal species - After careful review of fauna suspected to inhabit or migrate through the Bellefonte site and those animals whose distributional limits encompass the site, it was found that several species listed by the Department of the Interior Office of Rare and Endangered Species as threatened with extinction could conceivably be found in the area at certain times during the year. The Southern Bald Eagle is commonly seen on Watts Bar and Chickamauga Lakes upstream from Guntersville and these birds are occasionally seen at Wheeler National Wildlife Refuge. Two extremely rare species, American Peregrine Falcon and Red-cockaded Woodpecker, have been seen on Wheeler Refuge. Bachman's Warbler and Kirtland's Warbler could conceivably migrate through the area, but neither have been recorded at Wheeler Refuge. The Indiana bat, another endangered species, is a cave dweller and would be unlikely in the area, since there are no known caves on the Bellefonte site.

The Alabama Department of Conservation and Natural Resources has also published a list of rare and endangered species. Several animal species not included in the Department of Interior list are considered rare or endangered by Alabama. The southeastern shrew, southeastern myotis, and hoary bat are mammals considered to be threatened in Alabama. The Sharpshinned Hawk, Cooper's Hawk, Golden Eagle, Osprey, Peregrine Falcon, Bewick's Wren, and Ruffed Grouse along with the Bald Eagle are also considered threatened. Rare or endangered Alabama herptiles are the red milk snake and the Tennessee cave salamander. Appendix B2 contains a composite listing of rare and endangered animal species.

(3) Vegetation - The vegetation survey, made in September 1972, encompasses an area of 1,090 acres around the proposed Bellefonte Nuclear Plant site. No rare or endangered plant species listed in the U.S. Forest Service listing of southern wildflowers were found during ecological investigations. The state of Alabama has published no official listing of rare or endangered plant species.

The results are contained in Appendix B3. The five major vegetation types and their percentage of the site area are: cultivated land, 21 percent; elm-ash-soft maple, 17 percent; oak-hickory, 15 percent; mixed conifers and hardwoods, 15 percent; and broom sedge-lespedeza, 14 percent. Figure B3-1 indicates the location and distribution of the eight recognized vegetation types.

Recent heavy logging has substantially reduced the timber volume and perhaps changed the species frequency in the wooded types. This disruptive activity has opened the canopy and has encouraged an increase of low growing plant forms. A summary description of vegetation types is given below. Detailed discussions and descriptions of the types of understory species is given in Appendix B3.

(a) Elm-ash-soft maple - Twenty-nine percent of the forested plots were classified as elm-ash-soft maple. Winged elm, ash, and sweetgum were the remaining dominants in the heavily cut-over stands. Nine percent were in large sawtimber, 36 percent were in small sawtimber, 45 percent were in pole size stands, and 9 percent were classified as seedling and sapling stands. These figures reflect the fact that most of the forested land has been heavily logged.

(b) Mixed conifers and Hardwoods - Twenty-six percent of all forest stands were grouped as mixed conifers and hardwoods. These stands are found on well-drained soils on all topographic sites. Some stands were dominated by redcedar, some by loblolly or Virginia pine, some by other species. Due to only minor differences between plots these species were lumped together into a single broad type. (Two small, almost pure stands of pole-size loblolly pine are shown in Figure B3-1. Since the stands are small enough that no plots were located in them, however, they are not included as a separate type.)

In general, logging was much less intense in these mixed stands. Twenty percent were in large sawtimber and 60 percent were in small sawtimber, while only 20 percent were pole size.

(c) Oak-hickory - Twenty-six percent of the forested land was classified in the oak-hickory type. These stands consist of oaks and hickories with the more common associates including sweetgum, black locust, and sugar maple. Stands are found on moderate to well drained soils on the high terraces and hilly slopes. Twenty percent of the stands were in large sawtimber, 30 percent were in small sawtimber, 40 percent were in pole size timber, and 10 percent were in the seedling and sapling stand size.

(d) Black locust - Eleven percent of all wooded stands were classified as black locust. These were found on the lower slopes and terraces on well drained soils. Half of the stands were in pole size timber while the remaining half were split equally between small sawtimber and seedling-sapling stand sizes.

(e) Oak-gum - Eight percent of all sampled forest stands belonged to the oak-gum type. These stands were composed largely of cherrybark oak, water oak, and sweetgum. The stands were confined for the most part to bottomland sites on which drainage was poor. Two-thirds of the stands were classified as small sawtimber and one-third were pole size stands.

(f) Broom sedge-lespedeza - Nine plots representing 32 percent of the open land were classified as broom sedge-lespedeza. Broom sedge, sericea lespedeza, and assorted other grasses dominated the communities. The average percent cover for all species was 94 percent.

(g) Ragweed - Eighteen percent of the open land was placed in the ragweed community type. Average percent cover for all species was 96 percent. Ragweed and grasses dominated the community.

(4) Other aquatic life - The water level of the reservoir is managed within a narrow fluctuation limit of about 2 feet annually. Due to gradual slopes, extensive shallows are dewatered during periods of drawdown. These areas provide good habitat for species with short life cycles such as midges. These areas are not readily utilized by long lived species such as mussels; but snails may move in and out of these areas with the fluctuation in water levels.

When a stable pool is maintained, the natural river flow passes through the reservoir rapidly so that suspended or drifting organisms are retained in the reservoir for only a short time. Embayments and overbank areas protected by islands provide good aquatic environments throughout the year. The most stable shoreline habitat and environment is in the zones of embayments or along channels and islands with steep slopes.

The organisms found in the vicinity of the Bellefonte site are listed and described in Appendix B4.

9. Historical and archeological significance of the site - Adjacent to the plant site is the location of the former Jackson County seat of Bellefonte. It is listed in the Alabama Statewide Plan of Historic Preservation and the site is being processed for nomination to the National Register of Historical Places. An old tavern, dating back to 1845, is still standing but is in a deteriorated condition, as are some other remaining, but undated, structures. Part of the old stagecoach road is still in evidence, as is the old courthouse cistern.

It is planned to have initial construction access to the site over the county road which passes through the old town site. Thus, TVA has consulted with the Alabama State Historical Commission staff regarding this as an access alternative and found it to be preferred, providing that there be no destruction of structures, remains, or important sites. Should this route be chosen, TVA will use all available information to assure that this condition is met.

To assist in determining the physical extent of old town Bellefonte, an investigation of the historical significance of the town site has been proposed. A research proposal has been submitted to TVA by the University of Alabama at Birmingham. It proposes the undertaking of an archeological investigation of building sites and research of historical records and documents. It is expected that information obtained would make possible a better evaluation and assessment of the historical importance of Bellefonte to the region. Arrangements for carrying out this research investigation are being completed. Also, TVA has agreed to evaluate, in consultation with the Alabama State Historical Commission, the appropriate ways by which the historical aspects of the area could be accentuated.

An archeological investigation of the Bellefonte site was conducted during the summer of 1972. The investigative survey was directed by Mr. Carey B. Oakley, Research Associate in Archeology, Department of Anthropology, University of Alabama. The survey methods, sites, and results are given in Appendix C. The survey indicated that the Bellefonte site was never extensively utilized by the prehistoric Indian. However, two survey sites, 1 Ja 300 and 1 Ja 302, were identified as sites that should be investigated.

REFERENCES FOR SECTION 1.2

1. Volume I, Alabama Encyclopedia, Jesse M. Richardson, Copyright 1965.
2. Oil and Gas Wells in Alabama, Geological Survey of Alabama, Circular 43, January 1966.
3. Section 2.9.1, Seismic History, Sequoyah Nuclear Plant Preliminary Safety Analysis Report.
4. "Quality of Water in Guntersville Reservoir", TVA Division of Environmental Research and Development, Water Quality Branch, December 1970.

Table 1.2-1

AIR TEMPERATURE DATA*

Scottsboro, Alabama

Month		Mean Monthly (° F)	Mean Daily Maximum (° F)	Mean Daily Minimum (° F)	Highest Temp. (° F)	Lowest Temp. (° F)	Mean No. Days 90° F and Above	Mean No. Days 32° F and Below
December		43.2	53.7	32.5	80	4	0	16
January		42.7	53.4	32.2	81	-10	0	17
February		43.9	55.1	33.1	80	-16	0	13
	Winter	43.3	54.1	32.6	81	-16	0	46
March		52.2	64.0	40.3	90	5	0	11
April		60.4	72.9	47.6	92	23	1	2
May		68.4	81.0	55.8	98	31	6	0
	Spring	60.3	72.6	47.9	98	5	7	13
June		75.6	87.8	63.9	107	39	16	0
July		78.5	89.8	67.0	109	49	23	0
August		77.7	89.2	66.3	105	49	23	0
	Summer	77.3	88.9	65.7	109	39	62	0
September		72.7	84.9	60.3	108	34	10	0
October		61.5	74.8	48.3	96	23	1	2
November		50.3	62.9	37.6	94	1	0	13
	Fall	61.5	74.2	48.7	108	1	11	15
	Annual	60.6	72.5	48.7	109	-16	80	74

*Climatography of the United States No. 86-1; Decennial Census of the United States Climate; Climatic Summary of the United States - Supplement for 1951 through 1960, Alabama. Period of Record, 76 Years (1885-1960).

Table 1.2-2

PRECIPITATION DATA*

Scottsboro, Alabama

Month		Monthly Average (Inches)	Extreme Monthly Maximum (Inches)	Extreme Monthly Minimum (Inches)	Maximum in 24 Hrs. (Inches)	Average No. of Days With 0.01 Inch or More
December		5.16	13.67	1.06	5.75	9
January		6.01	13.80	1.99	4.12	11
February		6.07	13.50	1.02	4.10	10
	Winter	17.24				30
March		6.32	12.78	1.63	4.60	10
April		5.13	11.12	1.38	3.73	10
May		4.05	8.20	0.57	3.50	9
	Spring	15.50				29
June		4.12	8.11	0.81	3.72	9
July		5.22	11.18	1.16	3.43	10
August		3.44	9.65	0.05	3.20	9
	Summer	12.78				28
September		3.67	10.13	0.40	3.10	7
October		2.69	10.37	0.00	3.65	6
November		4.19	15.49	1.08	3.50	8
	Fall	10.55				21
	Annual	56.07				108

*Precipitation in the Tennessee River Basin, TVA, Division of Water Control Planning, Hydraulic Data Branch; period of record, 35 years (1935-1969).

Table 1.2-3

SNOWFALL DATA*

Scottsboro, Alabama

Month	Monthly Average (Inches)(1)	Monthly Average (Inches)(2)	Monthly Maximum (Inches)(1)
January	T	1.1	T
February	1.9	1.1	10.0
March	0.3	0.1	3.0
April	0	0	0
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	T	0.1	T
December	T	0.4	T
Annual	2.2	2.8	

*Climatography of the United States No. 86-1; Decennial Census of the United States Climate; Climatic Summary of the United States - Supplement for 1951 through 1960, Alabama. (1) Period of record, 10 years (1951-1960); (2) Period of record, 68 years (1893-1960).

Table 1.2-4

HEAVY FOG*

Chattanooga, Tennessee

1931-1960

Month		Mean No. of Days With Heavy Fog**
Dec.		4
Jan.		3
Feb.		2
	Winter	9
Mar.		2
April		2
May		2
	Spring	6
June		2
July		2
Aug.		3
	Summer	7
Sept.		4
Oct.		6
Nov.		4
	Fall	14
	Annual	36

*Local Climatological Data with Comparative Data, 1965, Chattanooga Tennessee, U.S. Department of Commerce, Weather Bureau, Climatological Standard Normals (1931-1960).

**Heavy fog is defined as fog reducing the visibility to 1/4 mile or less.

Table 1.2-5

PERCENT OCCURRENCE OF ATMOSPHERIC STABILITY*

Bellefonte Site

Pasquill Stability Class	Vertical Temperature	Percent Occurrence
A	$\Delta T < 1.9^{o}C/100m$	2.50
B	$-1.9 < \Delta T \leq -1.7^{o}C/100m$	2.80
C	$-1.7 < \Delta T \leq -1.5^{o}C/100m$	4.07
D	$-1.5 < \Delta T \leq -0.5^{o}C/100m$	19.47
E	$-0.5 < \Delta T \leq 1.5^{o}C/100m$	33.08
F	$1.5 < \Delta T \leq 4.0^{o}C/100m$	
G	$\Delta T > 4^{o}C/100m$	11.67
Total		100.00

*Extrapoled from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution date (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility, Bellefonte site.

Table 1.2-6

PERCENT OCCURRENCE OF WIND SPEED
FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY A

Bellefonte Site

Wind Direction	Wind Speed (mi/h) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≧12.5	Total
N	0.05	0.26				0.31
NNE	0.04	0.31	0.05			0.40
NE	0.05	0.31	0.08			0.44
ENE						
E						
ESE			0.32			0.32
SE			0.13			0.13
SSE						
S		0.08	0.05			0.13
SSW				0.13		0.13
SW		0.08	0.13			0.21
WSW						
W		0.05				0.05
WNW				0.05	0.05	0.10
NW		0.05		0.13		0.18
NNW		0.10				0.10
Total	0.14	1.24	0.76	0.31	0.05	2.50

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-7

PERCENT OCCURRENCE OF WIND SPEED FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY B

Bellefonte Site

Wind Direction	Wind Speed (mi/h) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≧12.5	Total
N			0.21	0.35		0.56
NNE		0.14	0.07			0.21
NE	0.07	0.46	0.28	0.07		0.88
ENE						
E		0.14				0.14
ESE						
SE						
SSE						
S						
SSW			0.7	0.16		0.23
SW		0.09	0.16	0.14		0.39
WSW			0.09			0.09
W						
WNW						
NW			0.16			0.16
NNW		0.07			0.07	0.14
Total	0.07	0.90	1.04	0.72	0.07	2.80

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-8

PERCENT OCCURRENCE OF WIND SPEED
FOR ALL WIND DIRECTIONS*

Stability Category C

Bellefonte Site

Wind Direction	Wind Speed (mph) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≥12.5	Total
N		0.03	0.12	0.15		0.30
NNE	0.03	0.19	0.18			0.40
NE	0.03	0.37	0.25	0.09		0.74
ENE		0.06	0.03			0.09
E			0.15			0.15
ESE						
SE		0.06	0.22			0.28
SSE			0.06			0.06
S		0.03	0.03	0.03	0.03	0.12
SSW		0.10		0.19		0.29
SW		0.06	0.15	0.31		0.52
WSW			0.06	0.21		0.27
W			0.10	0.19		0.29
WNW						
NW			0.06	0.09	0.03	0.18
NNW			0.03	0.31	0.04	0.38
Total	0.06	0.90	1.44	1.57	0.10	4.07

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-9

PERCENT OCCURRENCE OF WIND SPEED
FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY D

Bellefonte Site

Wind Direction	Wind Speed (mi/h) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≧12.5	Total
N	0.04	0.38	0.73	0.23		1.38
NNE	0.12	1.32	0.80			2.24
NE	0.24	2.28	0.88	0.19		3.59
ENE	0.04	0.53	0.13			0.70
E	0.01	0.11	0.09			0.21
ESE	0.01	0.22	0.13			0.36
SE	0.02	0.25	0.22			0.49
SSE	0.03	0.42	0.14	0.01		0.60
S	0.01	0.25	0.15	0.04	0.08	0.53
SSW	0.07	0.80	0.52	0.43	0.03	1.85
SW	0.09	0.90	0.73	0.58	0.07	2.37
WSW	0.01	0.29	0.33	0.36		0.99
W		0.12	1.38	0.31	0.13	1.94
WNW	0.01	0.07	0.21	0.25	0.01	0.55
NW	0.01	0.17	0.19	0.36	0.02	0.75
NNW	0.01	0.18	0.30	0.40	0.03	0.92
Total	0.72	8.29	6.93	3.16	0.37	19.47

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-10

PERCENT OCCURRENCE OF WIND SPEED
FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY E

Bellefonte Site

Wind Direction	Wind Speed (mi/h)					Total
	0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≥12.5	
N	0.01	1.55	0.38	0.05		1.99
NNE	0.37	3.69	0.32			4.38
NE	0.27	2.30	0.25			2.82
ENE	0.07	0.69	0.05			0.81
E	0.03	0.43				0.46
ESE	0.06	0.58	0.05			0.69
SE	0.05	0.53	0.07			0.65
SSE	0.09	1.14	0.30	0.02		1.55
S	0.09	1.06	0.32	0.10		1.57
SSW	0.25	2.44	0.73	0.44	0.03	3.89
SW	0.29	2.89	0.81	0.64	0.10	4.73
WSW	0.15	1.82	0.40	0.25		2.62
W	0.06	0.76	0.86	0.13		1.81
WNW	0.05	0.68	0.36	0.83		1.92
NW	0.05	0.68	0.37	0.14	0.01	1.25
NNW	0.10	1.14	0.46	0.23	0.01	1.94
Total	1.99	22.38	5.73	2.83	0.15	33.08

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-11

PERCENT OCCURRENCE OF WIND SPEED
FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY F

Bellefonte Site

Wind Direction	Wind Speed (mi/h) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≧12.5	Total
N	0.21	2.21	0.15			2.57
NNE	0.46	5.2	0.04			5.70
NE	0.34	3.4	0.01			3.75
ENE	0.18	1.74	0.01			1.93
E	0.02	0.39				0.41
ESE	0.05	0.65	0.09			0.79
SE	0.05	0.65				0.70
SSE	0.07	0.92				0.99
S	0.05	0.75	0.04			0.84
SSW	0.18	2.23	0.12			2.53
SW	0.18	2.23	0.49	0.04		2.94
WSW	0.05	0.67	0.15			0.87
W	0.01	0.29	0.35			0.65
WNW	0.01	0.29	0.07	0.32		0.69
NW	0.01	0.14	0.05	0.01		0.21
NNW	0.05	0.68	0.09			0.82
Total	1.92	22.44	1.66	0.37		26.39

*Extrapolated from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Table 1.2-12

PERCENT OCCURRENCE OF WIND SPEED FOR ALL WIND DIRECTIONS*

STABILITY CATEGORY G

Bellefonte Site

Wind Direction	Wind Speed (mi/h) 0.0-0.5	0.6-3.4	3.5-7.4	7.5-12.4	≥12.5	Total
N	0.03	0.31	0.01			0.35
NNE	0.11	1.51				1.62
NE	0.16	1.61				1.77
ENE	0.15	1.55				1.70
E	0.04	0.60				0.64
ESE	0.01	0.18				0.19
SE	0.01	0.24		0.30		0.55
SSE	0.01	0.28				0.29
S	0.03	0.40	0.01			0.44
SSW	0.10	1.32	0.01			1.43
SW	0.13	1.77	0.09			1.99
WSW	0.01	0.45	0.03			0.49
W	0.01	0.09				0.10
WNW		0.06				0.06
NW		0.01				0.01
NNW		0.04				0.04
Total	0.80	10.42	0.15	0.30		11.67

***Extrapolated** from:

1. Widows Creek annual wind direction and wind speed frequency data (1968-70) from the Valley meteorological station.

2. Sequoyah wind direction and wind speed frequency data (April 2, 1971-March 31, 1972).

3. Sequoyah joint frequency distribution data (April 2, 1971-March 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G.

4. Bellefonte joint frequency distribution data (May 12-July 31, 1972) for wind direction, wind speed, and Pasquill stability classes A-G from the temporary meteorological facility.

Date	Time CS 24-hr. Clock	Location in Stream	Depth	Total Coliforms	Temp.	DO	5-day 20°C. BOD	Color	Turb.	Threshold Odor	Nitrogens Org.N	NH_3-N	NO_2-N	NO_3-N	Phosphates Sol.	Phosphates Tot.	pH	Alkalinity $CaCO_3$ Phen.	Alkalinity $CaCO_3$ Tot.	Total Hardness $CaCO_3$	Ca	Mg	Cl	Na	K	Fe, Total	Mn, Total	Cu	Zn	SO_4	SiO_2	Specific Conductance at 25° C.	Solids Sus.	Solids Dis.	Solids Tot.
1963			ft.	MPN/100 ml	°C.	mg/l	mg/l	PCU	JCU	No.	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	Micromho/cm	mg/l	mg/l	mg/l
5-19	1400	Middle	Surf.	620	24.4	7.53	2.61	20	14	None	0.21	0.00	0.01	0.03	0.00	0.13	7.6	0.00	47.9	63.9	19.2	4.62	8.30	3.90	1.35	0.24	0.00			15.5	4.48	164	1	99	100
			10		21.6	7.52																													
			20		21.3	6.06																													
			30		21.3	6.18																													
6-12	1003	Middle	Surf.	360	25.4	6.31	2.94	20	8.5	None	0.29	0.00	0.00	0.05	0.00	0.02	7.4	0.00	45.1	57.0	17.6	3.76	14.0	3.90	0.96	0.00	0.10			20.0	1.20	147	9	90	99
			10		24.7	6.08																													
			20		24.7	5.95																													
	0955		30		24.7	5.90																													
7-14	1015	Middle	Surf.	230	25.1	5.99	4.24	20	14	None	0.40	0.05	0.00	0.00	0.04	0.07	7.4	0.00	51.0	63.8	20.5	3.65	17.9	5.05	1.25	0.02	0.22			16.4	2.14	164	16	76	92
			10		25.1	6.08																													
			20		25.0	6.02																													
	1001		30		24.7	6.35																													
8-31	1001	Middle	Surf.	230	26.9	5.44	1.39	0	-	None	0.42	0.07	0.00	0.15	0.01	0.08	7.4	0.00	43.3	54.3	17.5	3.12	6.13	5.52	1.25	0.00	0.07			15.5	5.32	147	25	70	95
			10		26.7	5.21																													
			20		26.7	5.34																													
	1013		25		26.6	5.73																													
9-24	-	Middle	Surf.	360	-	6.45	1.86	0	-	None	0.34	0.02	0.00	0.00	0.05	0.08	7.5	0.00	53.1	73.3	21.9	5.76	14.9	9.57	1.43	0.45	0.03	0.04	0.12	18.2	5.74	222	28	139	167
			10		-	-																													
			20		-	-																													
	-		30		-	-																						-	-						
10-24	1530	Middle	Surf.	2,300	21.2	6.78	0.83	5	7.6	None	0.23	0.00	0.00	0.00	0.05	0.11	7.7	0.00	53.0	76.4	23.9	5.17	19.4	11.2	1.43	0.20	0.03			18.2	9.80	217	36	97	133
			10		21.0	6.80																													
			20		21.0	6.74																													
	1615		30		21.0	6.70																						0.00	0.09						
11-26	1215	Middle	Surf.	1,300	13.2	8.72	1.05	0	6.0	None	0.12	0.02	0.00	0.00	-	0.09	7.6	0.00	54.0	79.4	23.4	6.41	21.8	12.2	1.43	0.21	0.03			20.9	8.40	222	7	106	113
			8		13.2	8.63																													
			18		13.2	8.69																													
	1210		28		12.9	8.71																						0.00	0.02						
12-18	1200	Middle	Surf.	360	7.0	9.81	0.74	5	8.5	None	0.38	0.09	0.00	0.10	0.05	0.15	7.7	0.00	51.0	80.2	24.3	6.06	22.5	12.4	1.43	0.52	0.03			22.7	7.04	227	11	113	124
			8		7.0	9.74																													
			18		7.0	9.60																													
	1215		28		7.0	9.78																						0.00	0.03						
1964																																			
1-16	1130	Middle	Surf.	1,300	5.0	11.67	0.81	0	25	None	0.17	0.00	0.00	0.00	0.08	0.15	7.5	0.00	49.4	64.7	20.1	4.43	15.7	8.95	1.16	0.37	0.05			20.9	4.64	196	53	87	140
			10		5.0	11.65																													
			20		5.0	11.67																													
	1145		30		5.0	11.54																						0.02	0.06						
2-17	1105	Middle	Surf.	6,200	6.6	10.54	1.10	5	19	None	0.01	0.00	0.00	0.02	0.14	0.19	7.4	0.00	42.0	63.5	20.0	4.20	13.7	6.85	1.02	0.37	0.05			17.3	2.40	167	87	86	173
			10		6.6	10.54																													
			20		6.6	10.54																													
	1120		29		6.6	10.54																						0.00	0.05						
3-17	1245	Middle	Surf.	16,000	11.0	10.83	1.72	0	140	1+	0.17	0.00	0.00	0.00	0.04	0.53	7.3	0.00	31.4	45.4	15.4	2.28	6.36	4.64	1.53	1.94	0.32			13.6	3.82	112	91	67	158
			10		10.8	10.88																													
			20		10.8	10.83																													
			30		10.8	10.65																													
	1235		35		10.8	10.68																						0.00	0.02						
4-22	1215	Middle	Surf.	1,100	16.8	8.48	1.26	0	25	None	0.00	0.01	0.00	0.08	0.03	0.12	7.5	0.00	36.7	45.8	14.9	2.74	6.16	2.48	1.03	0.73	0.11			12.8	4.98	112	23	72	95
			10		16.8	8.53																													
			20		16.8	8.46																													
	1230		30		16.8	8.38																						0.00	0.04						
Max.					26.9	11.67	4.24	20	140	1+	0.42	0.09	0.01	0.15	0.14	0.53	7.7	0.00	54.0	80.2	24.3	6.41	22.5	12.4	1.53	1.94	0.32	0.04	0.12	22.7	9.80	227	91	139	173
Min.					5.0	5.21	0.74	0	6.0	None	0.00	0.00	0.00	0.00	0.00	0.08	7.3	0.00	31.4	45.4	14.9	2.28	6.13	2.48	0.96	0.00	0.00	0.00	0.02	12.8	1.20	112	1	67	92

Table 1.2-13

OBSERVED WATER QUALITY DATA
GUNTERSVILLE RESERVOIR
TRM 385.9
1963-1964

	Station 1 — Tennessee River Mile 350.4						Station 4 — Tennessee River Mile 385.9					
	Alpha (pc/l)			Beta (pc/l)			Alpha (pc/l)			Beta (pc/l)		
Date	Diss.	Susp.	Total	Diss.	Susp.	Total	Diss.	Susp.	Total	Diss.	Susp.	Total
5-19-63	0 ± 0	0 ± 0	0 ± 0	8 ± 1	5 ± 1	13 ± 1	1 ± 0	1 ± 0	2 ± 0	13 ± 1	2 ± 1	15 ± 1
6-12-63	0 ± 0	1 ± 0	1 ± 0	9 ± 1	2 ± 1	11 ± 1	0 ± 0	0 ± 0	0 ± 0	11 ± 1	2 ± 0	13 ± 1
7-14-63	0 ± 0	0 ± 0	0 ± 0	11 ± 1	4 ± 1	15 ± 1	0 ± 0	0 ± 0	0 ± 0	12 ± 1	2 ± 0	14 ± 1
8-31-63	0 ± 0	0 ± 0	0 ± 0	12 ± 1	1 ± 0	13 ± 1	0 ± 0	0 ± 0	0 ± 0	15 ± 1	1 ± 0	16 ± 1
9-24-63	0 ± 0	0 ± 0	0 ± 0	13 ± 1	0 ± 0	13 ± 1	0 ± 0	0 ± 0	0 ± 0	10 ± 1	0 ± 0	10 ± 1
10-24-63	0 ± 0	0 ± 0	0 ± 0	11 ± 1	6 ± 1	17 ± 1	0 ± 0	0 ± 0	0 ± 0	7 ± 1	1 ± 0	8 ± 1
11-26-63	0 ± 0	0 ± 0	0 ± 0	7 ± 1	0 ± 0	7 ± 1	0 ± 0	0 ± 0	0 ± 0	13 ± 2	1 ± 0	14 ± 2
12-18-63	0 ± 0	0 ± 0	0 ± 0	7 ± 1	1 ± 0	8 ± 1	0 ± 0	0 ± 0	0 ± 0	10 ± 1	1 ± 0	11 ± 1
1-16-64	0 ± 0	1 ± 0	1 ± 0	4 ± 1	7 ± 1	11 ± 1	0 ± 0	0 ± 0	0 ± 0	11 ± 1	2 ± 0	13 ± 1
2-17-64	0 ± 0	0 ± 0	0 ± 0	16 ± 1	7 ± 1	23 ± 1	0 ± 0	0 ± 0	0 ± 0	13 ± 1	8 ± 1	21 ± 1
3-17-64	0 ± 0	0 ± 0	0 ± 0	11 ± 1	12 ± 1	23 ± 1	0 ± 0	1 ± 0	1 ± 0	9 ± 1	24 ± 2	33 ± 2
4-22-64	0 ± 0	0 ± 0	0 ± 0	11 ± 1	5 ± 1	16 ± 1	0 ± 0	0 ± 0	0 ± 0	12 ± 1	5 ± 1	17 ± 1

Table 1.2-14

SUMMARY OF GUNTERSVILLE RESERVIOR RADIOACTIVITY LEVELS

1963-1964

Table 1.2-15

SUMMARY OF OBSERVED TAILRACE WATER TEMPERATURE DATA

(Weekly Observations)

Week Number	Nickajack Dam 1968-71 Records: Maximum of the Four Weekly Temperatures °F	Nickajack Dam 1968-71 Records: Average of the Four Weekly Temperatures °F	Guntersville Dam 1967-71 Records: Maximum of the Five Weekly Temperatures °F	Guntersville Dam 1967-71 Records: Average of the Five Weekly Temperatures °F
1	50.0	45.2	46.4	44.6
2	44.6	42.2	44.6	42.1
3	44.6	42.8	46.4	43.0
4	44.6	42.5	46.4	44.4
5	48.2	44.6	48.2	45.1
6	44.6	42.8	46.4	44.6
7	43.7	42.1	46.0	44.5
8	44.6	43.3	50.0	46.2
9	50.0	45.5	48.2	45.5
10	48.2	45.5	51.8	47.7
11	50.0	48.2	51.8	48.9
12	50.0	50.0	53.6	51.3
13	53.6	51.4	57.0	53.4
14	57.2	54.7	60.8	59.7
15	59.9	58.1	64.4	62.1
16	64.4	61.3	68.0	64.6
17	64.4	63.5	68.0	65.8
18	66.2	64.4	68.0	66.9
19	68.0	66.7	68.0	67.3
20	69.8	67.6	71.6	69.8
21	73.4	70.7	71.6	69.8
22	77.9	73.9	73.4	71.6
23	75.2	73.6	77.9	73.9
24	77.0	76.1	80.6	77.2
25	78.8	77.7	81.5	79.5
26	80.6	79.0	86.0	83.0
27	82.4	80.4	85.1	83.8
28	82.4	80.6	88.7	83.3
29	82.4	80.8	86.0	84.2
30	82.4	80.6	84.2	81.7
31	82.4	78.4	84.2	82.6
32	82.4	80.2	84.2	82.4
33	80.6	80.2	85.1	81.7
34	81.5	79.9	84.2	81.1
35	80.6	78.8	82.4	80.0
36	80.6	78.8	84.2	79.5
37	80.6	78.4	86.0	79.9
38	80.6	76.1	83.3	77.2
39	78.8	76.1	80.6	72.3
40	78.8	74.8	78.8	72.9
41	75.2	71.6	74.3	72.7
42	71.6	69.4	72.5	69.1
43	69.8	66.8	66.2	64.0
44	69.8	64.4	71.6	64.8
45	60.8	59.4	62.6	59.5
46	59.0	57.4	61.7	57.5
47	57.0	54.0	58.1	54.5
48	52.7	51.6	53.6	52.9
49	51.8	49.1	51.8	50.0
50	51.8	48.7	54.5	50.0
51	51.8	47.8	53.6	49.8
52	51.8	50.2	53.6	48.0

Table 1.2-16

WATER SUPPLIES WITHIN 20-MILE RADIUS OF PROPOSED PLANT SITE AND

SUPPLIES TAKEN FROM TENNESSEE RIVER BETWEEN NICKAJACK AND GUNTERSVILLE DAMS

	Water Supply	Approximate Distance From Site*	Estimated Population Served	Average Daily Use	Source
	Public Supplies	Miles		Gallons	
1.	Albertville	33.6	23,045	3,250,000	Surface (TRM 360.8) Short Creek embayment (mile 2.4)
2.	Arab	36.8	12,620	750,700	Surface (TRM 356.0) Browns Creek embayment (mile 0.8) and Ground, Wells
3.	Bridgeport	21.6	3,132	310,000	Surface (TRM 413.6) and Ground, Spring
4.	Camp Maranatha	14.3	68	6,000	Ground, Wells
5.	Christian Youth Camp	23.8	125	6,200	Surface (TRM 368.2)
6.	Flat Rock Elementary School	12.6	280	7,000	Ground, Wells
7.	Grant	45.3	3,116	174,000	Surface (TRM 351.8) Honeycomb Creek embayment (mile 5.1)

*Radial distance to all supplies except those that take water directly from the Tennessee River which are shown as river mile distance from 392.0.

Table 1.2-16 (continued)

Water Supply	Approximate Distance From Site*	Estimated Population Served	Average Daily Use	Source
Public Supplies	Miles		Gallons	
8. Grove Oak Junior High School	19.7	165	4,100	Ground, Wells
9. Guntersville	34.0 38.2	6,580	1,249,000	Surface (TRM 358.0) and Surface (TRM 356.0) - Browns Creek embayment (mile 2.2)
10. Hollywood	3.4	485	40,000	Ground, Wells
11. Ider High School	13.5	1,044	26,100	Ground, Wells
12. Limrock Junior High School	15.7	70	1,800	Ground, Wells
13. New Prospect Elementary School	18.4	100	2,500	Ground, Wells
14. North Jackson Hospital	16.3	87	14,500	Ground, Wells
15. North Sand Mountain High School	19.5	508	12,700	Ground, Wells
16. Pisgah	4.2	385	35,000	Ground, Wells
17. Sand Mountain Water Authority	9.9	8,174	546,000	Surface (TRM 382.1)
18. Scottsboro	6.2 16.6	11,000	3,500,000	Surface (TRM 385.8) and Surface (TRM 377.4), North Sauty Creek embayment (mile 2.0)
19. Skyline Elementary School	14.2	370	9,200	Ground, Wells

*Radial distance to all supplies except those that take water directly from the Tennessee River which are shown as river mile distance from 392.0.

Table 1.2-16 (continued)

Water Supply	Approximate Distance From Site*	Estimated Population Served	Average Daily Use	Source
Public Supplies	Miles		Gallons	
20. Stevenson	11.7	1,600	117,000	Ground, Wells
21. South Pittsburg	26.0	4,820	528,000	Surface (TRM 418.0)
22. Ten Broeck Junior High School	19.8	131	3,300	Ground, Wells
Industrial Supplies				
1-I. Butler Rubber Co., Inc.	33.2	-	250,000	Surface (TRM 358.8) Big Spring Creek embayment (mile 1.7)
2-I. O. K. Tire and Rubber Co.	33.5	-	300,000	Surface (TRM 358.5) Polecat Creek embayment (mile 1.0)
3-I. Monsanto** (Under construction)	27.0	-	-	Surface (TRM 365)
4-I. Widows Creek Steam Plant**	15.6	465	$1,573 \times 10^6$	Surface (TRM 407.6)

*Radial distance to all supplies except those that take water directly from the Tennessee River which are shown as river mile distance from 392.0.

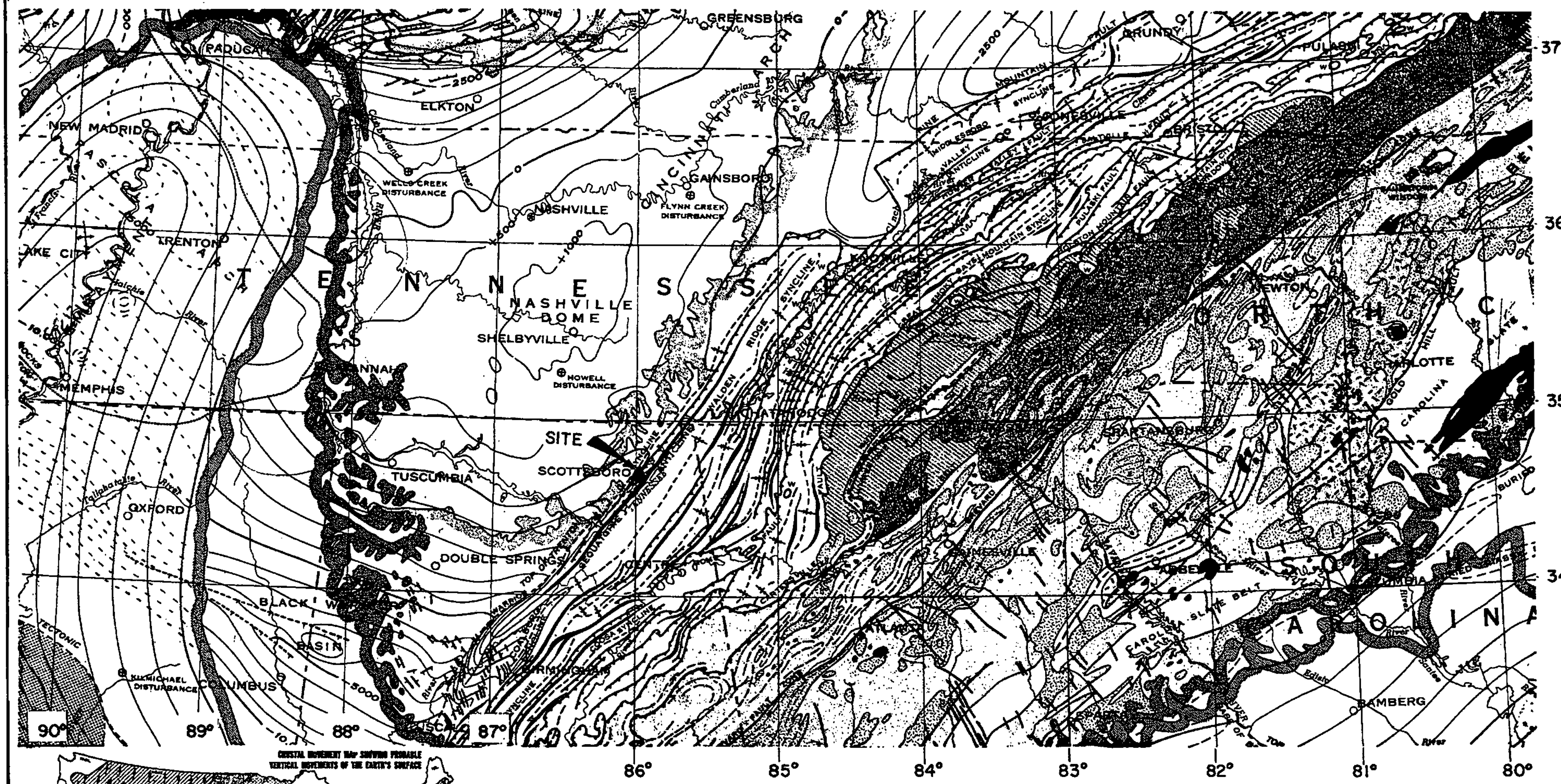
**Water supply is also used for potable water within the plant.

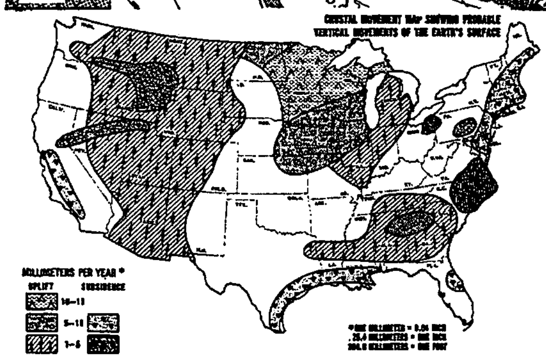
Table 1.2-17

*PARTIAL LIST OF AQUATIC MACROPHYTES NEAR THE PROPOSED BELLEFONTE NUCLEAR PLANT SITE, GUNTERSVILLE RESERVOIR

Scientific Name	Common Name	Growth Form
Myriophyllum spicatum	Eurasian watermilfoil	Submersed
Ceratophyllum demersum	Coontail	Submersed
Potamogeton crispus	Crispyleaf pondweed	Submersed
Potamogeton nodosus	American pondweed	Submersed
Najas minor	Spinyleaf naiad	Submersed
Najas guadalupensis	Southern naiad	Submersed
Egeria densa	Egeria	Submersed
Elodea canadensis	Elodca	Submersed
Heteranthera dubia	Waterstargrass	Submersed
Chara sp.	Muskgrass	Submersed
Saururus cernuus	Lizardtail	Emergent
Alternanthera philoxeroides	Alligatorweed	Emergent, Floating Mat
Nelumbo lutea	American lotus	Emergent, Floating Mat
Justicia americana	Waterwillow weed	Emergent
Eleocharis quadrangulata	Spikerush	Emergent
Eleocharis acicularis	Midget spikerush	Emergent
Ludwigia palustris	Waterpurslane	Emergent
Scirpus cyperinus	Woolgrass	Emergent
Scirpus validus	Softstem bulrush	Emergent
Scirpus americanus	Three-square	Emergent
Juncus effusus	Common bulrush	Emergent
Hibiscus militaris	Marshmallow	Emergent
Zizaniopsis miliacea	Giant cutgrass	Emergent
Polygonum sagittatum	Tear-thumb	Emergent
Polygonum hydropiperoides	Smartweed	Emergent
Polygonum pensylvanicum	Smartweed	Emergent
Echinodorus cordifolius	Burhead	Emergent
Carex sp.	Sedge	Emergent
Cyperus psuedovegetus	Sedge	Emergent
Cyperus sp.	Sedge	Emergent
Typha latifolia	Cattail	Emergent
Lemna perpusilla	Duckweed	Floating
Spirodela polyrhiza	Giant duckweed	Floating
Azolla caroliniana	Mosquito fern	Floating

*The list of aquatic macrophytes was compiled from a boat survey conducted on September 26, 1972, near the proposed Bellefonte Nuclear Plant site. The survey included portions of lower Raccoon, Mud, and Town Creek embayments with additional shoreline inspection from Sublett Ferry (TRM 390) to Raccoon Creek (TRM 396). This listing includes the more common emergent submersed, and floating aquatic macrophytes but does not include a complete floristic listing.





SCALE 1:2,500,000

25 0 25 50 75 100 125 150 175 200 MILES

Approximately 1 inch to 40 miles

Figure 1.2-1

NOTE:

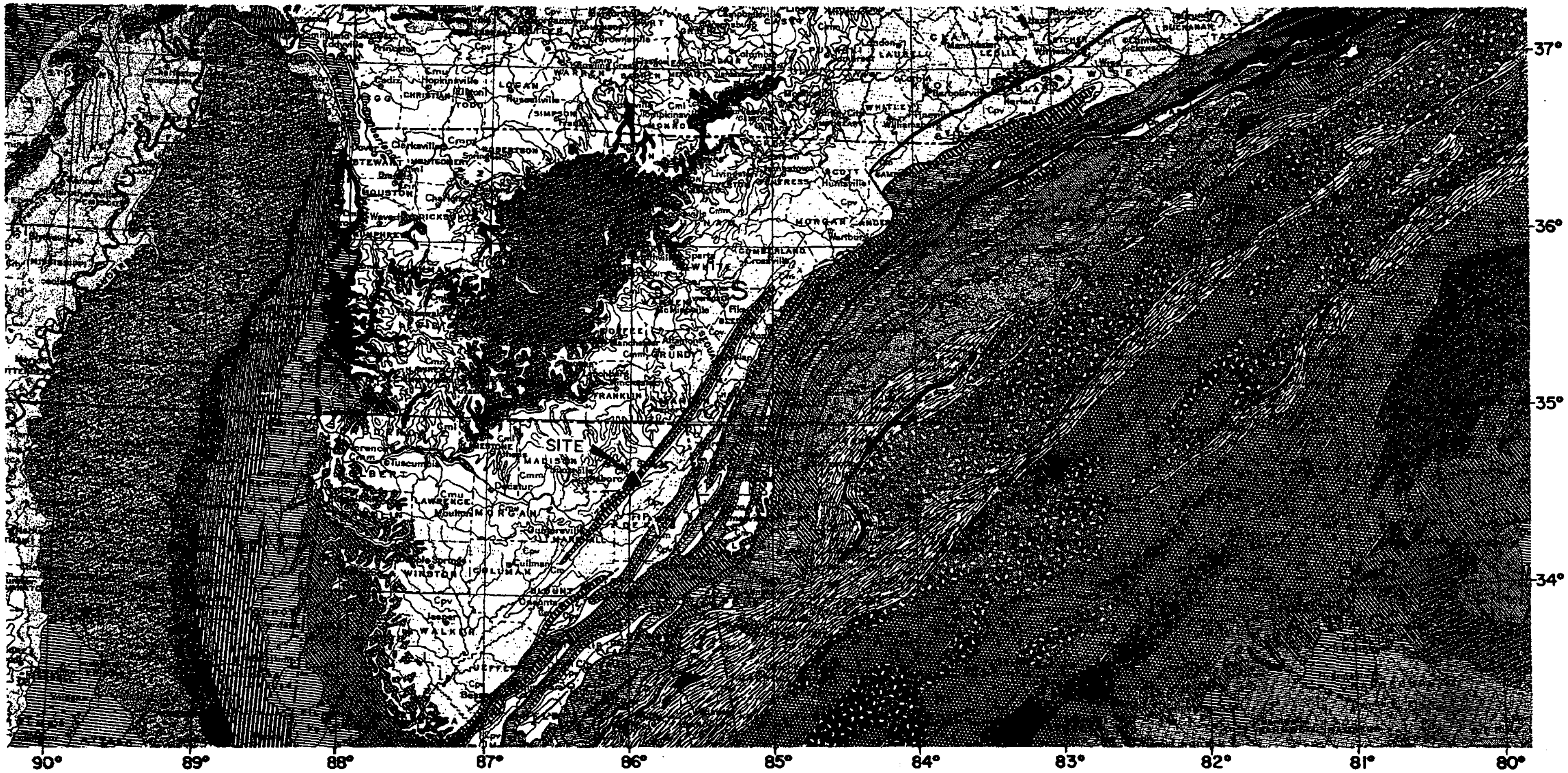
1. Taken from Tectonic Map of United States by U.S. Geological Survey, 1962.

GEOLOGIC INVESTIGATIONS

REGIONAL
TECTONIC MAP

BELLFONTE NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

SUBMITTED	RECOMMENDED	APPROVED
KNOXVILLE	1-26-73	88 GE 1 822B1964



Scale 1:2500000
Approximately 1 inch to 40 miles

25 0 25 50 75 100 125 150 175 200 Miles

25 0 25 50 75 100 125 150 175 200 Kilometers

NOTE:

Taken from GEOLOGIC MAP OF THE UNITED STATES by the United States Geological Survey 1932.

Figure 1.2-2

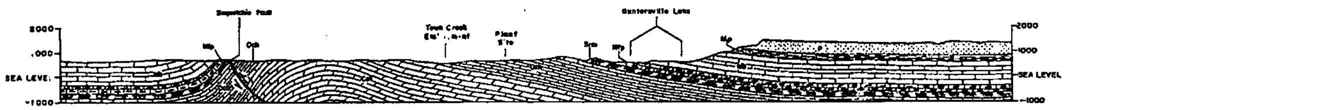
GEOLOGIC INVESTIGATION

REGIONAL GEOLOGIC MAP

BELLFONTE NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

SUBMITTED | RECOMMENDED | APPROVED

KNOXVILLE 1-26-73 88 GE 1 822B1963



SECTION A-A'

Figure 1.2-3

Scale 1:24,000

Contour Interval – 20 Feet

LEGEND:

Pennsylvanian
- P — Sandstone and Shale

Mississippian
- Pennington Shale and Limestone
- Mb — Bangor Limestone
- Mfp — Fort Payne Cherty Limestone

Silurian
- Srm — Red Mountain Formation—Shale and siltstone with thin Chattanooga Shale at top.

Ordovician
- Och — Chickamauga Formation

Cambro-Ordovician
- OCk — Knox Dolomite and Limestone

— *Major thrust fault.*

— *Formation contact.*

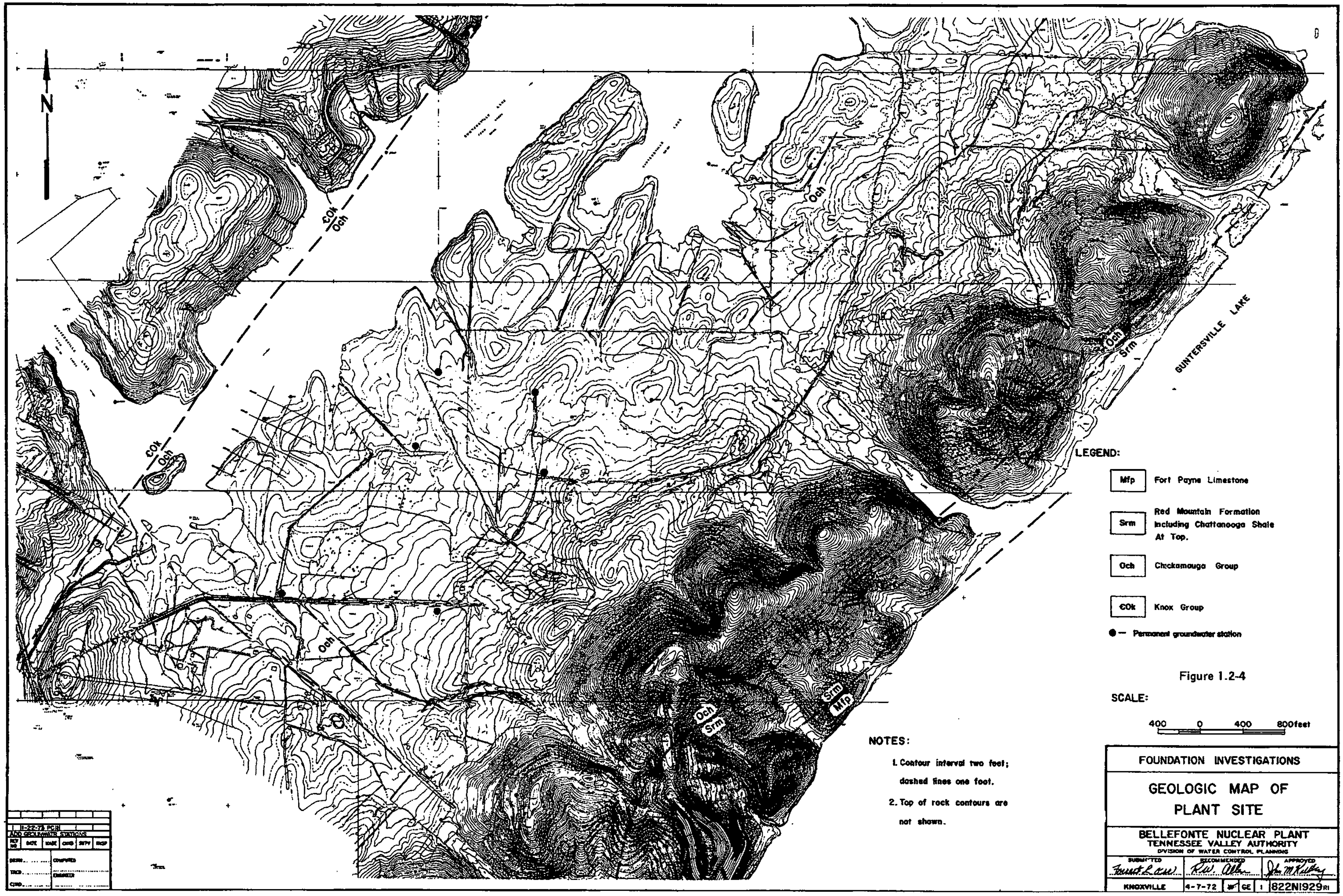
GEOLOGIC INVESTIGATIONS

GEOLOGIC AND TECTONIC MAP OF PLANT AREA

BELLEFONTE NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING

SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]

KNOXVILLE | 7-1-71 | W | CE | 1 | 822N1836 R1


N
COk
Och
Och
Srm
Mfp
GUNTERSVILLE LAKE
LEGEND:
Mfp Fort Payne Limestone
Srm Red Mountain Formation Including Chattanooga Shale At Top.
Och Chickamauga Group
COk Knox Group
● — Permanent groundwater station
Figure 1.2-4
SCALE:
400 0 400 800feet
NOTES:
1. Contour interval two feet; dashed lines one foot.
2. Top of rock contours are not shown.
FOUNDATION INVESTIGATIONS
GEOLOGIC MAP OF PLANT SITE
BELLEFONTE NUCLEAR PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF WATER CONTROL PLANNING
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
4-7-72
822N1929R1
11-22-78 PCB
ADD GROUNDWATER STATIONS

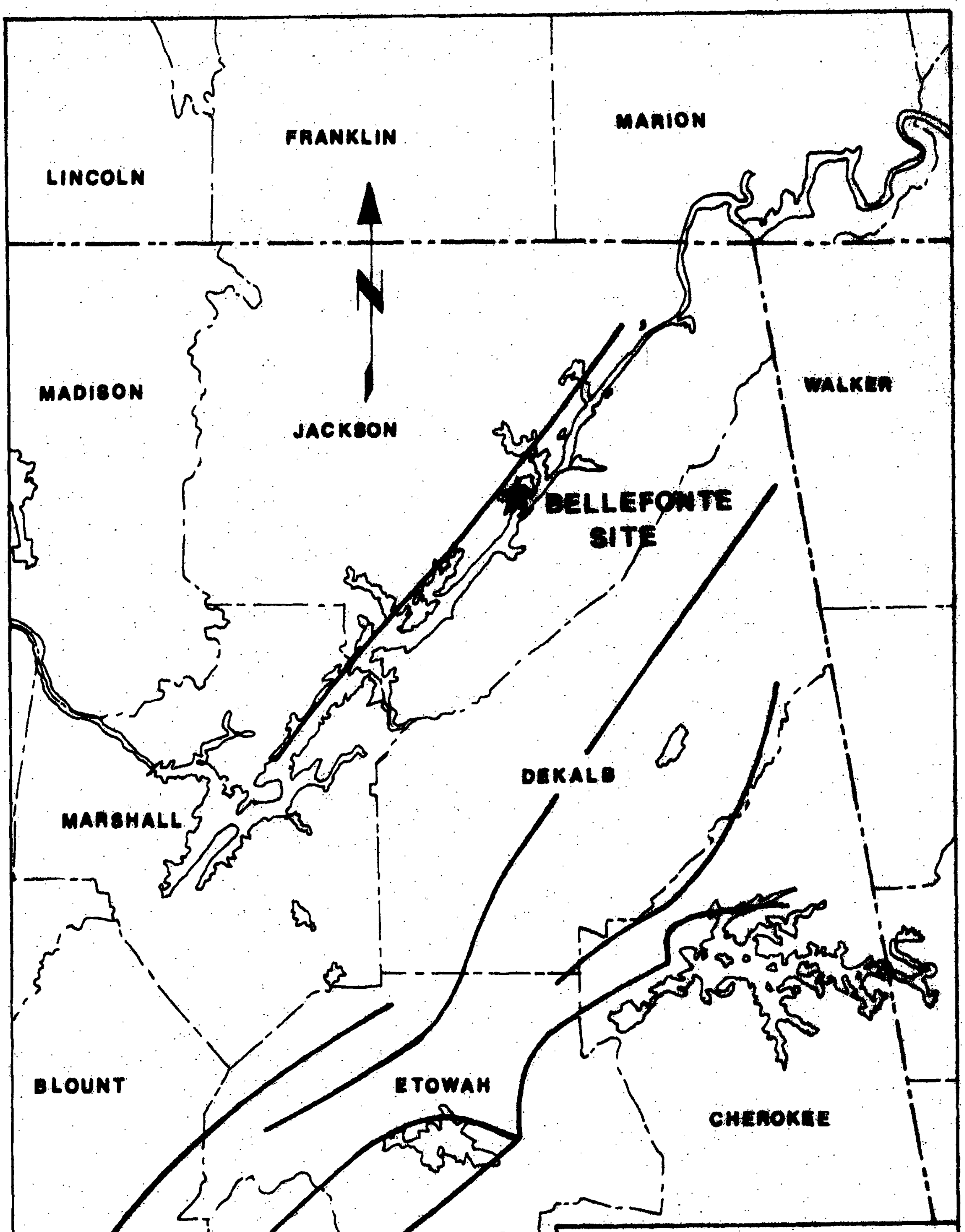
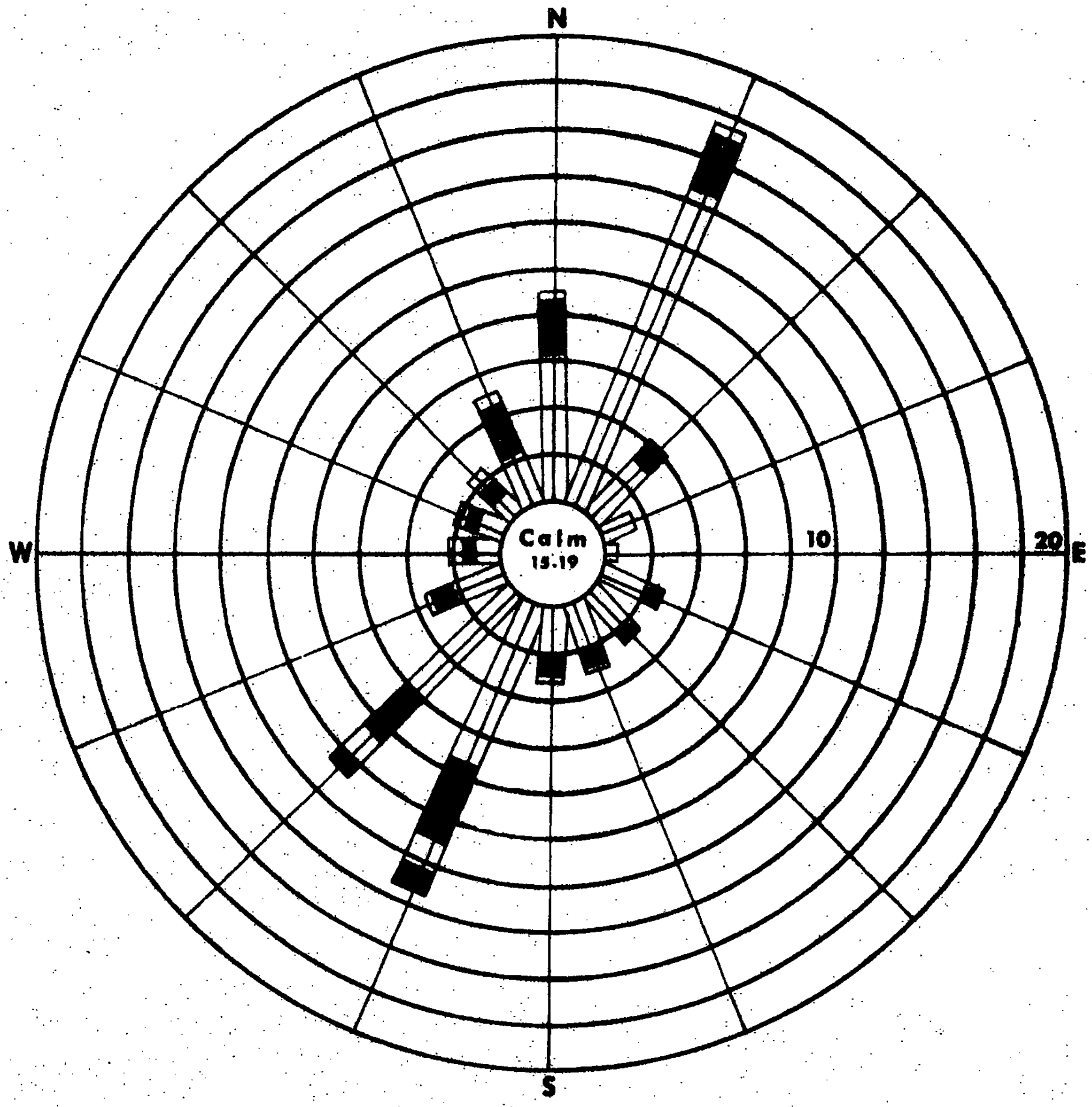
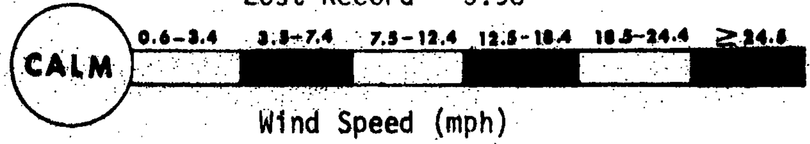


Figure 1.2-5
FAULT MAP
BELLEFONTE SITE



Lost Record = 3.98

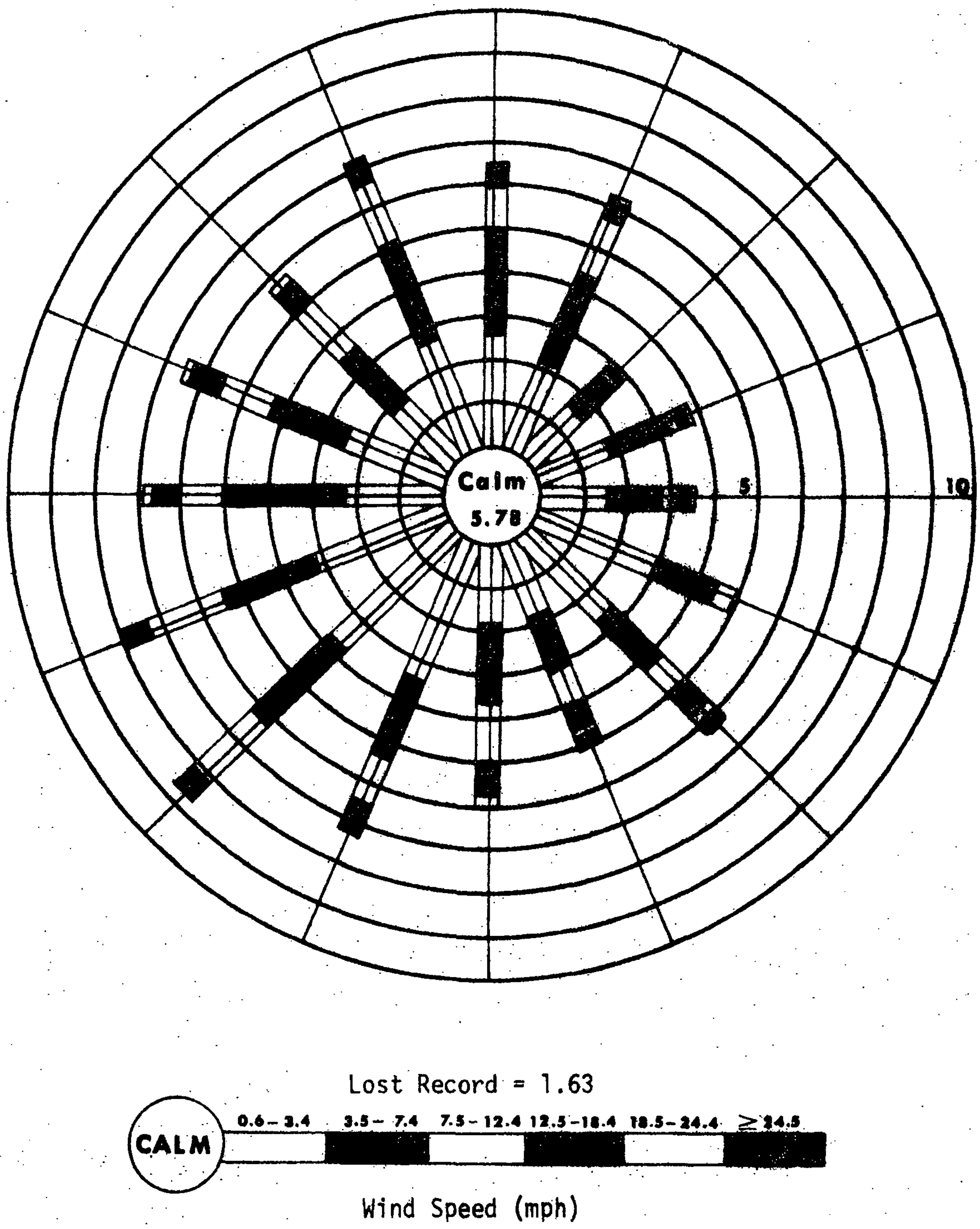


Wind Speed (mph)

Station located 19 miles NE of Bellefonte Site; Elevation 630 feet MSL; Wind instrument 44 feet above ground.

Figure 1.2-6

WIND ROSE
Annual 1971
WIDOWS CREEK POWER PLANT
VALLEY METEROLOGICAL STATION



Station located 15 miles NE of Bellefonte Site; Elevation 1450 feet MSL; Wind instrument 54 feet above ground.

Figure 1.2-7
WIND ROSE
Annual 1971
WIDOWS CREEK POWER PLANT
SAND MOUNTAIN METEROLOGICAL STATION

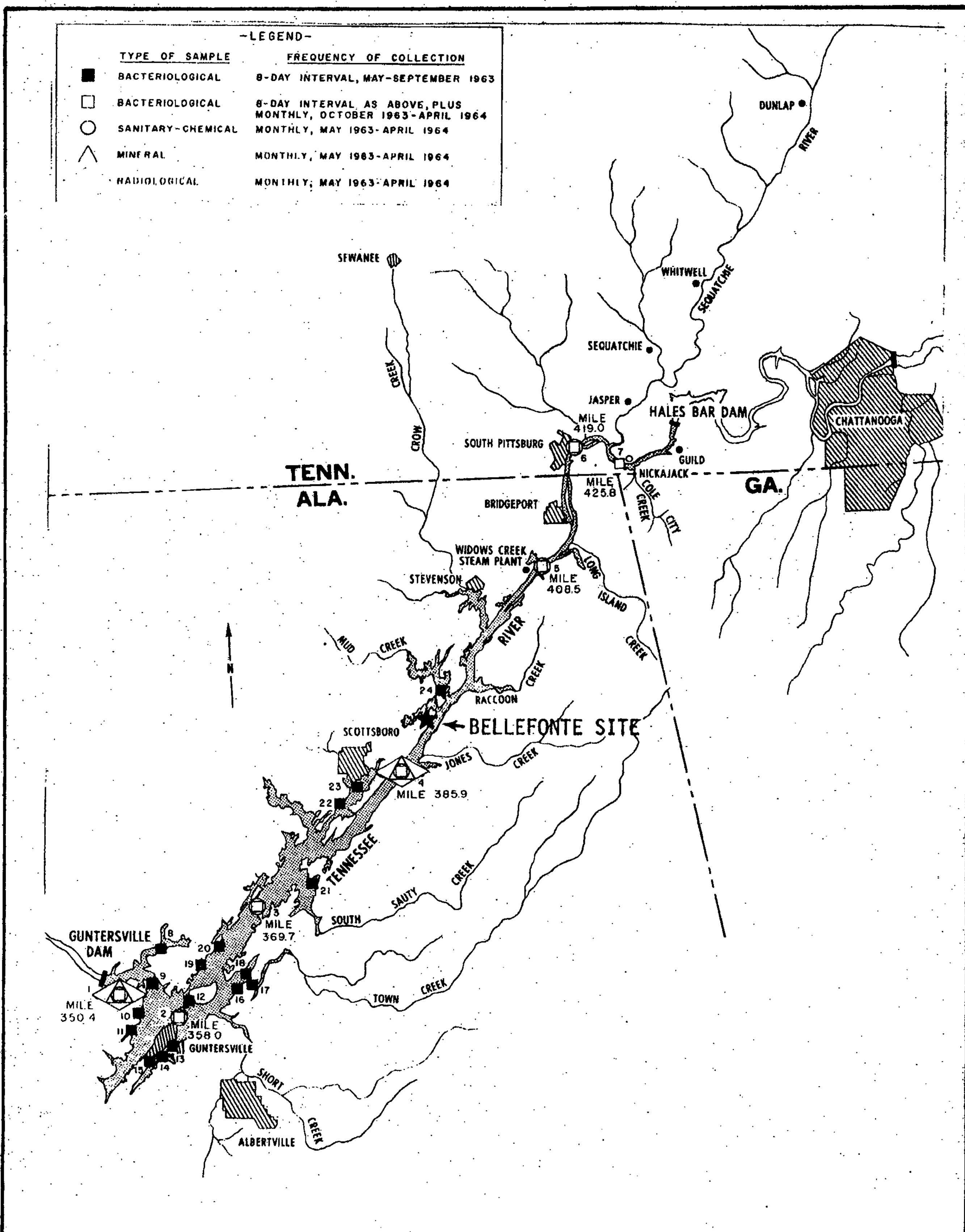


Figure 1.2-8

GUNTERSVILLE RESERVOIR WATER QUALITY SAMPLING STATIONS 1963-1964

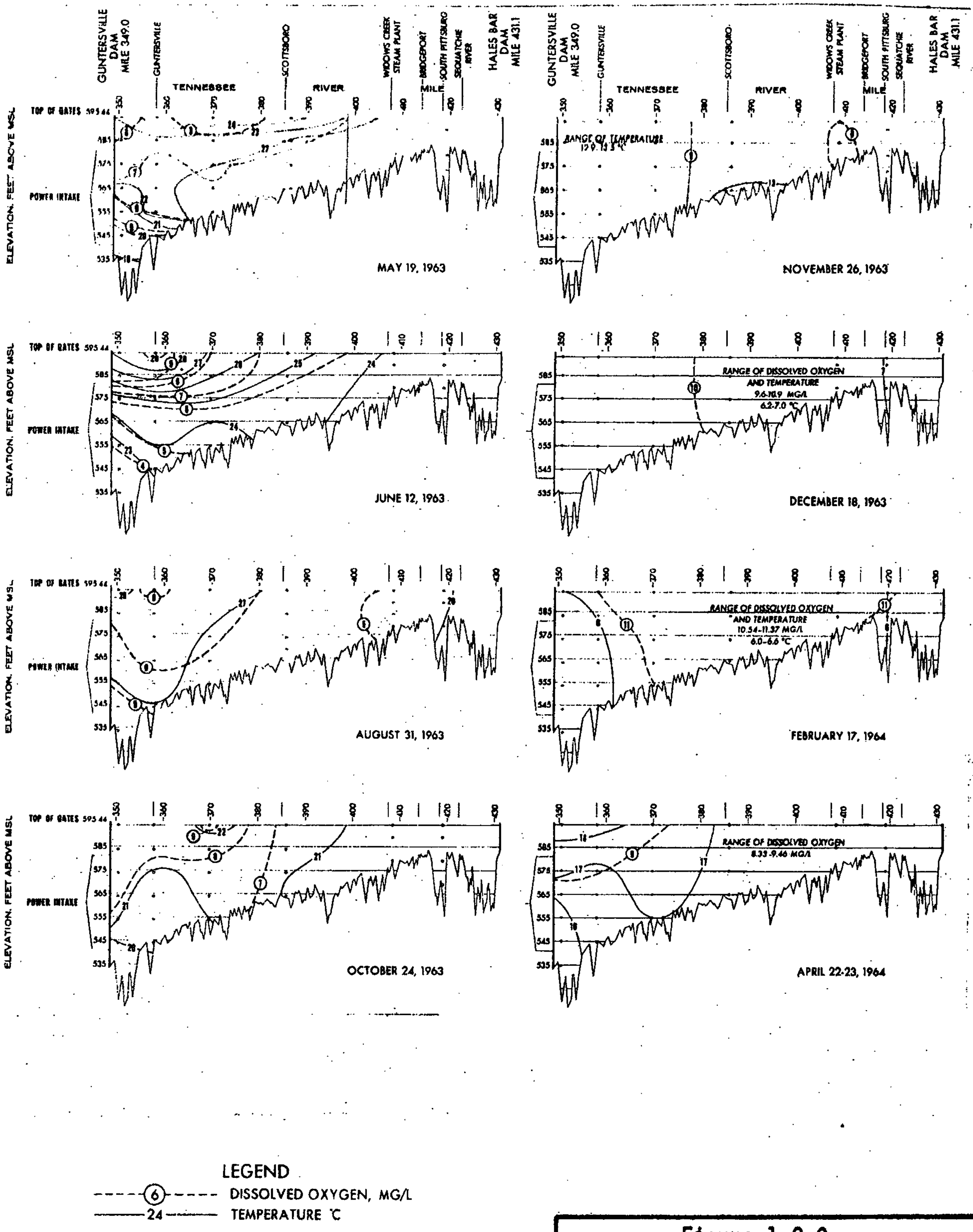


Figure 1.2-9
DISSOLVED OXYGEN AND TEMPERATURE PROFILES GUNTERSVILLE RESERVOIR 1963-1964

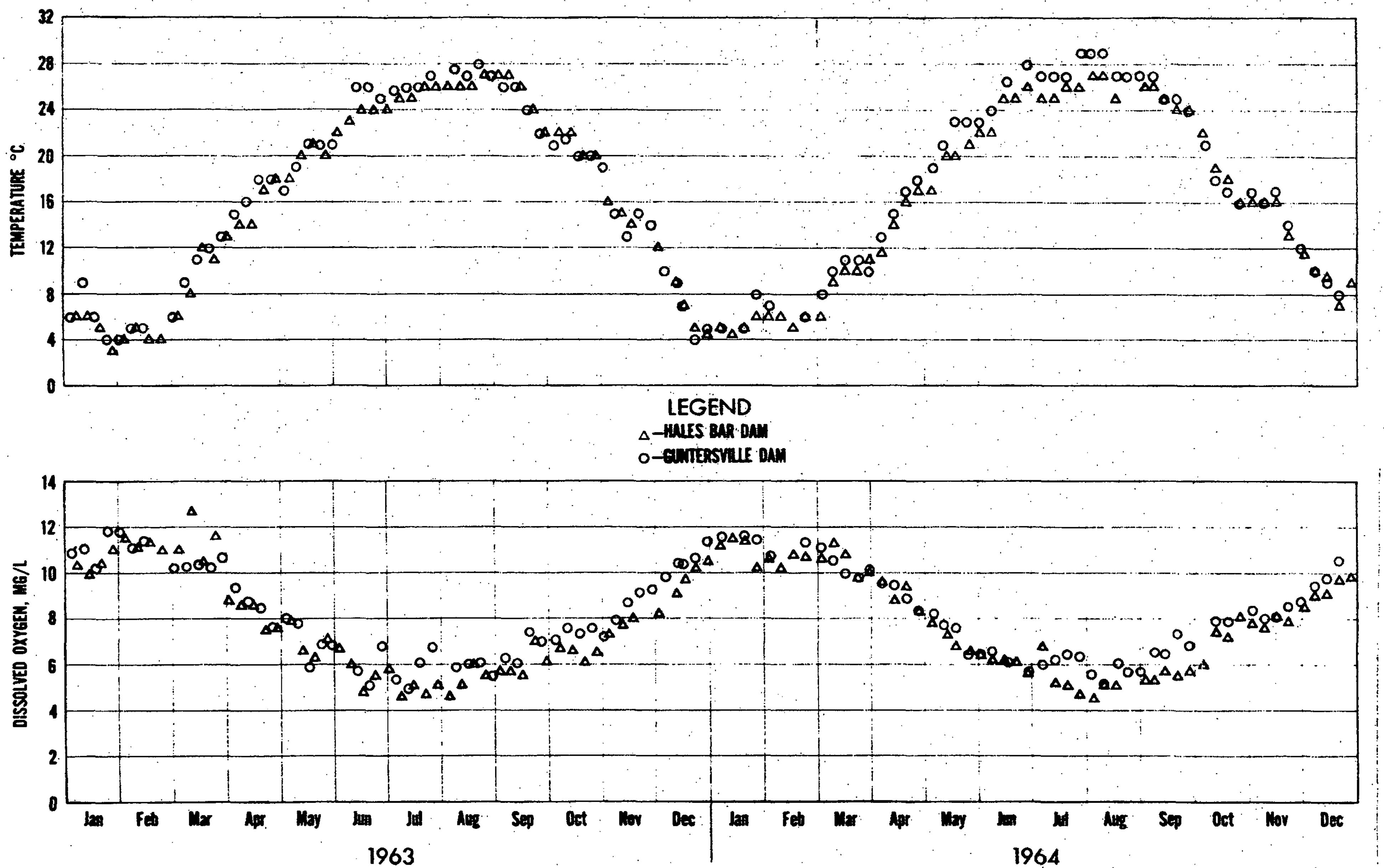
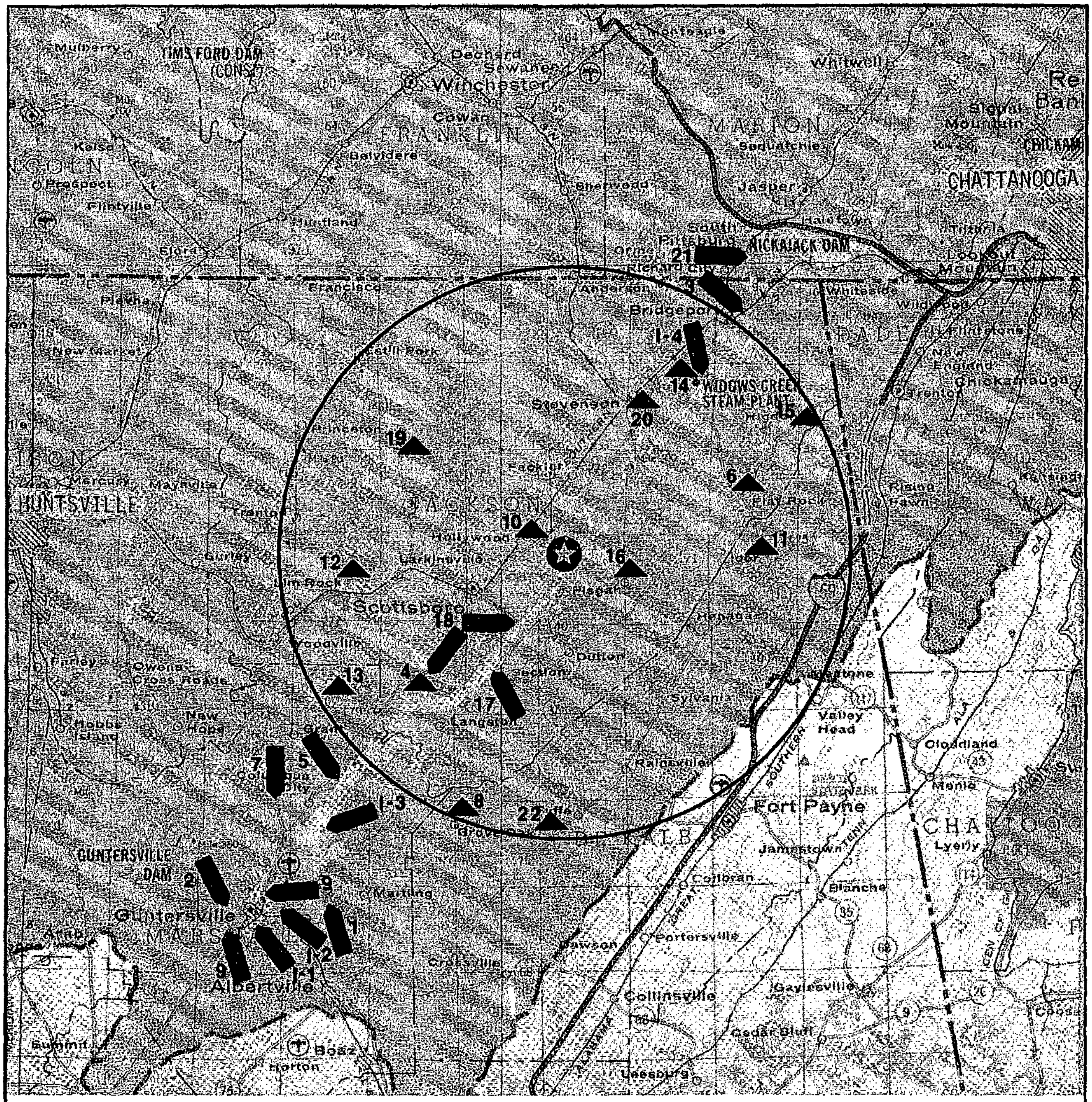


Figure 1.2-10
DISSOLVED OXYGEN AND TEMPERATURE
AT GUNTERSVILLE AND HALES BAR DAMS



Legend

Bellefonte Site

Surface Water Supply

Ground Water Supply

Note: The number associated with the type of supply corresponds to the numbering in table 1.2-16

N

Figure 1.2-11

SURFACE WATER SUPPLIES TAKEN FROM GUNTERSVILLE RESERVOIR AND GROUND WATER SUPPLIES WITHIN 20-MILE RADIUS OF THE BELLEFONTE SITE

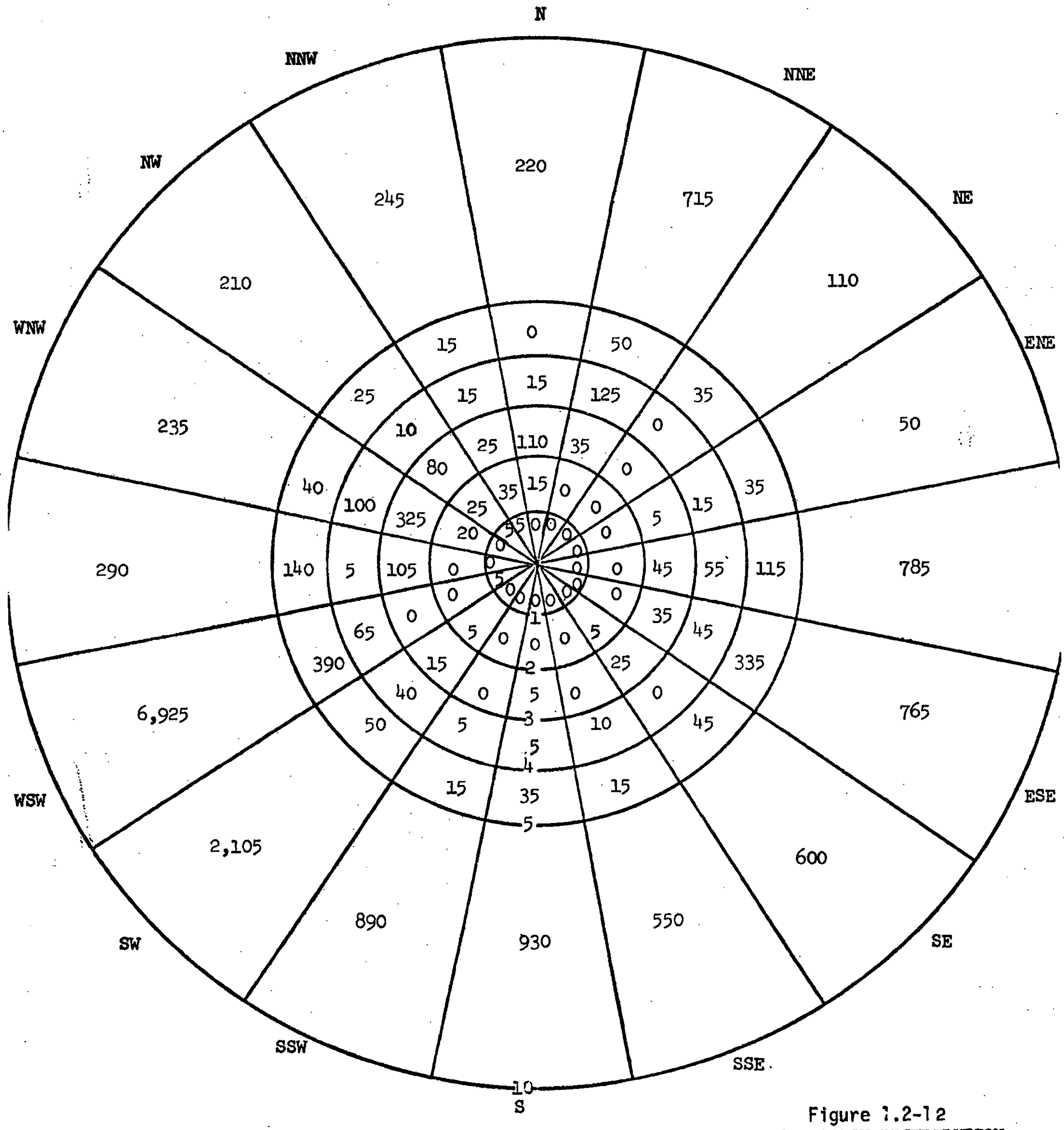


Figure 1.2-12
POPULATION DISTRIBUTION
WITHIN 10 MILES
YEAR 1970

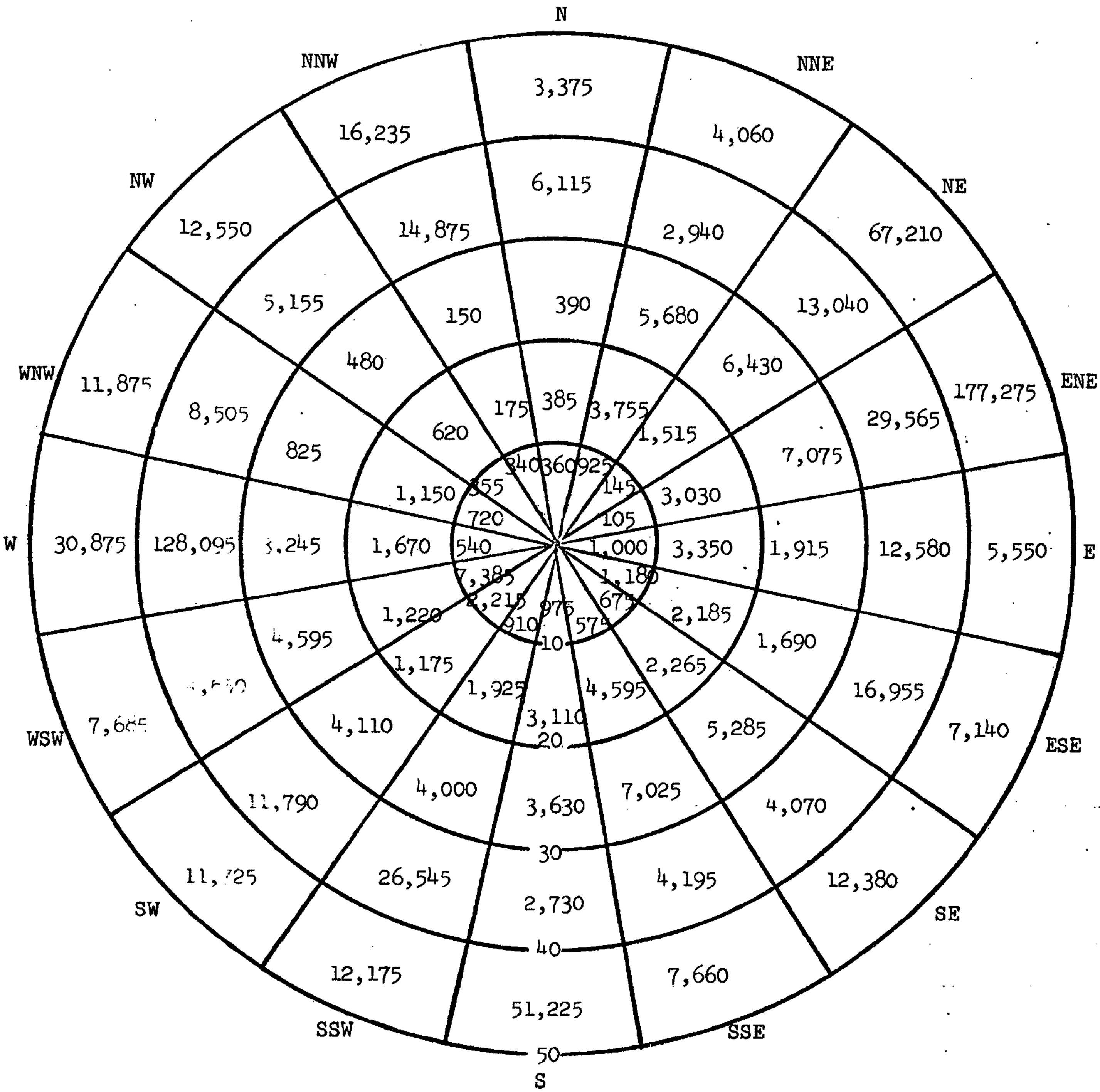


Figure 1.2-13
POPULATION DISTRIBUTION
WITHIN 50 MILES
YEAR 1970

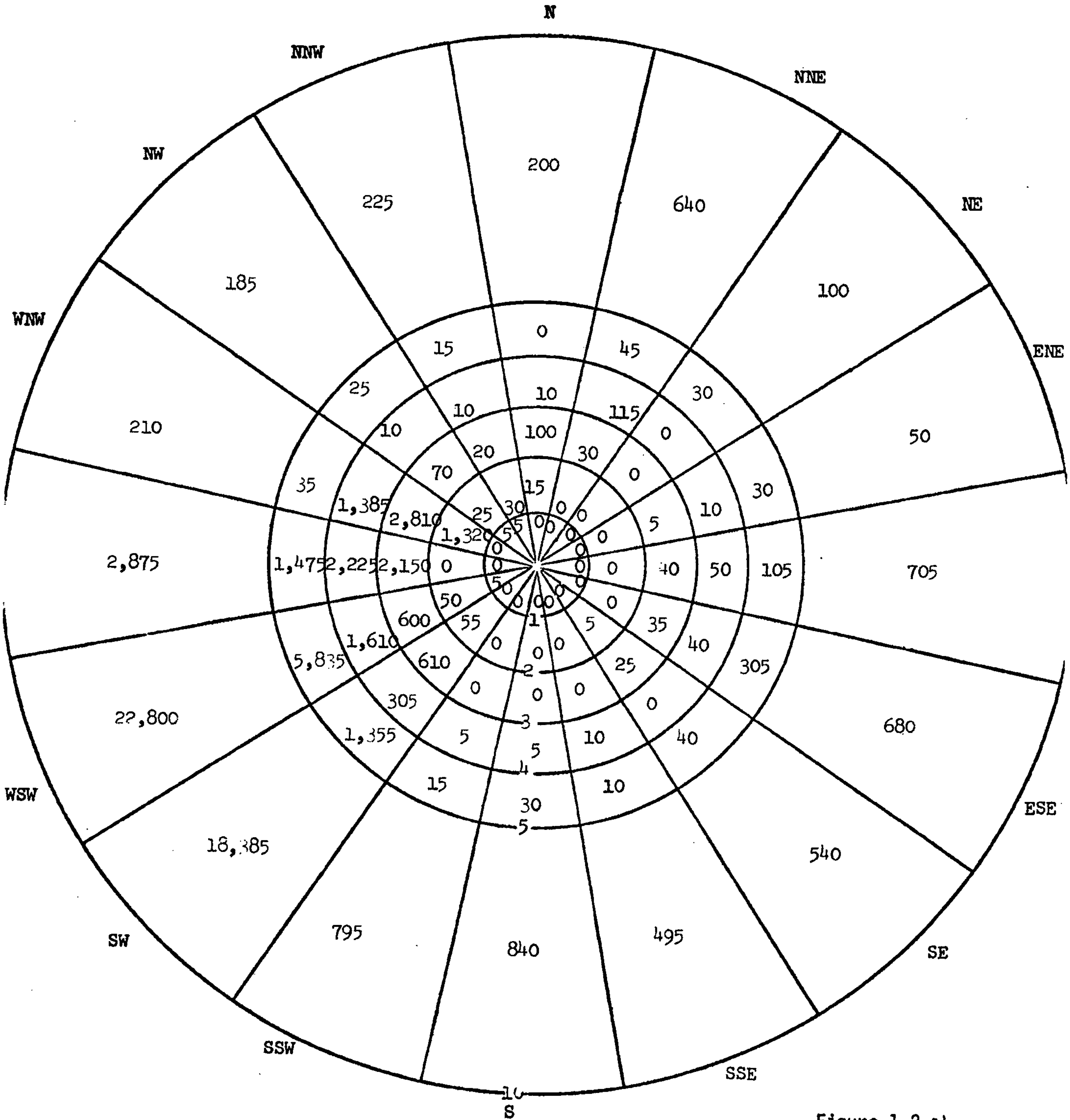


Figure 1.2-14
POPULATION DISTRIBUTION
WITHIN 10 MILES
YEAR 2020

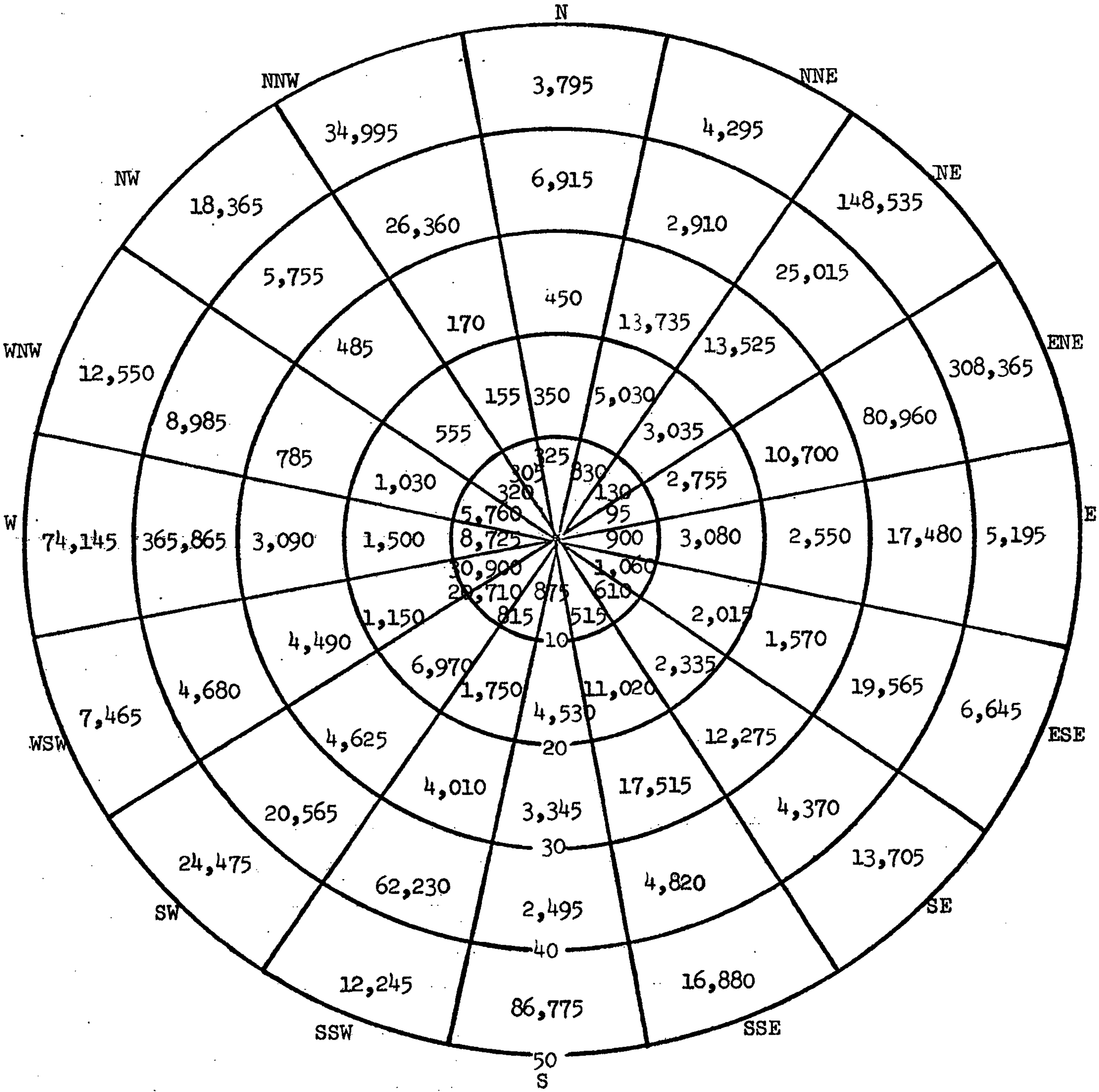


Figure 1.2- 15
POPULATION DISTRIBUTION
WITHIN 50 MILES
YEAR 2020

1.3 Electric Power Supply and Demand - TVA is the power supplier for an area of approximately 80,000 square miles containing about six million people. TVA generates, transmits, and sells power to 160 municipalities and rural electric cooperatives which in turn retail power to their own customers. The approximate areas served by these distributors are shown in figure 1.0-1. These distribution systems, which purchase their power requirements from TVA, serve more than 2 million electric customers, including homes, farms, businesses, and most of the region's industries. TVA also supplies power directly to 46 industries which have large or unusual power requirements and to 11 Federal installations, including the Atomic Energy Commission plants at Oak Ridge, Tennessee, and Paducah, Kentucky.

The importance of an adequate supply of power on the TVA system is by no means limited to electric consumers in the area which TVA supplies directly. This system, which with 20.6 million kilowatts of presently installed generating capacity is the Nation's largest, is interconnected at 26 points with neighboring systems with which TVA exchanges power. The TVA system is, in effect, part of a huge power network. In a time of power emergency, operation of the TVA power system could have a definite impact on power supply conditions from the Great Lakes to the Gulf of Mexico, and from New England to Oklahoma and Texas.

During the past 20 years, loads on the TVA power system have increased approximately 7 percent per year. This rate of growth in power requirements has meant that the capacity of the generating and transmission system has been doubled every 10 years. Until the end of World War II, most of TVA's generating capacity was hydroelectric. By that time, however, most of the suitable hydroelectric sites had been developed, and beginning in 1949 substantially all of the capacity increases were met by the construction of fossil-fueled plants. In the middle 1960's large-scale nuclear plants had become feasible, and TVA began to take steps to add nuclear capacity to its system. TVA has also begun providing pumped-storage and gas turbine capacity to meet system peak loads. Table 1.3-1 shows the TVA system capacity makeup as of June 30, 1972.

The amount of electricity generated in 1965 to meet customer requirements for power exceeded 74.4 billion kilowatt-hours. By 1970, annual electric generation for customer needs had reached 92.7 billion kilowatt-hours. Generating needs are expected to reach 135 billion kilowatt-hours by 1975. TVA presently must add an average of 1,500 megawatts or more of new generating capacity each year to keep up with the rapid increase in electric power usage in this region.

Estimates of future TVA loads are prepared by extending trends of the past while taking into account changes in factors affecting use. Loads are forecast by a number of geographic and class of service categories. Redundant methods are used, where possible, to increase forecast accuracy. Forecasting is preceded by analysis and adjustment of historical data and background preparation including a review of industry conditions, a review of current appliance sales and housing trends, a study of possible new loads, and other factors such as the outlook for the national and regional economy.

Residential uses are forecast by utilizing published forecasts of national household trends and historical trends for regional share of national households and number of customers per household. Average use is forecast by estimating the regional saturation of appliances and annual uses of appliances.

Peak load energy forecasts of large commercial and industrial loads served by municipalities and cooperatives are individually prepared on the basis of factors such as past history, stated plans for operating levels, type of product, and contract demand.

Large industrial and Federal loads which are directly served by TVA are also forecast on an individual basis. Industrial loads are grouped according to industry type, and known expansion and allowance for growth are considered.

1. Power needs - The TVA power system is a winter and summer peaking system with the highest annual peak loads in the TVA service area usually occurring between November and March. Due to seasonal exchange arrangements with other power systems, however, the loads which the TVA generating capacity must actually serve during the remainder of this decade will be greater in the summer than in the preceding winter. The following tabulation indicates TVA's expected power supply outlook during the 1979-82 peak load seasons based on the current capacity installation schedules:

Period	Estimated Peak Demand TVA System-MW	Interchange Delivered or Received-MW	Load Served by TVA-MW	Dependable Capacity-MW	Margin MW	Margin %
Winter 1979-80	30,300	-2,060	28,240	32,105	3,865	13.7
Summer 1980	26,270	+2,060	28,330	33,446	5,116	18.1
Winter 1980-81	31,850	-2,060	29,790	34,475	4,685	15.7
Summer 1981	27,520	+2,060	29,580	35,846	6,266	21.2
Winter 1981-82	33,400	-2,060	31,340	36,875	5,535	17.7

The above power supply projection is based on assumed commercial operating dates of the proposed Bellefonte nuclear units of September 1979 and June 1980.

2. Consequences of delays - The power supply situation for the winter peak periods in the interim from January 1980 through January 1982 are expected to be extremely tight, particularly during the winter periods of 1979-80 and 1980-81, even if the current projected schedules of capacity additions are achieved. These deficiencies are indicated in the following tabluation:

Period	Margins Desired MW	Margins Desired %	Margins Available MW	Margins Available %	Deficiency MW
Winter 1979-80	5,668	20.1	3,865	13.7	-1,803
Winter 1980-81	6,149	20.6	4,685	15.7	-1,464

TVA's desired reserve margins are determined by utilization of the loss of load probability method which has been adapted to the characteristics of the TVA system. TVA's planning criteria requires maintaining a desired reserve margin within a reliability risk level of one day in ten years and any reduction below these margins greatly increases the risk to serve firm load.

Any delay in operation of the Bellefonte units could result in the inability of the TVA system to adequately meet its obligations during the 1979-80, 1980-81, and 1981-82 winter peak periods with the now-scheduled generating capacity. The total consequences of such delays of the Bellefonte Nuclear Plant would be determined by the extent of these delays and the date when such delays were identified.

The following tabulation indicates the amounts by which reserves on the TVA system will be inadequate during various peak load seasons between 1979 and 1981, postulating a delay of 6 months for each of the Bellefonte units from their current schedule. (A delay of unit 1 results in an equal delay in unit 2.)

The deficiencies shown are based on the assumption that the winter peak occurs in January and the summer peak occurs in August since these are the months having the higher probability of the peaks occurring. The winter peak has occurred as early as November and the summer peak as early as June.

	TVA System Megawatt Reserve Deficiencies from Desired Margins Due to Unit Delays of 6 Months
Winter 1979-80	2858
Summer 1980	585[a]
Winter 1980-81	1464

a. Any Bellefonte unit delays would result in a serious deficiency of margins available for scheduled maintenance for all TVA generating units during the period of delay.

If the 1980-81 winter peak occurred in November 1980, unit 2 would not be available since it would be scheduled for December 1980 as a result of the 6-month delay. For the winter 1980-81 peak period the deficiency from the desired reserve margin would increase accordingly from 1,464 megawatts to 2,533 megawatts.

The following tabulation indicates the expected reserve deficiencies on the TVA system during various peak load seasons between 1979 and 1981, postulating a delay of 12 months for each of the Bellefonte units from their current schedule.

	TVA System Megawatt Deficiencies from Desired Margins Due to Unit Delays of 12 Months
Winter 1979-80	2,858
Summer 1980	1,632
Winter 1980-81	2,533

With the 12-month delay in Bellefonte units and the resulting deficiencies identified above, TVA would be unable to maintain a reliable supply of bulk power to serve firm load during the 1979-81 period. The magnitudes of the deficiencies for this period are more than could be covered by assistance from neighboring utilities, particularly the summer 1980 peak period since neighboring utilities are summer peaking systems.

In addition to jeopardizing the ability to serve firm load which would be caused by the 12-month delay of both units, a serious deficiency of margin available for scheduled maintenance for all of TVA's generating units would result for the entire period during 1980.

Deficiencies of the magnitude caused by delays of the Bellefonte units must be replaced either by installing alternative capacity on the TVA system or importing power from other utility systems; otherwise, the reliability of power supply to TVA's customers will be drastically reduced. By the time delays in the Bellefonte nuclear units would be confirmed, it is unlikely that additional capacity other than short lead time generating capacity could be installed to meet these deficiencies. Power in the magnitude being considered is not expected to be available from other utilities when it is needed on the TVA system.

The economic costs of any Bellefonte delays (which must ultimately be borne by the consumer) would consist of two parts: (1) cost of replacement capacity, and (2) increased production expense during the delay period because of unavailability of low-cost nuclear energy.

The estimated investment cost of 1,000 MW of replacement capacity which could be installed for the 1979-80 period is approximately $130 million (based on 1972 dollars). Annual fixed charges of about $13 million on such an investment must be borne by consumers in the form of higher rates until the effect of these additions can be absorbed in later years by system growth. The value of these fixed charges (assuming an 8 percent discount rate and a discount period of 4 years) would be about $43 million.

Fuel, operating, and maintenance expense for the Bellefonte nuclear units is estimated to cost about 2.1 to 2.2 mills per kWh during the 1979-80 period, while replacement energy which would be used in lieu of this nuclear energy in the event of delays would cost from 4.3 to 12.5 mills per kWh, depending on the source of this replacement energy. Studies of the effects of Bellefonte unit delays indicate that each month's delay on these units would result in increased production expenses on the TVA system of approximately $3.6 million.

In addition to these economic costs, each month's delay on the two Bellefonte nuclear units could require that approximately 545,000 tons of additional coal and 20.7 million gallons of oil be burned in plants on the TVA system or other systems to replace the lost nuclear energy. This could have an adverse environmental impact in terms of increased emissions of particulates, sulfur dioxide, and other materials to the atmosphere.

In summary, delays of the Bellefonte Nuclear Plant will have a twofold effect on the TVA power system:

1. Costs to TVA's customers would be increased by at least $3.6 million for each month of delay, assuming the delay did not require the installation of combustion turbines or combined-cycle units. If additional generating capacity were required to offset deficiencies due to Bellefonte delays, costs to TVA's consumers over and above those shown above could be increased by $43 million. These costs could total about $86 million for a 12-month delay.
2. Increased operation of TVA's older, less efficient fossil-fired units would be required during the period of further Bellefonte delays. Such operation would result in the increased emission of particulates, sulfur dioxide, and other materials into the atmosphere.

The analysis shown on page 1.3-4 shows that TVA cannot carry out its statutory obligation of providing an ample supply of electricity for the TVA region without the Bellefonte Nuclear Plant. Even with the Bellefonte plant the reliability risk level will be below that which TVA considers desirable. Without the plant, the reliability risk level would be increased to a loss of load probability of over 2 days per year, which is clearly unacceptable.

Table 1.3-1

TVA SYSTEM CAPACITY
(as of June 30, 1972)

Plant	Number of Units	Nameplate Capacity-kW Units	Nameplate Capacity-kW Total
TVA Thermal			
Thomas H. Allen[a]	3	330,000	990,000
Thomas H. Allen (Gas Turbines)	16	23,900	382,400
Bull Run	1	950,000	950,000
Colbert	5	2 @ 200,000	1,396,500
		2 @ 223,250	
		1 @ 550,000	
Gallatin	4	2 @ 300,000	1,255,200
		2 @ 327,600	
John Sevier	4	1 @ 223,250	823,250
		3 @ 200,000	
Johnsonville	10	4 @ 125,000	1,485,200
		2 @ 147,000	
		4 @ 172,800	
Kingston	9	4 @ 175,000	1,700,000
		5 @ 200,000	
Paradise	3	2 @ 704,000	2,558,200
		1 @ 1,150,200	
Shawnee	10	175,000	1,750,000
Watts Bar	4	60,000	240,000
Widows Creek	8	5 @ 140,625	1,977,985
		1 @ 149,850	
		1 @ 575,010	
		1 @ 550,000	
TVA Hydro			
Appalachia	2		75,000
Blue Ridge	1		20,000
Boone	3		75,000
Chatuge	1		10,000
Cherokee	4		120,000
Chickamauga	4		108,000
Douglas	4		115,000
Fontana	3		225,000
Fort Loudoun	4		133,390
Fort Patrick Henry	2		36,000
Great Falls	2		31,860
Guntersville	4		97,200

a. Leased January 1, 1965, from Memphis Tennessee, Light, Gas and Water Division.

Table 1.3-1
(continued)

TVA SYSTEM CAPACITY

(as of June 30, 1972)

Plant	Number of Units	Nameplate Capacity-kW Units	Nameplate Capacity-kW Total
TVA Hydro (cont.)			
Hiwassee	2		117,100
Kentucky	5		175,000
Melton Hill	2		72,000
Nickajack	4		97,200
Nolichucky	4		10,640
Norris	2		100,800
Nottely	1		15,000
Ocoee #1	5		18,000
Ocoee #2	2		21,000
Ocoee #3	1		27,000
Pickwick	6		220,040
South Holston	1		35,000
Tims Ford	1		45,000
Watauga	2		50,000
Watts Bar	5		150,000
Wheeler	11		356,400
Wilbur	4		10,700
Wilson	21		629,840
Alcoa Hydro*			
Bear Creek	1		9,000
Calderwood	3		121,500
Cedar Cliff	1		6,375
Cheoah	5		110,000
Chilhowee	3		50,000
Nantahala	1		43,200
Santeetlah	2		45,000
Tennessee Creek	1		10,800
Thorpe	1		21,600
Corps of Engineers Hydro			
Barkley	4		130,000
Center Hill	3		135,000
Cheatham	3		36,000
Dale Hollow	3		54,000
Old Hickory	4		100,000
J. Percy Priest	1		28,000
Wolf Creek	6		270,000
*Minor Alcoa Plants			6,240

1.4 Environmental Approvals and Consultations - In addition to its own standards, TVA as a Federal agency is subject to comprehensive and broad-scale environmental procedures and Federal and state consultation and coordination requirements of the National Environmental Policy Act of 1969, 42 U.S.C. § 4331 et seq. (1970) (as implemented by Executive Order 11514 (35 Fed. Reg. 4247)). In addition, TVA is subject to Executive Order 11507 (35 Fed. Reg. 2573), and Office of Management and Budget Circulars A-78 and A-81, relating to the prevention, control, and abatement of air and water pollution in Federal facilities, as well as certain provisions of the Clean Air Act, as amended, 42 U.S.C.A. § 1857 (1970), and the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) which relate to the applicability of various Federal, state, interstate, or local air and water quality standards. In addition, TVA is subject to the requirements of Office of Management and Budget Circular A-95 which insure that major generating and transmission projects are coordinated from the point of view of community impact and land use planning with state and local agencies.

TVA has been consulting with state and regional organizations since January 1971 about the possibility of a nuclear plant at the Bellefonte site and its implications on the development of the area.

On January 19, 1971, TVA's Regional Planning Staff met with the Top of Alabama Regional Council of Governments (TARCOG) staff to discuss the sites in north Alabama which might be the location for a nuclear plant. TARCOG is the regional clearinghouse agency. The historical significance of Bellefonte was first brought up at this meeting.

A short time later on January 22, 1971, the Regional Planning Staff met with key officials in the Alabama Development Office (ADO) which is the state clearinghouse agency. The meeting covered TVA's studies of all potential nuclear plant sites in Alabama, which included Bellefonte. The ADO officials were the Director and the State Clearinghouse Officer.

On March 8, 1971, Regional Planning Staff, Alabama Historical Commission, and TARCOG staffs made a field investigation to locate significiant historic structures and sites. Location of a stagecoach inn and evidence of the courthouse cistern were determined.

The Regional Planning Staff reviewed TVA's plans with the Alabama State Historical Commission staff in light of the historical aspects of land adjacent to the site. This meeting was held on May 17, 1971, and culminated in a number of suggestions by the Commission's staff as to how the historical site might be improved by TVA.

The Regional Planning Staff met with TARCOG on May 18, 1971, to discuss the relationship of the proposed plant to regional and local development objectives. In addition to general support for the proposal, TARCOG staff made some specific suggestions as to how the necessary rail and highway access to the plant site might be constructed to enhance the development potential of other nearby sites.

On May 21, 1971, the State Clearinghouse Office was apprised of TVA's meetings with the Historical Commission and TARCOG and was requested to provide any comments it felt appropriate at that time.

The Regional Planning Staff was notified by the Alabama Historical Commission on August 6, 1971, that Bellefonte would be nominated to the National Register of Historic Places. The Commission also made specific recommendations as to how TVA might participate in preservation of the site. Shortly thereafter, TARCOG notified TVA that they concurred with the Historical Commission's recommendations.

TVA has consulted with the Alabama Historical Commission about investigating the historical significance of the Bellefonte townsite. Further consultations will determine the appropriate state agencies that should contract to carry out the investigation.

The acceptability of using a lake as a cooling facility was explored with the Alabama Water Improvement Commission. On October 18, 1972, the Acting Chief Administrative Officer, AWIC, notified TVA that the Commission had previously approved a cooling pond for another power generating facility located in Alabama and that AWIC would not be opposed to evaluating such a system for the Bellefonte site should studies show the cooling pond to be the most feasible cooling alternative.

The Birmingham National Weather Service, Birmingham, Alabama, was consulted in gathering climatological information to discuss severe weather conditions in the Bellefonte area.

The Environmental Data Service state climatologists in Montgomery, Alabama, were consulted for information on frequency and severity of tornadoes in the Bellefonte area.

1.5 Emergency Planning - TVA has developed a Radiological Emergency Plan (REP) which sets forth the policies, purposes, delegations, standards, guidelines, and, where feasible, specific instructions necessary for TVA to discharge its responsibilities during a radiological emergency in order to comply with pertinent directives applicable to the protection of the health and safety of the public and TVA personnel, plants, and properties.

The REP consists of the basic document and annexes. The basic document contains program delegations and broad guides, which apply generally to all TVA nuclear operations. Annexes to the basic document will include detailed radiological emergency plans for each TVA nuclear plant. In addition, the annexes will contain a Radiological Emergency Medical Assistance Plan for dealing with employees who might be injured during an accident. A site radiological emergency plan annex will be prepared for the Bellefonte Nuclear Plant.

TVA is coordinating all aspects of the REP with the appropriate state agencies, such as the Departments of Public Health and Public Safety. The TVA Radiological Emergency Plan defines the details of authority and responsibility of all offsite agencies involved in an emergency situation. Responsibilities such as evacuation, housing, and feeding evacuees are defined so that the responsible agencies may take the initiative in expeditiously executing their phases of the plan. The standards and procedures used are consistent with regulatory programs of state and other Federal agencies. To ensure that their latest recommendations are considered, TVA maintains liaison with these agencies.

In developing the Radiological Emergency Plan, meetings have been held with the State Health Departments of Alabama, Georgia, South Carolina, and Tennessee to ensure workability of the plan and delegation of responsibility, authority, and emergency assignments. In addition, the State Health Department of Kentucky has been contacted and arrangements made for participation in the event of a transportation accident involving radioactive materials.

Each state through which radioactive material from a TVA plant is to be transported either has or will have a radiological assistance plan for use in the event of a transportation accident within its jurisdiction. These plans have been or will be obtained and incorporated in the REP as they are available. The plans will be completed prior to shipment of radioactive material from the factory.

Contacts have also been made with the appropriate Atomic Energy Commission Operations Offices to ensure that assistance can be obtained through the Interagency Radiological Assistance Plan, if necessary.

The Eastern Environmental Radiation Laboratory, EPA, has agreed to provide additional analytical laboratory services in the event of an accident if these services are not available within TVA.

Written agreement among participating state and Federal agencies and TVA will be obtained outlining each agency's responsibilities. The individual states' health department radiological assistance plans will be incorporated in the annexes to the TVA Radiological Emergency Plan.

1. Meetings with outside agencies - Representatives of TVA will meet with appropriate representatives of the following states to discuss the plans for radiological emergencies which might result as a consequence of the operation of the Bellefonte Nuclear Plant: Alabama, Georgia, South Carolina, Tennessee, Kentucky, and Illinois. Other agencies, such as the Environmental Protection Agency and Atomic Energy Commission, will also be contacted where necessary.

2. Responsible agencies to be notified in case of accident - Appropriate TVA personnel receiving notice of a transportation accident shall notify the TVA load dispatcher who notifies the Central Emergency Control Center director who shall notify as appropriate key persons in the states involved, as well as EPA and AEC.

2.0 ENVIRONMENTAL IMPACT OF THE PROPOSED FACILITY

The Bellefonte Nuclear Plant will interact with the environment as a result of its construction, connection with TVA's power transmission system, and subsequent operation. Construction will result in a physical alteration of a portion of the site area and will result in some erosion, noise, dust, and smoke during various phases of construction. Connection of the plant to TVA's power transmission system will result in easement restrictions on new transmission line rights of way and minor construction effects. Operation of the plant will result in minor releases of heated water, chemicals, and radioactive liquids and gases. These interactions and resulting impacts have been evaluated considering the environment in the area as described in Section 1.2, Environment in the Area.

Since many of the details of the environmental monitoring programs are closely related to the final plant design, the monitoring programs described in several sections of this statement are tentative. As details of the final plant design are completed, the respective environmental monitoring programs will be reevaluated and modified as needed to insure adequate environmental monitoring programs. When this is completed, the resulting proposed monitoring programs will then be reviewed and coordinated with the appropriate Federal, state, and local agencies as required by Executive Order 11514.

The interactions and impacts discussed in the following sections have been examined for their potential effects on land, water, and air uses, including industrial operations, transportation, farming, forestry, recreation, wildlife preserves, waterways, government reservations, and water supplies. No adverse impacts on these uses other than those identified in the following sections are anticipated, and no other loss of use of land, water, and air is expected to occur.

2.1 Transportation of Nuclear Fuel and Radioactive Wastes - While specific details of TVA's transportation plans for shipment of radioactive materials for the Bellefonte Nuclear Plant are not available at this stage, the following discussion is appropriate to the environmental review.

About 100 tons of nuclear fuel will be shipped annually to and from the plant, and packaged radioactive waste totaling about 120 tons will be shipped annually from the plant to AEC-licensed disposal areas. These two types of radioactive materials will be shipped in accordance with applicable Federal and state regulations. 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.

The protection of the public from radiation during the shipment of nuclear fuel and radioactive waste depends on the limitations on the contents, the package design, the external radiation levels as well as the method, routing, and safeguards to be followed in transport. These factors are discussed below in regard to the shipment of new fuel, spent fuel, and radioactive wastes.

1. New fuel shipment - Fuel elements for the plant require an annual commitment of about 200 tons of natural uranium in the form of U_3O_8 for each reactor. However, some of this uranium may come from reprocessed spent fuel.

New fuel for the plant is made of slightly enriched uranium dioxide pellets which have been sintered and compacted to form very dense pellets having high strength and high melting points. The pellets are approximately 1/2 inch in diameter by 3/4 inch long and are stacked inside zircaloy tubing with space left at the end of the tubing to provide for collection of gas generated during the fission process. These tubes are welded shut at both ends, forming a fuel rod, and are subjected to rigorous quality control to ensure their integrity. These rods are included in a 15 rod by 15 rod array to form a fuel assembly. A more detailed description of the fuel assemblies will be given in the safety analysis report which will be filed in support of the construction permit application.

TVA will apply for a special nuclear material license to provide for receipt, possession, and storage of fuel elements before the initial core of the reactor is shipped to the plant. In addition, all fuel assemblies will be delivered to the TVA plant site in accordance with shipping procedures and arrangements authorized for use by the fuel fabricator under special nuclear material license in accordance with AEC regulations.[1] Fuel will be shipped in shipping containers which will have been demonstrated to provide safety from criticality under both normal and accident conditions.

(1) Method and frequency of shipment - The Babcock & Wilcox Company (B&W) is the fabricator of the initial core fuel assemblies and is responsible for shipment of these fuel assemblies to the reactor site. B&W presently has a fuel fabrication plant at Lynchburg, Virginia. This fuel will most likely be shipped by truck trailers in quantities up to six shipping containers per load, each containing two fuel assemblies, thereby providing a maximum of twelve fuel assemblies per truck shipment. About twelve such shipments by truck will

be received at the plant annually (about 18 shipments in the initial core for each unit).

(a) Shipping routes - It is assumed that B&W will ship the initial core fuel assemblies by truck from its fabrication plant in Lynchburg, Virginia, to the plant. The major population centers encountered over an assumed 375-mile route include the following:

City	1970 Population	Density Persons/mile^2
1. Lynchburg, VA--by way of U.S. 460 to	54,083	2,153
2. Roanoke, VA--by way of U.S. 220, I-81, and I-40 to	92,115	3,412
3. Knoxville, TN--by way of I-75 to	174,587	2,267
4. Chattanooga, TN--by way of I-24 and U.S. 72 to	119,082	2,267
5. Bellefonte Plant Site		

(b) Shipment activity - Relatively low levels of radiation are emitted from unirradiated new fuel assemblies. Because the type of radiation emitted by uranium is reduced by even thin layers of metal and the self-shielding properties of the fuel reduce the cumulative effect, no additional gamma or beta shielding is required in shipping packages for new fuel. The following properties of the fabricated new fuel limit the radiological impact on the environment to negligible levels:

- No radioactive fission products.
- No radioactive gases.
- High melting point.

- Insoluble solid.
- Zircaloy clad.
- Fuel assemblies will not disruptively react or decompose under expected or postulated thermal conditions.

(2) Environmental effects - The population exposure resulting from the normal shipments of new fuel has been evaluated for the people who reside on either side of the transport route. The radiation dose as a function of distance from a shipping container drops off quite rapidly. Because the container will be stationary for only brief intervals and because of the low activity level of new fuel, the total exposure to an individual living along the transport route will be an insignificant fraction of the exposure from natural background radiation.

(a) Normal shipments - Because of the estimated low dose rates due to new fuel at the time of shipment (<0.1 mrem/h at 6 feet from the container), the only exposure from routine shipments of new fuel is to persons along the transport route during the brief period such a shipment is in direct view and to the individual truck drivers driving the trucks. For example, a member of the general public who spends 3 minutes at an average distance of 6 feet from the container would receive a dose not exceeding 0.005 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 12 shipments of new fuel would be about 0.0006 man-rem.

Based on an estimated radiation level in the cab of the truck of <0.1 mrem/h, exposure to transportation personnel is estimated to be less than 1 mrem per shipment. A total dose to all drivers for a given year, assuming two drivers per vehicle, would not exceed 0.02 man-rem.

It is concluded that there are no environmental risks from radiation associated with the normal shipment of new fuel.

(b) Accident occurrences - The problems which might result from a transportation accident equivalent to that specified in 10 CFR Part 71 would consist of the physical damage of the impact and the interference associated with having to send the fuel back to the fabricator for inspection. A subsequent determination would then be made to determine whether there had been damage which would affect the operation of the fuel in the reactor. There would be no release of radioactive materials and no increase in radiation dose rates over those from normal shipment. Thus, it is concluded that there would be no significant environmental risks from radiation resulting from an accident involving a shipment of new fuel.

2. Spent fuel shipment - Spent fuel removed from the two reactors during the annual refuelings is expected to contain on a weight basis in excess of 99 percent of the fission products formed inside the fuel. The water in the pool serves as both a radiation shield and coolant while the short-lived fission products decay. At the end of a storage period of about 3 to 4 months, the spent fuel is loaded into ruggedly built shielded containers for shipment to a fuel

reprocessing plant. There the spent fuel is chemically reprocessed to recover its unused fuel content, uranium and plutonium, for future use. It is possible to ship spent fuel by rail, truck, or barge.

(1) <u>Method and frequency of shipment</u> - All the equipment and services for spent fuel transportation and reprocessing are to be provided to TVA by contract. This includes transport vehicles, special shielded containers, services associated with container loading, and all transport arrangements. Even though TVA contracts these services, it will specify the scope, terms, scheduling, transportation, and reporting of shipments as appropriate and in accordance with AEC and the Department of Transportation regulations. Presently, there are fuel reprocessing plants in operation or under construction in Morris, Illinois; West Valley, New York; and Barnwell, South Carolina.

There are several possible shipping methods for irradiated fuel. These range from truck shipments with cask capacities from 0.4 to 1.2 metric tons of uranium to rail shipments with cask capacities from 3.2 to 5.0 metric tons of uranium at a time. Water transportation of spent fuel with about 5 metric tons of uranium could also be used.

Truck shipment of spent fuel from Bellefonte would require about 140 legal-weight shipments (73,280 pounds) over a period of about 4 to 6 months each year or about 70 shipments if a 90,000-pound truck load limit is permitted.

Rail shipments originating from the plant would require about 10 to 14 shipments annually. The shipments would be in a special rail cask holding from about 10 to 15 fuel assemblies. If necessary, fuel assemblies which have identified clad perforations will be sealed in special containers before being loaded into the spent fuel cask.

Since it will not be necessary to ship spent fuel from Bellefonte to a reprocessing plant until approximately 1980, TVA has not entered at this time into a contract for shipment of spent fuel from this plant. Even though the exact mode of transportation and other details related to spent fuel shipments have not yet been defined, rail shipments have been assumed for purposes of routing and estimating the environmental effects.

(a) Shipping routes - It is assumed that the spent fuel from Bellefonte would be shipped about 425 miles by rail to the closest fuel reprocessing plant which is at Barnwell, South Carolina. The major population centers encountered along the assumed route are:

City	1970 Population	Density Persons/mile^2
1. Bellefonte Site--by way of Southern to	--	--
2. Chattanooga, TN--by way of Southern to	119,082	2,267
3. Atlanta, GA--by way of Seaboard Coast to	496,973	3,779
4. Barnwell, SC (AGNS site)	4,439	562

(b) Shipment activity - Fuel elements which are removed from the reactor will be essentially unchanged in outward appearance. However, in addition to a portion of the original useful uranium fuel, these fuel elements will contain some reactor-generated plutonium and an accumulation of fission products. This irradiated spent fuel is subsequently shipped to a reprocessing plant for recovery of its unused fuel content (fissionable uranium and plutonium).

The estimated inventory of fission product activity and decay heat of the Bellefonte spent fuel at the time of shipment is given in Table 2.1-1. It should be noted that effectively all of this contained radioactivity is tightly bound within the insoluble, high-melting-point uranium dioxide pellets. Therefore, even if the shipping cask should be breached in an accident and the fuel cladding should be ruptured, there is still no ready mechanism for dispersing any substantial fraction of the total contained radioactivity.

(2) Environmental effects - Prior to shipment, the fuel will be allowed to radioactively decay for about 3 to 4 months. Then all noble gases with the exception of krypton-85 will have decayed to insignificant levels and iodine-131 will have decayed to low levels. Further, the rate of decay heat generation by the spent fuel will have decreased. Of the iodine isotopes, only iodine-131 is present in significant amounts. Fission products other than a portion of the noble gases and iodine are strongly held within the uranium dioxide fuel pellets. Hence, only noble gases and iodine which have escaped from the fuel could escape through a penetration in fuel clad to the shipping cask cavity.

(a) Normal shipment - The principal normal environmental effect from spent fuel shipments would be the direct radiation dose from the fuel as it moves from the reactor to the reprocessing plant. The population exposure resulting from normal shipments of radioactive materials has been evaluated based on the assumption that there would be about 42,500 people living in the area within 1/2 mile of both sides of the transport route along the estimated 425-mile route. It has also been assumed that the shipments are made at the maximum permitted level of 10 mrem/h at 6 feet from the nearest accessible surface.[2] Figures D-1 and D-2 of Appendix D show the location of the shipping container relative to people living adjacent to the transport route and the rapid decrease in radiation exposures as a function of distance from the shipping container. The calculation does not include reductions of exposures due to shielding from structures, topographic features, or other radiation-attenuating materials.

Assuming a maximum of 14 shipments per year, each moving at only 20 mi/h, the maximum exposure received by any individual residing 100 feet from the center of the transport route would be about 0.004 mrem per year. The average exposure for these 14 shipments to an individual living along the transport route would be about 0.0002 mrem per year. On the basis that there would be a total of about 42,500 people living within 1/2 mile on either side of the transport route between the fuel reprocessing plant at Barnwell, South Carolina, these people would receive an annual dose of about 0.009 man-rem per year. Train brakemen or a member of the general public might spend a few minutes in the vicinity of the car, at an average distance of 6 feet, for an average exposure of about 0.5 mrem per shipment. With 10 different brakemen and 10 members of the general public so involved along the route, the total dose for 14 shipments during the year is estimated to be about 0.14 man-rem.

Since the exposure to the people who reside along the route and to each person who might come within 6 feet of the railcar for a short period is only 0.0002 and 0.4 percent respectively of the exposure these same people receive from natural background radiation, it is concluded that no adverse environmental effects will result from the normal transportation of spent fuel from Bellefonte to the fuel reprocessing plant.

(b) Accident occurrences - The principal potential environmental effects from an accident are those from direct radiation resulting from increased radiation levels, from gaseous release of noble gases and iodine, and from release of contaminated coolant.

Evaluation of exposure from direct radiation assumes that the radiation exposure rate is the maximum permitted by regulations, 1,000 mrem/h at 3 feet from the surface of the container, and that people have surrounded the container beginning at about 50 feet from the container.[3] Figure D-3 of Appendix D shows the exposure rate for accident conditions as a function of distance from the container. The exposure rate at 50 feet would be about 17 mrem/h. Assuming a tightly packed crowd, there would be 154 people in the front row, and as shown on figure D-1, these people would provide shielding such that people in subsequent rows would receive greatly reduced radiation exposure. If a person remained in the front row for 2 hours, his exposure would be about 34 mrem. Further, the increased radiation level would most likely be from only a localized area on the container, and thus only a small number of people in even the front row of a crowd would be exposed to these radiation levels.

Calculations for a probable shipping container indicate that there would be no gaseous releases unless there were a substantial quantity of decay heat in the shipping container and some additional external heat such as from a fire. Thus, it is assumed that the heated air currents surrounding the container would carry any released fission gases to a height of 10 meters before they are dispersed in the environment. Assuming a person stands in the plume during the entire accident, the resulting whole-body exposure would be 2 mrem, the skin dose would be about 86 mrem, and the thyroid dose would be about 5 rem. For the noble gas release, assuming an average population density of 100 people per square mile, the total whole-body population dose from the accident would be 0.07 man-rem. TVA considers the average population to be a realistic number for analyzing transportation accidents because of the small fraction of the total distance travelled in high population density areas and because accidents in such areas generally occur at lower speeds and thus could be expected to be less severe.

The contaminated coolant in the shipping container is basically low specific activity material. In the event the coolant were drained from the container in an accident, emergency plans for containing the contaminated liquid and preventing a radiation hazard to the public and the environment will be initiated.

The principal environmental risk resulting from an accident would be the potential whole-body radiation exposure due to direct radiation and the noble gases released and potential thyroid dose due to the iodines released. Because of the dose reduction with distance and the mitigating effect of proposed emergency actions, it can be concluded that the whole-body radiation exposure to the public will be negligible. Because of the unlikely combination of circumstances which must be present to result in a significant dose due to the release of iodine, the probability of significant doses due to this occurrence is considered extremely small.

3. Radioactive waste shipment - The radioactive wastes to be shipped for disposal will be concentrates from the waste evaporator, spent demineralizer resins, miscellaneous dry solid wastes, irradiated or contaminated equipment components, and tritiated water.

The radwaste packaging facility at Bellefonte will be equipped to use standard DOT17H[4] drums. The waste evaporator bottoms and spent demineralizer resins will be solidified before shipment to a disposal site regulated by AEC and the state.

(1) Method and frequency of shipment - Waste evaporator concentrates and spent demineralizer resins are collected in the plant and may be stored for decay of short-lived isotopes. After up to 120 days' decay, the only significant radioactive isotopes present will be long-lived corrosion products such as cobalt-60.

Based on the estimated quantities and activities, there will be about 16 shipments of waste evaporator concentrates and 8 shipments of spent demineralizer resins each year. Waste evaporator concentrates are drummed and placed in an approved container for shipment to an AEC-licensed disposal area. The resins may be shipped in specially constructed lead-steel containers similar to the LL-60-150 cask planned to be used for shipping the higher activity radioactive material from the Browns Ferry Nuclear Plant. The casks will be decontaminated if necessary at the disposal area and returned to the plant.

Appropriately packaged compressible wastes will generally be shipped to the disposal area on flatbed trucks. There will be approximately one shipment per year of such compressible wastes.

Radioactive equipment components will generally have low volumes. No shipments are expected during the first years of operation. Radioactive components will be stored in the spent fuel pit until sufficient quantities are available for a shipment.

Tritiated water will be shipped in tank trucks licensed for low specific activity liquids. Beginning between 7 to 12 years after initial operation, about 50,000 gallons of tritiated water will be shipped annually. This will require use of about 13 tank truck loads with each containing about 35 Ci of tritium.

(a) Shipping routes - It is assumed that radwaste shipments from Bellefonte would be by truck about 400 miles to the closest AEC-approved disposal area at Morehead, Kentucky. The major population centers encountered over the assumed route are:

	City	1970 Population	Density Persons/mile^2
1.	Bellefonte site--by way of U.S. 72 and I-24 to	--	--
2.	Chattanooga, TN--by way of I-75 to	119,082	2,267
3.	Knoxville, TN--by way of I-75 to	174,587	2,267
4.	Lexington, KY--by way of I-64 to	108,137	4,702
5.	Morehead, KY	7,191	4,494

(b) Shipment activity - The estimated activity and quantities of the radioactive wastes to be shipped from Bellefonte are summarized as follows:

	Type Waste	Annual Amount	Expected Activity @ Shipment
1.	Waste evaporator concentrates	1,750 ft^3	0.03 Ci/ft^3
2.	Spent demineralizer resins	710 ft^3	0.5 Ci/ft^3
3.	Miscellaneous dry solids	900 ft^3	0.01 Ci/ft^3
4.	Radioactive equipment components	*	--
5.	Tritiated water	50,000 gal**	2.5 μCi/cc

*Low volume, no shipments during early years of operation.
**No shipments assumed for first 7 years' operation, thereafter quantity shown shipped.

(2) Environmental effects - The environmental effects for these radioactive wastes for normal shipments and during accident occurrences are evaluated for the potential exposure to transport workers and the general public. It is assumed for purposes of calculating the environmental effects that radioactive wastes are shipped by truck at the regulatory radiation level limit of 10 mrem/h

at 6 feet from the nearest surface.[2] It is also assumed that the exposure rate to transportation personnel is not greater than the regulatory level limit of 2 mrem/h in occupied positions of vehicles.[2]

(a) Normal shipment - The estimated 25 shipments of solid waste containers between the reactor site and a disposal location will be done periodically. Regulations pertaining to such shipments, packaging, and shipping safeguards will be adhered to in all cases.

Under normal conditions, the truck driver might receive as much as 15 mrem per shipment. A total dose to all drivers for a given year, assuming two drivers per vehicle, would not exceed 0.75 man-rem.

Because of the low dose rates permitted at the time of shipment (10 mrem/h at 6 feet from the nearest surface), the only exposure to people from routine shipments is for the brief period such a shipment is in direct view. For example, a member of the general public who spends 3 minutes at an average distance of 6 feet from the vehicle would receive a dose not exceeding 0.5 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 25 shipments of solid radioactive waste would be about 0.125 man-rem.

Figure D-1 of Appendix D shows the location of the shipping container relative to people living adjacent to the transport route that was used to calculate radiation exposures. The radiation dose as a function of distance from a stationary shipping container is shown in figure D-2 of the same appendix. On the basis that there would be a total of about 40,000 people living along the assumed

400-mile transport route between Bellefonte and the waste burial facility at Morehead, Kentucky, these people would receive an annual dose of about 0.016 man-rem per year. A summary of these effects is given in Table 2.1-2.

The shipments of compressible wastes would not contribute significant radiation exposure to the public. The low energy radiation from tritium will be shielded by the shipping vessel (tank truck) and will not be a source of radiation exposure during transport.

Since the exposures to the people who reside along the route, to each truck driver per shipment, and to each person who might come within 6 feet of the vehicle for a short period are only 0.0003, 11, and 0.4 percent, respectively, of the exposure these same people receive from natural background radiation and since compressible waste and tritiated water shipments contribute no radiation exposure, it is concluded that no adverse environmental effects will result from the transportation of radioactive waste from Bellefonte to the disposal facilities.

(b) <u>Accident occurrences</u> - Although transportation accidents involving radioactive material from the Bellefonte plant may be expected to occur about once every 22 years based on the national truck accident statistics for 1969,[5] it is highly unlikely that a shipment of new fuel or solid radioactive waste will be involved in a severe accident during the life of the plant. This is based on data on accidents involving TVA trucks during the past 10 years which show a rate of 4.06 accidents per million miles travelled. Based on these data and using the estimated annual shipment miles of new fuel and radioactive waste for the Bellefonte plant, truck accidents may be expected to occur about once every 17 years. However, about 90 percent of the accidents included in the TVA data are of a minor nature, and since radioactive shipments will be made in accordance with the stringent conditions imposed by AEC and DOT procedures and regulations, the probability of an accident of a severity which would result in release of significant quantities of radioactive materials to the environment would not be likely during the life of the plant.

If a shipment of compressible wastes in appropriate containers 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 or the public would not be expected to be significant. Waste evaporator bottoms and spent demineralizer resins which have been solidified will be shipped in Type A or Type B packages as appropriate.[6] The allowable contents of Type A packages and the probability of release from a Type B package in a severe accident is sufficiently small that, considering the form of the waste and the very low probability of the severe accident occurrences, the likelihood of significant exposure would be extremely small.

Consideration has been given to the radiological impact of the shipment of tritiated water. The low energy radiation from tritium will be shielded by the shipping container and will not be a source of radiation exposure during normal transportation. Calculations have been performed for an accidental release of the entire contents of a 3,700-gallon container of tritiated water with a tritium concentration of 2.5 μCi/cc. A conservative upper limit for the resulting radiation dose is computed by assuming that all of the tritiated water evaporates into the atmosphere and is blown directly to an individual who remains at the maximum dose point for the entire period of release to the atmosphere. With these assumptions the maximum whole-body dose is computed to be 440 mrem. This dose decreases rapidly with distance, as shown in figure D-5, and at 600 feet is about 17 mrem. Assuming a uniform average population density, the population dose within 50 miles is less than 0.08 man-rem.

4. Shipping safeguards - The protection of the public from radiation during shipment of nuclear fuel and radioactive waste is achieved by a combination of limitations on the contents of the package according to the quantities and types of radioactivity, the package design, and the external radiation levels. In addition to these shipping safeguards, transportation accident procedures will provide for rapid and orderly use of personnel and equipment in the event an accident occurs in the shipment of radioactive materials by TVA.

The Department of Transportation (DOT) has regulatory responsibility for safety in the transport of radioactive materials by all modes of transport in interstate or foreign commerce (rail, road, air, and water), except postal shipments.[7] Those shipments not in interstate or foreign commerce are subject to control by a state agency in most cases. The Atomic Energy Commission (AEC) also has responsibility for safety in the possession and use, including transport, of radioactive materials.[8] Both Title 10 and Title 49 of the Code of Federal Regulations set forth the limitations and classifications of the contents, design, and external radiation levels of transport packages.

(1) Governing regulations - This section identifies and summarizes the governing regulations affecting the transport of nuclear fuel and radioactive material. The major aspects of package design and the technical bases of the regulations and the control of the radiation emitted from individual packages are also discussed. In addition, the external radiation levels permitted for low specific activity (LSA) are listed.

Package classification depends on the type, form, and quantity of radioactive material being shipped in the individual container. Small quantities and certain materials of low specific activity are exempted from specification packaging, marking, and labeling when transported on a sole-use vehicle. All other types and quantities of radioactive materials are divided into two broad classes as either "special form" or "normal form." "Special form" radioactive materials means those which, if released from a package, might present some direct radiation exposure but would present little hazard due to radiotoxicity and little possibility of contamination. This may be the result of inherent properties of the material (such as metals or alloys) or acquired characteristics (such as through encapsulation). "Normal form" materials which do not meet these criteria are classified into one of seven transport groups and listed in a table of individual radionuclides.[9]

Varying quantities of special form and normal form radioactive materials are specified for Type A packaging, larger quantities for Type B packaging, and in excess of Type B quantities for "large quantity" radioactive materials. The Type A packaging standards are for normal conditions of transport. Type B and large quantity packaging standards are for accident conditions. The large quantity standards, in addition to considering both normal and hypothetical accident test conditions, must take into account other factors such as radioactive decay heat produced by the contents. Fissile radioactive materials also require consideration of the potential for accidental criticality.

Low specific activity packages must not have any significant removable surface contamination, and the external radiation levels must not exceed the following dose rates when transported in a sole-use vehicle:

(a) 1,000 mrem/h at 3 feet from the external surface of the package (closed transport vehicle only);

(b) 200 mrem/h at any point on the external surface of the car or vehicle (closed transport vehicle only);

(c) 10 mrem/h at 6 feet from the surface of the car or vehicle; and

(d) 2 mrem/h in any normally occupied position in the car or vehicle.

The shipment of radioactive material from Bellefonte will be in full accordance with these and other regulations governing such shipments.

(2) Package design - The following discussion relates the new fuel, spent fuel, and radwaste container designs to AEC and DOT regulations for both normal and accident conditions. Radioactive material packaging is evaluated in light of these conditions to assure that packages have the requisite integrity to be safely transported.

(a) New fuel container description and licensing - Babcock & Wilcox (B&W) is the new fuel fabricator for the initial core fuel assemblies. An AEC special nuclear material license[10] authorizes B&W to deliver special nuclear material to a carrier for transport. Authorization to transport new fuel assemblies has also been obtained by B&W from the Department of Transportation under Special Permit No. 6206.

New fuel assemblies are enclosed in polyethylene wrappers and placed in metal containers which support the fuel assemblies along the entire length during transportation. This container also provides necessary impact protection to meet the hypothetical accident test requirements of the AEC and DOT regulations.[11,12] The metal container is gasketed and bolted shut and has provisions for pressurization and humidity control. The characteristics of a typical new fuel shipping container are given below.

- All metal reinforced cylindrical outer shell divided longitudinally into two parts
- Reinforced steel beam fuel assembly supports
- Capacity of two fuel assemblies
- Weights

  Empty - about 3,940 lb

  Loaded - about 7,300 lb
- Type B packaging requirements met
- Package design meets requirements for Fissile Class II and III shipments

(b) Spent fuel container description and licensing - Spent fuel shipping casks generally have heavy gauge stainless steel inside and outside shells separated by some dense shielding material, such as lead or depleted uranium.

Normal shipping conditions require that the package be able to withstand temperatures ranging from -40°F to 130°F and to withstand the normal vibrations, shocks, and moisture that could be expected during normal transport.

In addition, casks must withstand specified accident conditions with the release of no radioactivity other than slightly contaminated cask coolant and no more than 1,000 curies of radioactive noble gases. The cask design accident conditions include a 30-foot free fall onto a completely unyielding surface, followed by a 40-inch drop onto a 6-inch diameter metal pin, followed by 30 minutes in fire at a temperature of at least 1,475°F, followed by 8 hours' immersion under at least 3 feet of water. Appendix E of this statement indicates how these 10 CFR Part 71 accident conditions compare to conditions the container might experience as a result of a transportation accident.

It should be noted that there is a wide margin of safety in container designs. For example, the General Electric IF-300 spent fuel shipping cask which will be used at Browns Ferry and may be used at Bellefonte is designed with energy-absorbing fins which absorb the total impact of a 30-foot free fall onto an essentially unyielding surface with only outer fin deformation.[13] As a result of these energy-absorbing fins, there is a wide margin between the damage that would be experienced by the cask in absorbing the energy of the 30-foot free fall and that which would be required to breach the container. It is estimated that a significant container breach would require from five to ten times the energy which the cask absorbs in the 30-foot free fall. Thus, in the unlikely event that the cask does experience conditions as severe as those imposed by the 10 CFR Part 71 requirements, no container breach is expected.

The accident conditions are judged to be representative of conditions at least as severe as those which would be experienced by containers in transport accidents. Since the tests are applied to the containers in sequence, the cumulative severity of these tests in all probability far exceeds the severity of an accident in transportation. It is highly improbable that a container would be subjected to conditions as severe as one of these conditions, let alone all three in the sequence provided for in the test.

The permissible radiation levels and releases under normal and accident shipping conditions are shown below.

NORMAL AND ACCIDENT SHIPPING REQUIREMENTS

	Normal Conditions	Accident Conditions
External Radiation Levels		
Surface of vehicle	200 mrem/h	NA
3 feet from surface of container	NA	1,000 mrem/h
6 feet from external surface of vehicle	10 mrem/h	NA
Permitted Releases		0.1% of total package radioactivity
Noble gases	none	1,000 Ci
Contaminated coolant	none	0.01 Ci alpha, 0.5 Ci mixed fission products 10 Ci iodine
Other	none	none
Contamination Levels		
Beta and gamma	2,200 dpm/100 cm^2	NA
Alpha	220 dpm/100 cm^2	NA

In most cases the containers should have radiation levels and releases during accidents somewhat less than those permitted by the regulations because the fuels and materials which will be handled are not expected to be at the cask design activity levels.

Since spent fuel will not be shipped until about 1980, contracts have not been made for the equipment and services for spent fuel shipments. Thus, the exact details of cask design and safety analysis in support of a specific licensing effort are not available at this time. However, TVA will ensure that the AEC, DOT, and any other applicable criteria for spent fuel casks become conditions of the contract for these services.

(c) Radwaste container description and licensing - The design of the solid waste packaging station permits the use of several different types of containers or packages. The exact type of container to be used for shipments of the higher activity low level wastes from the plant has not been determined at this time. However, for purposes of evaluating the environmental risks associated with shipment of radioactive wastes from this plant, TVA has used the design and safety analyses made under contract with ATCOR, Inc., for the Browns Ferry Nuclear Plant shipping cask. The container designed under this contract (LL-60-150) has been licensed (41-08165-06) for shipping the higher activity low level wastes from Browns Ferry.

The LL-60-150 cask is designed to meet or exceed the requirements established by AEC and the Department of Transportation for the shipment of large quantities of radioactive material. The evaluation made by ATCOR, Inc., in support of licensing for this cask considers both normal and accident conditions of transport.[14] An analysis was performed to demonstrate that the cask provides adequate shielding to satisfy dose rate levels in the vicinity of the cask as required for normal conditions of transport. A shielding analysis was also performed in order to assure that the cask meets the dose rate requirements after a shielding loss has occurred due to a hypothetical accident occurrence.

Accident analysis showed that the lead may slump towards the bottom of the cask as a result of the hypothetical 30-foot drop accident. The level of the lead falls 1.6 inches which will not remove the lead shielding from the top of the solid waste source. At 3 feet from the surface of the cask, the dose rate is estimated to be less than 500 mrem/h (assuming 4.02 mrem/h at 6 feet before the accident), which is less than half the limit of 1,000 mrem/h at 3 feet stated in 10 CFR Section 71.36(a)(1).

The analysis for puncture resistance was performed and it was found that when considering any point along the 1-1/2-inch thick outer shell, failure in this mode will not occur and no release of radioactive material to the exterior or dose rates in excess of 10 CFR Section 71.36 limits will occur. An analysis has been performed of the hypothetical fire accident. The thermal conductivity across the outer and inner steel shells plus the air gap is sufficiently low to keep the temperature of the lead about 150^{o}F below its melting point. It was also shown that the cask is capable of holding the vapor pressure resulting from the elevated temperatures.

Immersion of the cask under 3 feet of water for more than 24 hours will not cause any detrimental effect since the cask was established in the analysis to be leaktight following the preceding accident conditions.

For lower activity level wastes (activities of 0.5 Ci/ft^3 or less), an all steel cask holding about 183 ft^3 has also been designed and is being constructed by ATCOR, Inc., for use at Browns Ferry and could be used at Bellefonte.

Low activity compressible wastes will be packaged for shipment in appropriate containers. Radioactive equipment components will be shipped by contract with a specialist who will provide the necessary containers, such as modified spent fuel casks.

(3) Transportation procedures - Elements of the procedures to be followed by TVA for handling radioactive materials for transportation and while in shipment are given below. These procedures will cover the normal and accident conditions which might be encountered.

(a) Onsite procedures - The administrative control of radioactive materials intended for offsite shipment will include the following:

a. Certify container contents.

b. Assure performance of all tests on loaded containers as required by 10 CFR Section 71.35, 49 CFR Section 173.393(j), and 49 CFR Section 173.397(a).

c. Ensure that container and vehicle meet the applicable requirements of regulatory bodies for movement offsite.

d. Qualified personnel with appropriate equipment to be available to make routine determinations as required by (b) above.

e. Provide estimated time of arrival (ETA) at destination.

f. Provide approximate routing, mode of transport, estimated entry and exit times to various states as appropriate.

(b) Offsite procedures - The driver of the vehicle will be responsible for control of shipments en route and for following the transportation procedures delivered to him before leaving the site.

The state requirements for notification and responsible party to notify when radioactive materials are scheduled to be shipped through various states are given in Table 2.1-3.

(c) Accident occurrences during transport - Each state through which these materials pass will have developed emergency plans for radioactive transportation accidents. These plans, in conjunction with TVA transportation accident procedures, will provide for rapid and orderly use of state facilities and personnel, augmented as necessary by TVA, carrier, and municipal emergency personnel and AEC radiological assistance teams in the event an accident occurs in the shipment of radioactive materials by TVA. In the event of an accident, emergency plans will be initiated to minimize a radiation hazard to the public and the environment.

Accident procedures regarding transportation of radioactive material are described in TVA's nuclear plant procedure manual[15] and the TVA Radiological Emergency Plan.[16] Elements of the procedures for handling transportation accidents for which TVA has responsibility will include, but are not limited to, the following:

1. Vehicular Accidents - General
   a. In the event of vehicular accident involving radioactive material, establish a restricted area [10 CFR Section 20.203(b) and (c)].
   b. Use radiation survey meter to establish the perimeter of the restricted area.
   c. If survey meter is inoperable, calculate from experience and training a very conservative perimeter.
   d. If survey meter is operable and no radiation hazard exists and the vehicle is in safe operating condition,

the driver may continue en route if not detained by other accident-related conditions.

e. In any case, immediately after establishing a restricted area or before proceeding on way, TVA shall be notified.

2. Notification and Reports of Incident

a. Appropriate TVA personnel receiving notice of a transportation accident shall notify the TVA load dispatcher who notifies the Central Emergency Control Center (CECC) director.

b. The CECC director notifies as appropriate the AEC Operations Office, the State Department of Public Health, the state police, and the AEC Division of Compliance.

c. The CECC director will provide assistance for cleanup and recovery operations as needed.

TVA has consulted and will consult further with appropriate state agencies regarding the necessary emergency planning for shipments of radioactive material through the state and to seek the state's agreement with TVA's Radiological Emergency Plan.

5. Conclusion - Due to the integrity of the containers used for shipping new fuel elements, spent fuel elements, and low-level radioactive wastes; the emergency plans for vehicular accidents; the administrative control exercised over transportation; and coordination with appropriate state agencies; it is concluded that an insignificant environmental risk will result from the transportation of fuel elements from the fuel fabrication plant to the reactor, or spent fuel elements to the fuel reprocessing plant, and of low-level waste to offsite disposal grounds.

REFERENCES FOR SECTION 2.1

1. Atomic Energy Commission Regulations. Title 10 Code of Federal REgulations Part 70 (10 CFR 70).

2. Department of Transportation Regulations. 49 CFR Section 173.393.

3. Department of Transportation Regulations. 49 CFR Section 173.398.

4. Department of Transportation Regulations. Shipping Container Specifications, Title 49 Code of Federal Regulations Part 178 (49 CFR 178).

5. Department of Transportation. "1969 Accidents of Large Motor Carriers of Property," December 1970.

6. Department of Transportation Regulations. 49 CFR Sections 173.24; 173.389 through 173.399.

7. Department of Transportation. Transportation of Hazardous Materials, Title 49 Code of Federal Regulations Part 171 through Part 179 (49 CFR 171-179).

8. Atomic Energy Commission. Packaging of Radioactive Materials for Transport, Title 10 Code of Federal Regulations Part 71 (10 CFR 71).

9. Atomic Energy Commission Regulations. 10 CFR Part 71, Appendix C.

10. Atomic Energy Commission. License for Delivery of Radioactive Material to a Carrier for Transport, Special Nuclear Material License--SNM-1168, Docket No. 70-1201, Amendments 71-1, Babcock & Wilcox.

11. Atomic Energy Commission Regulations. 10 CFR Section 71.36.

12. Department of Transportation Regulations. 49 CFR Section 173.398.

13. Design and Analysis Report, submitted to AEC in support of licensing of IF-300 Shipping Cask - Docket No. 50-268, Amendment 71-1 - General Electric Company.

14. Safety Analysis Report for the Shipment of Radioactive Solid Waste in the LL-60-150 Cask from the Tennessee Valley Authority Browns Ferry Nuclear Plant Units 1 and 2 - ATCOR, Inc.

15. Tennessee Valley Authority, Division Procedures Manual, Division of Power Production, August 11, 1972.

16. Tennessee Valley Authority, TVA Radiological Emergency Plan.

Table 2.1-1

RADIOACTIVITY OF IRRADIATED FUEL[a]

(Ci/MTU)[b]

	Cooling Period (in days)		
	90	150	365
Fission Products	6.19×10^6	4.39×10^6	2.22×10^6
Actinides (Pu, Cm, Am, etc.)	1.42×10^5	1.36×10^5	1.24×10^5
Total	6.33×10^6	4.53×10^6	2.34×10^6

PREDOMINANT FISSION PRODUCTS IN GASEOUS FORM INCLUDED IN RADIOACTIVITY OF IRRADIATED FUEL

(Ci/MTU)

	Cooling Period (in days)		
	90	150	365
Krypton-85	1.13×10^4	1.12×10^4	1.08×10^4
Xenon-131m	1.06×10^2	3.27	1.08×10^{-5}
Iodine-131	3.81×10^2	2.17	1.98×10^{-8}

THERMAL ENERGY IN IRRADIATED FUEL

(Watts per metric ton of uranium)

	Cooling Period (in days)		
	90	150	365
Thermal Energy	2.71×10^4	2.01×10^4	1.04×10^4

a. Estimated burnup 33,000 MWD/MTU - Siting of Fuel Reprocessing Plants and Waste Management Facilities - ORNL - 4451, July 1970.

b. Approximately two assemblies per MTU.

Table 2.1-2

RADIOACTIVE MATERIALS TRANSPORTATION - SUMMARY OF EFFECTS

(Normal Conditions)

Type	Transportation: Mode	Transportation: Frequency (Shipments/yr)	Stationary Cask Radiation Exposure (mrem/h): at 6 ft	Stationary Cask Radiation Exposure (mrem/h): at 100 ft	Cask Moving at 20 mi/h Individual Exposure (mrem/trip): Maximum	Cask Moving at 20 mi/h Individual Exposure (mrem/trip): Average	Population Exposure (man-rem/yr)
Spent Fuel	Rail (5 MTU/ shipment)	14	10	$\sim$0.1	0.00029	0.000016	0.009
Waste							
Low Level	Truck	25[a]	10	$\sim$0.1	0.00029	0.000016	0.016
						Total	0.025[b]

(10 CFR Part 71 Accident Conditions)

Type Shipment	Transportation: Mode	Transportation: (Shipments/yr)	Direct Radiation Dose Rate (mrem/h): at 3 ft	Direct Radiation Dose Rate (mrem/h): at 50 ft	Fission Gas Release External Dose (mrem): Whole body	Fission Gas Release External Dose (mrem): Skin	Fission Gas Release Whole Body Population Dose (man-rem)	Thyroid Dose (rem)
Spent Fuel	Rail (5 MTU/ shipment)	14	1,000	17	2	86	0.07	5
Waste								
Low Level	Truck	25[a]	500					

a. Design conditions.

b. This population group receives about 11,500 man-rem/yr exposure from natural background radiation (140 mrem/yr).

Table 2.1-3

NOTIFICATION REQUIREMENTS OF STATES
FOR SHIPMENT OF RADIOACTIVE MATERIAL

State	Requirements	Notify
Alabama	Telephone or telegraph Route, mode of transportation, time of arrival in state	Director Division of Radiological Health Room 311, State Office Building Montgomery, AL 36104 Telephone: 205-269-7634
Georgia	Letter, telephone or telegraph Approximate route and mode of transportation	Chief Radioactive Materials Control Section Division of Radiological Health 535 Milam Avenue, SW Atlanta, GA 30314 Telephone: 404-762-6111
Illinois	Letter, telephone or telegraph Route, estimated arrival time in state	Director Department of Public Health 535 West Jefferson Springfield, IL 62706 Telephone: 217-525-6550
Indiana	No notification required	Director Division of Radiological Health 1330 West Michigan Indianapolis, IN 46206 Telephone: 317-633-6340
Kentucky	Letter, telephone or telegraph Route, estimated entry and exit times in state Additional: Identify carrier and approximate activity of each shipment	Director Radiological Health Program Kentucky State Department of Health 275 East Main Street Frankfort, KY 40601 Telephone: 502-564-3700

Table 2.1-3 (continued)

Missouri

Requirements:	Notify:
Letter, telephone or telegraph Route, mode of transportation, entry and exit times in state	Director, Radiological Health Division Broadway State Office Building Jefferson, MO 65101 Telephone: 314-635-4111

Additional:

Truck shipments - license number and/or other identifying numbers, color of truck, entry and exit points in state, highway patrol will meet truck at border and provide protective following as a safety feature

Rail shipments - name of railroad, shipment car number and its location within the train, notification in transit if other cars are added or deleted from train, thus changing relative location of shipment within train, highway patrol will provide surveillance at locations where possible

North Carolina

Requirements:	Notify:
Letter or telegraph Route, mode of transportation	Director Division of Radiation Protection North Carolina State Board of Health P.O. Box 2091 220 North Dawson Raleigh, NC 27607 Telephone: 919-829-4283

Comment:

Notification for each individual shipment may not be necessary if specific time interval when several shipments may be made can be scheduled. State is now in the process of formulating emergency planning with regard to shipments of this sort, and requirements have not been formalized.

South Carolina

Requirements:	Notify:
No notification required	Director Division of Radiological Health South Carolina State Board of Health 2600 Bull Street Columbia, SC 29201 Telephone: 803-758-5548

Tennessee

Requirements:	Notify:
Letter or telephone Approximate route and mode of transportation	Director Division of Radiological Health 727 Cordell Hull Building Nashville, TN 37219 Telephone: 615-741-3161

2.2 Environmental Aspects of Transmission Lines - Transmission lines for the Bellefonte Nuclear Plant will be constructed in two steps which are coincident with the initial operation of units 1 and 2. The following table summarizes the lines which are required for the Bellefonte Nuclear Plant.

STEP I

Line Name	Voltage (kV)	Approximate Length of New Construction (Miles)	Approximate Date Required
Widows Creek-Madison, Loop into Bellefonte Nuclear Plant	500	22.0	March 1979
Widows Creek-Scottsboro, Loop into Bellefonte Nuclear Plant	161	3.0	March 1979
STEP II			
Bellefonte-Widows Creek No. 2	500	22.0	January 1980
Bellefonte-Madison No. 2 (via Guntersville)	500	63.0	January 1980

Under Step I, two 500-kV transmission lines will provide system connections for the Bellefonte Nuclear Plant Unit 1. These connections will be provided by opening the existing Widows Creek-Madison 500-kV Transmission Line and extending the resulting line sections approximately 11 miles to the nuclear plant switchyard. This will establish 500-kV transmission lines to Widows Creek Steam Plant and Madison Substation.

Station service power to the nuclear plant will be provided by opening the existing Widows Creek-Scottsboro 161-kV Transmission Line in the vicinity of Bellefonte and constructing two line sections to the nuclear plant switchyard. Approximately 1.5 miles of new construction will be required for each 161-kV line.

Under Step II, two additional 500-kV transmission lines will be required when the second Bellefonte unit is placed in service. One of these lines will be a second line to Widows Creek Steam Plant. The other will be a line to the Madison 500-kV Substation via a future 500-kV Substation in the Guntersville area.

The transmission line routes as shown on figure 2.2-2 will require approximately 110 miles of new transmission line construction and necessitate the purchase of 2,910 acres of new right of way easements. Approximately 25 percent of the required rights of way is presently in woodland, 25 percent is used for farming with the remainder being farmland lying idle. Approximately 69 miles of existing rights of way will be utilized for the line connections to Bellefonte. New transmission lines will be constructed on 29 miles of common rights of way.

1. <u>General considerations</u> - As a first step in the transmission line location process, topographic maps are examined in the office to determine the best apparent route. Then a field reconnaissance is made using these maps. In the field, engineers first look for the best places to cross major highways and secondary roads, at the same time avoiding, to the extent possible, residential, commercial and industrial areas; recreational areas and other developments; and areas of historical, cultural or scenic significance. Locations on crests of mountains and ridges are generally avoided to minimize visual impacts.

Route selection will be coordinated with municipal, county and state planning boards with municipal, state and Federal authorities when crossing of public lands is involved. At the same time care is taken to minimize the visual and physical impact of transmission facilities on residential properties. Locations along property lines and away from homes and barns are chosen where feasible.

In general, final route selection will be made in keeping with the Environmental Criteria for Electric Transmission Systems.[1]

Topographic maps are frequently several years old and do not reflect recent manmade features on the land. When this is the case aerial photographs are made along the route tentatively selected so that a final route can be determined with full knowledge of land use developments.

In selecting routes for transmission lines, TVA attempts to locate the lines so that no family or business relocations are required. This policy is being followed in the selection of routes for the lines from the Bellefonte Nuclear Plant and no relocations are anticipated. However, in the event relocations are required, assistance will be provided in accordance with "Uniform Relocation and Real Property Acquisition Policies Act of 1970" (Public Law 91-646).

To the extent possible TVA avoids routing its lines through residential areas. However, such areas frequently develop adjacent to the cleared areas created by the construction of transmission lines. When residential areas cannot be avoided, environmental impacts are minimized by following property lines as much as practicable, preserving natural vegetation and avoiding the splitting of land use zones.

Open land that is not being cultivated is generally preferred to timbered land for line locations, and routes are chosen to minimize conflicts with existing land uses. However, routes which result in substantial increases in length are generally avoided.

It is frequently necessary in the construction of transmission lines to cross rivers or other bodies of water. Four transmission lines that connect to the Bellefonte Nuclear Plant will cross the Tennessee River (Guntersville Reservoir). Two of the lines will be constructed on common structures, thereby reducing the number of separate crossings. In selecting locations for these crossings, conflicts with residential, commercial and industrial developments, game sanctuaries, and scenic and recreational areas are avoided.

In crossing streams under the jurisdiction of state agencies onsite inspections are made with agency representatives to assure agreement on the location. All river crossings are coordinated with the appropriate local, regional and state planning agencies.

When a navigable stream or reservoir is crossed the work is coordinated with the United States Corps of Engineers. Crossings of streams and drainage areas having water conservation projects planned by the Department of Agriculture's Soil Conservation Service are coordinated with that agency.

The new transmission line routes will be closely coordinated with the Top of Alabama Regional Council of Governments; the Section, Alabama Planning Commission; the Scottsboro, Alabama Planning Commission;

the Alabama Conservation Department; the Alabama Highway Department; and the Department of Agriculture, Soil Conservation Service.

Within TVA the line routes will be closely coordinated with the Division of Navigation Development and Regional Studies, the Division of Reservoir Properties, the Office of Tributary Area Development, the Division of Environmental Planning, and the Division of Forestry, Fisheries, and Wildlife Development.

The transmission line structures for these lines will be self-supported steel towers. This self-supporting aspect of the structures eliminates the need for guys. The small amount of land occupied by the structures is the only part of the right of way which cannot be used for other purposes. The balance of the rights of way remain clear of obstructions and are available for a variety of other uses.

2. Beneficial uses of transmission line rights of way -

(1) Shear clearing of rights of way - In the construction of new lines through wooded areas, the rights of way will be "shear cleared" (cleared of trees and other vegetation to the ground level) and seeded except where outcropping of rock or steep slopes makes it impracticable. New rights of way are seeded with pasture-type grasses or wildlife food and cover if preferred by the property owner.

The interface or "edge" between two diverse plant communities will often produce or attract more kinds and number of animals than would occur in either habitat type alone. This phenomenon is referred to as the "edge effect" and occurs on utility lines where the low herbaceous and woody plant growth meets the forest, or where adjacent cropland and weedy or "brush" rights of way merge.

Power line rights of way have great potential as wildlife habitat because of the "edge effect" they create and the high food and cover productivity of early vegetative successional stages. Many power line rights of way support wildlife without special management because of these two factors.

Utility line rights of way can rarely go longer than 5 years without mechanical maintenance of some type. Early stages of plant succession, particularly the first 6 to 8 years, are the most productive for many wildlife food and cover plants. In addition, the low herbaceous plant growth support insects which provide the high protein content necessary in the diet of many young bird species (game and nongame).

Shear clearing through heavily forested areas is consistent with good forestry and wildlife principles. A common wildlife management practice in large sections of unbroken forest land is to "open" the tract by means of small evenly spaced clearings. Rationale for this practice is to provide diversity and food in the forest environment and to create "edge." Wildfires originally provided this type of habitat. Power line rights of way create long linear forest openings which are regularly maintained to prevent power outages. The sunlight penetrating the forest via the right of way stimulates understory growth adjacent to the power line. Periodic power line maintenance perpetuates these beneficial wildlife habitat conditions.

Line maintenance operations will involve periodic repairs and cutting of vegetation along the rights of way to maintain electrical clearance between the conductors and the ground cover. Growth of vegetation is controlled by mechanical cutting, replacement planting, or the use of herbicides. The herbicides used are Tandex, Tordon 101, Tordon 10K pellets, 2,4,5-T and Hychlor. These herbicides are now approved for this specific use by the Federal Working Group on Pest Management. The cuttings usually are piled in windrows along the edge of the rights of way where they provide game habitat. Brush killed by herbicides is allowed to stand. It deteriorates in a year or two and falls to the ground or is obscured by new growth.

TVA employees responsible for right of way maintenance work closely with wildlife biologists and foresters of TVA's Division of Forestry, Fisheries, and Wildlife Development. The combined expertise of these TVA employees and other TVA specialists insures that biologically sound and economically feasible recommendations are made to improve wildlife habitat on the rights of way of property owners.

TVA, in cooperation with the Tennessee Game and Fish Commission, has published a booklet for distribution to landowners describing inexpensive practices they may employ to benefit wildlife on their land.[2]

(2) Multiple use of rights of way - As a general rule where transmission line rights of way cross wooded areas, TVA is willing to perform the necessary clearing or invest as its part of a cooperative arrangement an amount which approximates the average cost to clear or later reclear the area as dictated by maintenance requirements. TVA negotiates with county agents, state and Federal park commissions, soil conservation agencies, sportsmen groups, and other interested agencies that propose compatible uses for wooded land within easement areas that will meet the goals of the interested parties. Under such an arrangement, forest development interest can be implemented which allow growing of small

trees such as Christmas trees and nursery stock. Also, buckwheat, Korean and Kobe Lespedeza, and other low-growing seed crops and grasses which are beneficial to small game habitat can be planted for the establishment of shooting preserves. Rights of way not totally cleared can be utilized for production of many low-growing forest products.

It is recognized that many additional multiple right of way uses can be identified. If the landowners desire to use the rights of way for the establishment of playgrounds, athletic fields, golf courses, parks, picnic areas, or trails for hiking and horseback riding, such use would be permissible under the terms of TVA's easement.

TVA recognizes there is an annual loss of forest products due to the construction and operation of transmission lines. Where transmission lines traverse wooded areas, timber production is lost for the life of the line. However, the forest resources that are lost in this period are not significant in terms of the total forest resources of the areas traversed. Furthermore, there are offsetting benefits such as the provision of wildlife habitat and recreational opportunities as discussed earlier.

3. Solid waste disposal - TVA contracts most right of way clearing for the construction of transmission lines. Open burning is normally employed for disposal of forest slash cleared from rights of way in compliance with local, state, and Federal air pollution guidelines. This results in releasing some particulates and gases into the atmosphere. However, these minor effects are local and generally short-lived.

A burning method which results in further minimizing the release of smoke into the atmosphere is utilized in areas where open burning is undesirable or not permitted. In this method forest slash is burned by using an air curtain incinerator. The slash is placed in a large pit (approximately 10 feet deep, 15 feet long, and 10 feet wide) and set on fire. Air, fed to the fire by blowers, is supplied at the proper rate for minimum smoke emission. At least one guard and as many men as required to supervise the burning process are kept on duty night and day until all fires have been extinguished.

In cases where disposal by burning is not possible, slash is piled in windrows along the edge of the right of way or in scattered brush piles along slopes and ravines. An alternate method of disposal is being explored involving mechanical chipping and scattering or piling of chips on the soil for wildlife habitat.

In general, other solid waste generated by transmission line construction is very small. These minor construction waste items consist of protective wood cribbing attached to conductor reels, line insulator cardboard shipping cartons and steel bands used to bind tower structural items and other line hardware. This waste will be returned to the staging areas for disposal.

At staging or material assembly points, relatively large quantities of the used packing material which accumulates is transported to state-approved sanitary landfills. However, in localized areas, smaller quantities of wood and paper are disposed of by controlled burning.

4. Erosion control practices - Construction of transmission lines will involve the use of heavy equipment for tower erection and stringing of conductor. Although this equipment may cause temporary rutting along the rights of way, precautionary measures are taken so that the effects of soil erosion on regional water quality is not significant. The erosion of local areas that results is controlled to a significant degree by: (1) using special construction procedures which limit the use of heavy equipment in areas of high erosion potential, diverting runoff from exposed land to settling ponds, and keeping vegetation on the land as long as possible before construction; and (2) scheduling construction activities in certain areas to coincide with favorable dry weather conditions.

When line construction is completed, the rights of way are contoured and usually seeded with pasture-type grasses or planted in wildlife food and cover to control soil erosion and provide wildlife habitat.

Where possible, access roads for transmission line construction will follow existing farm roads, and after construction TVA will restore these roads to their original or an improved condition. In the event that a new access road is required, the property owner will be consulted regarding the route which will be most beneficial to him after construction. Any grading required will be engineered to balance cut and fill, thereby eliminating the need for a separate borrow pit. The road routes will be selected to minimize damage to existing growth. Drainage ditches, terracing and ground cover will be provided in order to prevent soil erosion.

5. Miscellaneous impacts -

(1) Ozone - Ozone can be produced from corona discharges (ionization of the air) in the operation of transmission lines and substations, particularly at the higher voltages. It can be harmful if breathed in sufficient concentrations over prolonged periods. However, it is not considered to be injurious to vegetation, animals, and humans unless concentrations exceed about 0.05 ppm.

Corona discharges can result from abrasions, foreign particles or sharp points on electric conductors and electric equipment, or incorrect design which produce excessively high potential gradients.

Extensive field tests to detect ozone in the vicinity of 765-kV lines were recently completed by the Battelle Memorial Institute under a variety of meteorological conditions. From these tests it was concluded that no significant adverse effects on vegetation, animals, or humans are to be expected from levels of ozone that may be produced in the operation of transmission facilities at voltages up to 765-kV. Consequently, any levels of ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum nominal voltage) would be environmentally inconsequential.

TVA gives careful attention to the design and construction of its transmission facilities to minimize corona discharges. TVA specifications require that transmission line hardware and electrical equipment for operation at 500,000 volts be factory tested to assure corona-free performance up to maximum operating voltage levels.

As of 1972 TVA has accumulated approximately 5,300 mile-years of operation of its 500-kV transmission system with no known adverse effects attributable to the production of ozone from corona discharges.

A more detailed report of ozone characteristics, sources, and a discussion of tests and reference material can be found in Appendix F.

(2) Compatibility with communications equipment - High-voltage power lines operating in close proximity to telephone and signalling equipment can produce undesirable effects on the communication circuit through inductive coupling. However, it is TVA's normal practice to send transmission line vicinity maps to railroad and telephone companies having tracks or communication lines in the general area of proposed power lines for the purpose of making inductive coordination studies. If corrective action is indicated, the problem will be jointly studied and any required changes will be provided at TVA's expense. This procedure will be followed for the new transmission line connections for Bellefonte Nuclear Plant.

No inductive coordination problems have been experienced on the Widows Creek-Madison 500-kV Transmission Line which has been in operation for several years. It is expected that no new problems will be encountered when this line is altered in the vicinity of Bellefonte Nuclear Plant to form the Bellefonte-Widows Creek and Bellefonte-Madison 500-kV lines. For the selected routes, we do not anticipate any inductive coupling problems for the other proposed transmission lines.

(3) Historical and archaeological compatibility - This project will be investigated by an archaeologist and coordinated with the Alabama Historical Commission and other appropriate agencies to identify any historical and/or archaeological sites traversed by the proposed transmission line routes. Any conflicts which might occur will be avoided to the fullest extent practicable. Should artifacts occur on the transmission line easement areas, the overhead lines would cause virtually no interference with the potential recovery of such artifacts.

(4) Impacts on aviation - Tall transmission line towers are normally required to accomodate the long spans associated with major river crossings. If any of these towers exceed certain heights as prescribed by the Federal Aviation Administration, they will be coordinated with the FAA to conform to air safety regulations.

(5) Impact of support facilities - In defining the scope of this environmental statement, all identified major power system support facilities have been included. Although not specifically described, terminal structures and switching equipment will be required at the Bellefonte Nuclear Plant site, Madison 500-kV Substation and Widows Creek Steam Plant. These items do not require separate facilities but rather are part of the total facilities at each of these locations.

At this time no transmission line construction other than that described in the proposed action has been specifically identifed. It is assumed that in the future, as in the past, generation plant siting studies will consider existing plant expansion as well as new plant site development. On this premise, it is possible that transmission system needs may someday warrant additional line connections at Bellefonte Nuclear Plant. However, the same rigid environmental evaluations and tests will be applied to these facilities as early as possible in the planning process.

(6) General impacts - During normal operations no adverse environmental impact is expected to occur on either 500- or 161-kV transmission lines. During inclement weather and unusual atmospheric conditions a light humming may be heard directly under 500-kV lines, but this noise is rarely heard off the rights of way. Transmission lines can, under certain conditions, cause mild static charges to develop on fence wires and other ungrounded objects under the lines. These charges are similar to the common static charges people experience when walking on certain types of indoor carpeting in dry weather.

The landowner retains all mineral rights to his land, and he may use the land for whatever purposes he wishes so long as such uses do not conflict with the terms of the easement. In many instances the existing land uses--particularly agricultural uses--may continue. However, such things as buildings, signboards, stored personal property, or other obstructions which create fire hazards and/or interfere with the operation and maintenance of the line may not be located on the rights of way. Except in very unusual situations, the transmission lines will have no effect on aerial crop dusting.

Damage to fences, gates, bridges, and other structures will be paid for or repaired by TVA following construction, and landowners are reimbursed by TVA for the value of crops damaged by construction or later maintenance activity.

6. Tentative transmission line route selections - Based on the above considerations, the tentative line routes and alternate routes for connecting the Bellefonte Nuclear Plant were investigated. The routes shown on figure 2.2-2 are feasible at present. However, changes within the next few years may require that these routes be shifted to avoid new development.

The enlarged insert shown on figures 2.2-1 and 2.2-2 shows the Bellefonte Nuclear Plant site, the 500-kV and 161-kV switchyards and land adjacent to the nuclear plant site which has been designated for various purposes. The community of Bellefonte, which is of hisotrical importance, is located at the southwest end of Town Creek inlet of Guntersville Reservoir. Considering these factors, route selections in the vicinity of the proposed nuclear plant were quite limited.

For identification purposes the line connections to Bellefonte Nuclear Plant which are shown on figures 2.2-1 and 2.2-2 are numbered as follows:

1. Bellefonte - Widows Creek 500-kV Transmission Line No. 1
2. Bellefonte - Madison 500-kV Transmission Line No. 1
3. Bellefonte - Widows Creek 161-kV Transmission Line
4. Bellefonte - Scottsboro 161-kV Transmission Line
5. Bellefonte - Widows Creek 500-kV Transmission Line No. 2

6. & 7. Bellefonte - Madison 500-kV Transmission Line No. 2

(1) Bellefonte - Madison No. 1 and Bellefonte - Widows Creek No. 1 500-kV Transmission Lines - The existing Widows Creek-Madison 500-kV Transmission Line will be looped into the Bellefonte Nuclear Plant to form the Bellefonte-Madison No. 1 and Bellefonte-Widows Creek No. 1 500-kV lines. As seen from figure 2.2-2, the existing line is located to the west of Guntersville Reservoir; therefore, a routing from the nuclear plant site in a northwestward direction is desirable. The selected routes are shown schematically on figure 2.2-2 and are designated Routes 1 and 2. They leave the substation switchyard generally in a northwestward direction for a distance of approximately 1.8 miles and cross the Town Creek inlet of Guntersville Reservoir to the north of the community of Bellefonte. This route will pass south of a housing project which is being developed on the northern bank of Town Creek inlet. The route will turn northward until it intersects with the existing Widows Creek-Madison 500-kV Transmission Line, a distance of about 9.2 miles.

Two routes for this last section are still under study and investigation, one location to the east and another to the west of Poorhouse Mountain. The length of right of way required for either of these alternates is approximately the same. The route creating the least environmental impact will be selected. The 500-kV loop connection will be approximately 11 miles in length with 9.5 miles being constructed on 350 foot wide easement right of way. The remaining 1.5 miles will be constructed on 450 foot easement right of way common with the 161-kV connections to Bellefonte.

(2) Bellefonte-Widows Creek and Bellefonte-Scottsboro 161-kV Transmission Lines - Station service power for Bellefonte

Nuclear Plant will be provided by looping the Widows Creek-Scottsboro 161-kV Transmission Line into the nuclear plant to form the Bellefonte-Widows Creek and Bellefonte-Scottsboro 161-kV Transmission Lines. These line routes which are shown schematically as Routes 3 and 4 respectively will leave the Bellefonte switchyard in a northwestward direction until they intersect with the existing 161-kV line, a distance of about 1.5 miles. These lines will be constructed parallel to and on opposite sides of the Widows Creek-Madison 500-kV loop connection previously described. This will provide sufficient 161-kV line separation to comply with the safety criteria[3] set forth by the Atomic Energy Commission.

(3) Bellefonte-Widows Creek 500-kV Transmission Line No. 2 - Coincidental with the installation of the second unit at Bellefonte Nuclear Plant will be the need for additional transmission facilities. One of these transmission lines will connect the Bellefonte Nuclear Plant with the Widows Creek Steam Plant. Several route locations were investigated for this connection and the one causing the least environmental impact is proposed. The proposed route selected is shown schematically as Route 5 on figure 2.2-2 and is described below.

After leaving the Bellefonte 500-kV switchyard in a northwestward direction for one or two spans, the route turns southwestward until it intersects the southern property line of the Bellefonte Nuclear Site. Turning southeastward, the route follows the property line, crossing the Tennessee River at River mile 390.6. To reduce the number of river crossing structures, double circuit steel towers will be installed at this location. This provides for a second 500-kV line to Madison via the future Guntersville 500-kV Substation. Approximately one mile east of the Tennessee River, the route turns in a northeastward direction to the vicinity of Christian Homes, Alabama.

The route then proceeds northwestward and crosses the Tennessee River again before reaching the Widows Creek Switchyard. The route chosen will be from one to three miles east of the Tennessee River, thereby avoiding the potential river front industrial land. This route is approximately 22 miles long, and requires a 200 foot right of way easement except for about 1.5 miles which will be located on the proposed Bellefonte Nuclear Plant site property.

Since the Bellefonte Nuclear Plant and the Widows Creek Steam Plant are both located west of the Tennesee River, a route west of the river was investigated. The location shown as Route 5a on figure 2.2-1 was considered. The route would have paralleled the new section of the Bellefonte-Widows Creek 161-kV Transmission Line over the Town Creek inlet and then have turned northeastward paralleling the existing portion of the Bellefonte-Widows Creek 161-kV line to the Widows Creek Steam Plant Switchyard. This proposed route would have crossed U.S. Highway 72 twice and the Mud Creek and Little Crow Creek Wildlife Game Refuges. The land adjacent to U.S. Highway 72 is rapidly developing, and some of the land along Mud Creek and Little Crow Creek Inlets has residential development potential. The arrangement of the 161-kV and 500-kV switchyards at Widows Creek Steam Plant would require a 500-kV transmission route from this direction to cross over 13 existing 161-kV transmission lines.

Present developments along Route 5a would not eliminate it at the present time; however, future developments along U.S. Highway 72 probably will make rights of way unavailable for line construction when required in 1978. Route 5 described earlier proved to be the best location for this connection.

(4) Bellefonte-Madison 500-kV Transmission Line No. 2 - The fourth 500-kV connection will be from the Bellefonte Nuclear Plant to Madison 500-kV Substation via the future Guntersville 500-kV Substation site. This transmission line connection will be required under Step II of this project. Two routes for the Bellefonte-Guntersville section were given serious consideration. The first route investigated shown schematically as Route 6 proved to be the best location. This route leaves Bellefonte 500-kV switchyard in a northwestward direction for one or two spans, then turns southwestward until it intersects with the southern property line of the Bellefonte Nuclear Plant site. The route then turns southeastward and follows the property line, crossing the Tennessee River at river mile 390.6. From the switchyard to the river crossing, Route 6 parallels Route 5 and both lines cross the Tennessee River on double circuit transmission line towers, thereby minimizing right of way and the number of separate river crossings. Approximately one-half mile east of the river, the route will head southwestward toward the future Guntersville, Alabama 500-kV Substation site. The proposed route will be approximately 1.5 to 2.0 miles east and parallel to the Tennessee River. The transmission line will not be visible from the River or Guntersville Reservoir except where it crosses Jones Creek and South Sauty Creek inlets. Existing trees will be left to form a screen adjacent to these crossings. Route 6 will be approximately 27 miles long of which 1.5 miles will be located on nuclear plant property. The remaining 25.5 miles will be constructed on right of way 200 feet wide.

An alternate route which was investigated is shown schematically as Route 6a on figure 2.2-1. This route leaves the Bellefonte 500-kV switchyard in a northwestward direction until it intersects the existing Widows Creek-Scottsboro 161-kV Transmission Line. The route then turns southwestward and parallels the above mentioned line for about 2.5 miles. The next 2.5 mile section turns generally southward and crosses the Tennessee River north of Alabama State Highway 35. Approximately one mile of this section adjacent to Dry Creek has marginal developmental potential and is aligned to provide a 90° crossing of the Tennessee River. About one-half mile east of the river, the route heads southwestward to the future Guntersville, Alabama 500-kV Substation site. The land on the northwest bank of the river and adjacent to the proposed river crossing is rapidly being developed. The river crossing is south of the Boy Scouts of America Campground and north of the Section Bluff Cabin Site Area. Route 6a is about 29 miles long of which 5.5 miles is parallel to either proposed or existing transmission lines.

The land northeast of Scottsboro, Alabama has good industrial development potential because of the accessibility of rail, road, and river transportation in the area. Future industrial developments in this area probably will make this part of Route 6a unavailable for line construction when required in 1978. Route 6a crosses the Tennessee River one mile downstream from the proposed Widows Creek-Bellefonte 500-kV line No. 2 line crossing. The 5.5 mile section of parallel construction in the vicinity of Bellefonte Nuclear Plant involves crossing of the Town Creek inlet and encircles the community of Bellefonte.

After considering the advantages and disadvantages of both locations, Route 6 was selected as the preferred route.

From the vicinity of the future Guntersville 500-kV Substation site, the line turns in a northwest direction crossing Guntersville Lake and Alabama State Highway 79 at about a right angle. One mile west of Guntersville Lake the proposed route turns north for four miles placing it midway between the communities of Grant and Swearengin, Alabama. The route then proceeds northwestward for 6 miles to the bottom land adjacent to Paint Rock River. From this point two routes shown schematically on figure 2.2-1 as Route 7 and 7a were considered.

Route 7, although slightly longer, proved to be the preferred location. From the end of the section described above, Route 7 turns westward for 2.5 miles and then swings northwestward following the lower slopes of Keel Mountain to the bottom land adjacent to Hurricane Creek. The line route then turns northward for about 8 miles traversing the low ground along Hurricane Creek and crossing U.S. Highway 72 at a right angle. The next 4.0 mile portion runs generally northwestward until it intersects the existing Widows Creek-Madison 500-kV line. The remaining 2.5 mile section to Madison parallels this existing line.

The section of line shown as Route 7a on figure 2.2-1 was investigated as an alternate location. Approximately 11 miles northwest of the river, this route leaves Route 7 in a northward direction and follows the low land adjacent to Paint Rock River where the river flows between Keel and Splitrock Mountains. The route crosses U.S. 72 and Southern Railroad at a slight angle and then parallels the highway and the railroad for about 4 miles of this 6.5 mile section.

The route then turns northwestward for about 8.5 miles and intersects proposed Route 7. The transmission line will be visible from the highway, the railroad and Paint Rock, Alabama, which is located on U.S. 72 at the base of Keel Mountain.

Route 7, which was selected as the preferred line is about 36.0 miles long. Thirty three and one-half miles of this line will be constructed on right of way 200 feet wide with the remaining 2.5 miles being constructed on right of way common with the Widows Creek-Madison 500-kV Transmission Line.

7. Conclusion - The transmission lines involve the commitment of the resources used in the construction of the facilities and will cause some minor limitations in land use. No significant permanent alterations in topography are involved.

The amount of land required in proportion to the added transmission capacity has been greatly reduced by TVA's use of extra high voltage lines to transmit the power generated at the Bellefonte Nuclear Plant. One 500-kV line can transmit more power than ten 161-kV lines while requiring only twice as much right of way as one 161-kV line.

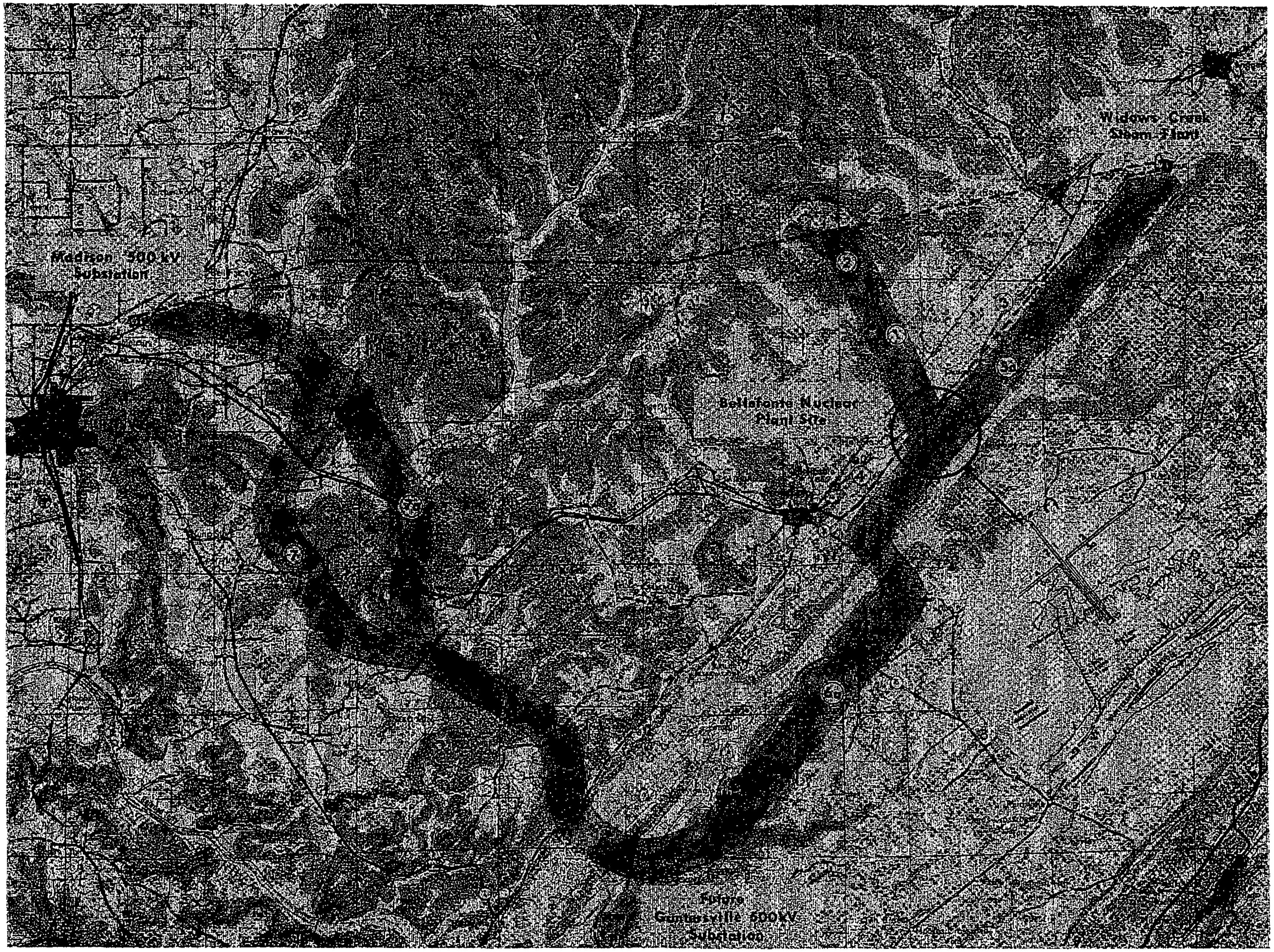
No significant irreversible and irretrievable commitments of resources are associated with the transmission line connections. No water or air damage is anticipated; very little if any objectionable noise will result; and only minor land use limitations are involved.

REFERENCES FOR SECTION 2.2

[1]U.S. Department of Interior and U.S. Department of Agriculture, Environmental Criteria for Electric Transmission Systems, Washington, DC, U.S. Government Printing Office, 1970, 0-404-932.

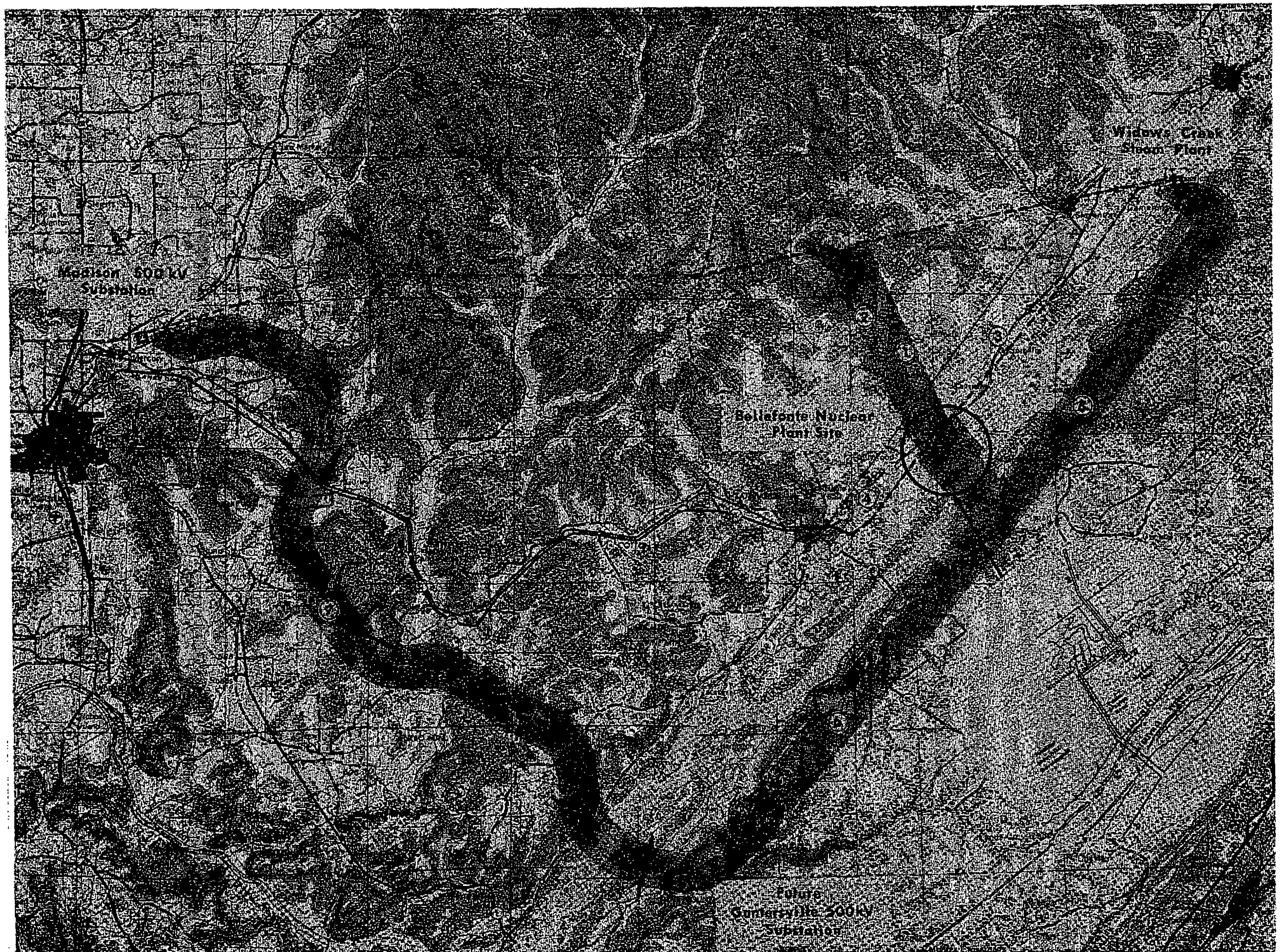
[2]Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife Development and Tennessee Game and Fish Commission, What You Can Do To Benefit Wildlife on Your Land?, 1969.

[3]General Design Criteria 17, Electric Power Systems, Appendix A to Title 10 Code of Federal Regulations, Part 50.



TRANSMISSION FACILITIES
Bellefonte Area

Figure 2.2-1



TRANSMISSION FACILITIES
Bellefonte Area

Figure 2.2-2

2.3 **Radiological Effects of Accidents** - To aid in developing the overall balancing of environmental costs and benefits of the Bellefonte Nuclear Plant, an assessment has been made of the consequences that might result from the occurrence of postulated accidents. In order to appraise realistically the environmental risks of postulated radiological accidents, parameters, physical characteristics, and phenomena which reflect the present state of the art have been used in the analyses. Best estimates are used where experimental evidence is not sufficient to describe a situation. This approach to the analyses is therefore different from that used in safety analysis reports where conservative values are used to establish limits for design bases.

In accordance with AEC requirements, TVA will submit with its application for permits to construct units 1 and 2 a safety analysis report which describes the technical features of the plant and the provisions for ensuring the health and safety of the public. It is expected that the analyses present in this safety analysis report will demonstrate that even for postulated accidents of great severity analyzed using highly conservative assumptions, the radiological consequences would be within the reference values of 10 CFR Part 100.

Those postulated accidents having the potential for uncontrolled release of radioactive material to the environment have been divided by the Atomic Energy Commission into nine classes based on the systems involved and the type and potential consequences of the release. These classes are shown in Table 2.3-1. The accident analyses presented in Appendix G are based on the guidance given by AEC in the proposed annex to Appendix D, 10 CFR 50.[1] This approach will allow comparison between reactors of different types at different sites.

In order to assess risk, some measure of probability is required. In general, TVA believes that certain "accidents" may reasonably be expected to occur during the lifetime of the plant. These (accident subclasses 1.0, 2.0, and 5.1) are included in the estimates of routine radioactive discharges. The accidents in classes 3.0 and 5.0 are not expected to occur duing the 40-year lifetime of the plant. Accidents in classes 6 and 7 are relatively less probable but still are possible. The probability of occurrence of class 8 accidents is very small. The postulated occurrences in class 9 involve 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 low that their environmental risk is extremely small. 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 low in probability that the environmental risk is extremely small.

Appendix G of this statement, "Outline of Accident Analyses," describes the accidents analyzed and the more important assumptions. In general, coolant activities are based on 0.5 percent failed fuel (as indicated by Reference 1), and on fuel element fission product inventories calculated using the model given in TID-14844.[2] Atmospheric dispersion values are shown in Figure G-1 and Safety Guide No. 4.[3] Doses to hypothetical individuals at the minimum exclusion distance (1,085 meters) and the dose commitment to the population within 50 miles of the plant are presented in Table 2.3-2. A more detailed discussion is given in Appendix G. Reasonable assumptions other than those given in Reference 1 can be used to calculate releases, but the conclusions as to the environmental risks due to postulated radiological accidents will be similar.

Table 2.3-2 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 corresponds to approximately 240,000 man-rem/yr based on a natural background level of 0.145 rem/yr. When multiplied by 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 background. It is concluded from the results of the analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

REFERENCES FOR SECTION 2.3

1. "Consideration of Accidents in Implementation of the National Environmental Policy Act of 1969," Federal Register, Vol. 36, No. 231 (December 1971), p. 22851.

2. Di Nunno, et al. "Calculation of Distance Factors for Power and Test Reactor Sites," TID-14844.

3. Atomic Energy Commission. "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors," AEC Safety Guide No. 4.

TABLE 2.3-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

No. of Class	Description	Example(s)
1	Trivial incidents	Small spills Small leaks inside containment
2	Miscellaneous small releases outside containment	Spills Leaks and pipe breaks
3	Radwaste system failures	Equipment failure Serious malfunction or human error
4	Events that release radioactivity into the primary system	Fuel failures during normal operation; transients outside expected range of variables
5	Events that release radioactivity into the secondary system	Class 4 & heat exchanger leak
6	Refueling accidents inside containment	Drop fuel element Drop heavy object onto fuel Mechanical malfunction or loss of cooling in transfer tube
7	Accidents to spent fuel outside containment	Drop fuel element Drop heavy object onto fuel Drop shielding cask--loss of cooling to cask Transportation incident onsite
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Reactivity transient Rupture of primary piping Flow decrease--steamline break
9	Hypothetical sequences of failures more severe than Class 8	Successive failures of multiple barriers normally provided and maintained

Table 2.3-2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses At the Exclusion Distance (Fraction of 10 CFR 20 Limit)	Dose Commitment To Population (Man-Rem)
1.0	Trivial incidents	*	*
2.0	Small releases outside containment	*	*
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	4.2×10^{-1}	4.1×10^{1}
3.2	Release of waste gas storage tank contents	1.6	1.6×10^{2}
3.3	Release of liquid waste storage tank contents	4.1×10^{-2}	7.3
4.0	Fission products to primary system (BWR)	NA	NA
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	*	*
5.2	Offdesign transients that induce fuel failure above those expected and steam generator leak	2.3×10^{-3}	3.0×10^{-1}
5.3	Steam generator tube rupture	2.3×10^{-1}	2.6×10^{1}
6.0	Refueling accidents		
6.1	Fuel bundle drop	8.8×10^{-3}	9.8×10^{-1}
6.2	Heavy object drop onto fuel in core	1.8×10^{-1}	2.0×10^{1}

*Evaluated as routine release in section 2.4.

Table 2.3-2
(Continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses At the Exclusion Distance (Fraction of 10 CFR 20 Limit)	Dose Commitment To Population (Man-Rem)
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	8.8×10^{-3}	9.8×10^{-1}
7.2	Heavy object drop onto fuel rack	7.8×10^{-3}	9.6×10^{-1}
7.3	Fuel cask drop	1.2×10^{-3}	1.2×10^{-1}
8.0	Accident initiation events considered in design basis evaluation in safety analyis report		
8.1	Small loss-of-coolant	7.5×10^{-5}	1.0×10^{-2}
8.1	Large loss-of-coolant	3.2×10^{-1}	5.4×10^{1}
8.1a	Instrument line break	NA	NA
8.2(a)	Rod ejection accident	3.3×10^{-2}	5.7
8.3(a)	Small MSLR	6.5×10^{-7}	2.0×10^{-4}
8.3(a)	Large MSLR	3.4×10^{-6}	1.0×10^{-3}

2.4 Radioactive Discharges -

1. Waste management policy - TVA's policy is to keep the discharge of all wastes from its facilities, including nuclear plants, at the lowest practicable level by using the best and highest degree of waste treatment available under existing technology within reasonable economic limits.

All equipment installed by TVA to reduce radioactive effluents to the minimum practical level will be maintained in good operating order and will be operated to the maximum extent practicable. The waste treatment facilities can be modified or supplemented if a higher degree of treatment should be required in the future.

The radioactive waste disposal system provided under TVA's contract with Babcock & Wilcox afforded a high degree of waste treatment. As the design progressed, several changes were made to further reduce radioactivity releases. Under the original system all liquid wastes were treated and discharged. Tritium-containing liquids are to be segregated from those low in tritium and the tritium-containing water is treated and recycled. Since most of the radioactivity is associated with the tritium-containing liquid, this change significantly reduces the amounts of tritium and other radioactive materials to be discharged from the plant.

Another change was the addition of an auxiliary waste evaporator to process so-called nontritiated liquids as well as spent regenerant solutions from the condensate demineralizers. The original system did not provide for the spent regenerants, which, in the event of steam generator leakage, would contain radioactive materials.

The installation of additional equipment for extended treatment of radwaste to reduce exposure of the general public may cause increased exposure of plant personnel. The majority of the exposure will be received during maintenance of processing equipment. Consideration is being given to location, operational requirements, and maintenance schedules in order to minimize unnecessary exposure to personnel during work involving the additional equipment. The protection provided the employee during the time he is working in the plant will be addressed in detail in the Bellefonte Nuclear Plant Preliminary Safety Analysis Report.

Evaluation of the gaseous waste system showed that gas decay tanks, originally designed for 45-day storage, have adequate capacity to store gas for 60 days. TVA will operate the tanks with a minimum storage time of 60 days.

Additional changes include the provision of high-efficiency particulate filters and charcoal iodine-removal filters to reduce radioactivity emission at several points of gaseous release.

2. Origins of radioactivity released - Radioactivity released from the plant results from the deliberate removal of liquid from the reactor coolant system or by leakage of this liquid. Radioactive materials present in the reactor coolant are produced in the following ways:

1. Fissioning creates radioactive fission products in the fuel which leak out through perforations in the fuel clad.
2. Corrosion products are derived from metallic components in the reactor coolant system which are made radioactive by neutron interaction as the corrosion products circulate with the reactor coolant through the reactor core.
3. Oxygen combined as water in the reactor coolant interacts with neutrons to produce the radioactive isotopes nitrogen-13,

nitrogen-16, and oxygen-19.

Radioactive materials produced by these methods are either dissolved or suspended in the reactor coolant. The dissolved materials include the radioactive noble gases, xenon and krypton.

Radioactive tritium is an isotope of hydrogen. While it may originate in elemental form, it is normally found in the coolant combined as HTO. The separation of HTO from H_2O cannot be accomplished by ordinary chemical means. Complex and expensive multi-stage processes are required, and it is not now feasible to carry out the separation at a nuclear power station. Tritium is formed by the following methods:

1. Tritium is formed as one of the fission products. Approximately 1 percent of the tritium so formed escapes from the fuel through perforations in the clad or by diffusion through the clad.
2. Boron and lithium, which are normal constituents of the reactor coolant, interact with neutrons to produce tritium.
3. Deuterium, an isotope of hydrogen present in small amounts in water, can absorb a neutron to become tritium.

If boron carbide were used as the neutron absorber in the reactor control rods, this would be an additional and major source of tritium. The Bellefonte reactors, however, will use silver-indium-cadmium in the control rods instead of boron carbide, thereby avoiding this mode of tritium production.

The estimated concentrations of radioactive materials in the reactor coolant liquid are given in Table 2.4-1. Table 2.4-2 gives escape rate coefficients used in estimating the reactor coolant activity, and Table 2.4-3 lists the bases for the determination of coolant activity.

3. Radioactive waste disposal system - The radioactive waste disposal system includes facilities for the treatment of liquid, gaseous, and solid wastes.

(1) Makeup and purification, chemical addition and boron recovery systems - These systems, while technically not a part of the waste disposal system, are discussed here because they treat for recycle large quantities of liquid that would otherwise be waste and because they constitute the principal pathway by which radioactive gases enter the gaseous waste disposal system. The basic portions of these systems are shown schematically in figure 2.4-1. Each reactor unit has a separate makeup and purification system. Each also has a chemical addition and boron recovery system with crossties to the corresponding system of the other reactor.

The makeup and purification system is in continuous use during reactor operation. It may also be used during shutdowns, including refueling outages.

Reactor coolant is withdrawn from the reactor coolant system at a rate of 50 gal/min, is reduced in pressure, and is cooled by passage through a heat exchanger. The cooled liquid is filtered and is passed through purification demineralizers. The liquid then passes through another filter before entering the makeup tank. A hydrogen atmosphere is provided in the makeup tank to maintan a dissolved hydrogen content of about 30 cc H_2/kg in the coolant. The dissolved hydrogen supresses the radiolysis of water in the reactor and combines with any free oxygen that may be present. Liquid is pumped back to the reactor coolant system from the makeup tank.

During shutdown of the reactor, gas released from the coolant as it cools is vented from the makeup tank to the gaseous waste disposal system.

In order to change the boron concentration in the reactor coolant, a quantity of coolant is transferred to the chemical addition and boron recovery system via the makeup and purification system. A corresponding quantity of boric acid and distillate is supplied to the reactor coolant system through the makeup tank. Boron concentration changes are made during base-load operation for chemical shim adjustment and are made each time a significant change in reactor power is made. Concentration changes are made also at each startup and shutdown.

These functions are carried out by the chemical addition and boron recovery system. Liquid is transferred from the makeup and purification system at a point downstream of the demineralizers and is collected in a 120,000-gallon reactor coolant bleed tank. Letdown of the coolant to a pressure slightly above atmospheric in the bleed tank releases much of the dissolved hydrogen, xenon, and krypton from the liquid to the gas space in the tank, from which it is transferred to the gaseous waste disposal system. Liquid is pumped from the bleed tank through a mixed-bed demineralizer and a filter to a 30-gal/min reactor coolant bleed evaporator. Distillate from the evaporator is collected in one of a pair of test tanks, from which it is pumped through a demineralizer to a 120,000-gallon distillate storage tank. The evaporator concentrate, containing from 5 to 7 percent boric acid, is pumped to one of two 31,000-gallon boric acid storage tanks. Recovered distillate and boric acid are supplied to the reactor coolant system via the makeup and purification system in the proportions and amounts required.

The evaporation process removes substantially all of the hydrogen and noble gases from the liquid. The gases vented from the evaporator are sent to the gaseous waste disposal system.

Recovered distillate will be low enough in radioactivity content to permit storage in tanks without shielding. Shielding will be provided for the boric acid tanks, but it too is expected to be low in radioactivity content.

(2) Liquid waste disposal system - The sources of radioactive wastes, the estimated amounts, and the bases for these amounts are given in Table 2.4-4. A portion of the waste is relatively high in tritium content, while the remainder contains little tritium. Drains which normally carry tritiated liquid are segregated from those which normally carry nontritiated liquid. In a few instances, where a waste source may be of either category (e.g., reactor building floor drain collector tank contents), provision is made to route the liquid either way. It is necessary to have a dividing line between tritiated and nontritiated liquid. TVA has decided to treat liquid which has a tritium concentration equal to 10 percent or more of the reactor water tritium concentration as tritiated water. Although the dividing line varies from day to day, this particular formula permits operating practices to remain fairly constant throughout plant life.

(a) Tritiated liquid waste - The essential features of the system for treating tritiated liquid waste is shown in figure 2.4-2.

Leakage from the reactor coolant system is collected in equipment drains and routed to reactor coolant drain tanks.

Normally, this liquid is then pumped to the reactor coolant bleed tank for processing in the chemical addition and boron recovery system. It may, however, be transferred to the tritiated waste holdup tank. Tritiated liquids from the sources shown in Table 2.4-4 are collected in the tritiated waste holdup tank. Periodically, a batch of liquid is processed by filtering and evaporating. The concentrates from the 2-gal/min waste evaporator are sent to solid waste disposal for packaging. The distillate is collected in one of two test tanks. The distillate is then passed through a demineralizer to the distillate storage tank, which is a part of the chemical addition and boron recovery system. From there, the liquid is recycled to the reactor coolant system.

TVA intends to recycle tritiated water back into the primary system until the primary coolant tritium concentration reaches a maximum level which will not exceed permissible operating personnel dose limits. The exact concentration which will be considered the maximum safe level will be determined largely by doses which could be received by plant personnel during refueling operations. Tentatively, this concentration has been set at 2.5 Ci/ml for analysis purposes, and based on the assumptions used for estimating routine releases, this level would be reached about 7 years after startup. Tritiated water will be periodically extracted from the primary system to maintain the maximum safe level. TVA will continue its investigations into the questions posed by tritium recycle and the transfer of tritiated water to an AEC-approved disposal area. If future developments indicate that it is desirable to permit controlled releases of tritium, TVA will modify its operations accordingly.

Figure 2.4-3 shows the buildup of tritium in the primary system and in the refueling water volume for each unit, based on maintaining an upper limit of 2.5 μCi/ml in the primary system. The upper curve describes the tritium concentration in the primary system as a function of time. The tritium concentration of the refueling water is given by the bottom of each vertical line. For example, during the refueling outage at year 5, the tritium concentration in the refueling volume (not including the spent fuel pool) is 0.5 μCi/ml. The water returned to the refueling water tank after the refueling is at this same concentration. The concentration in the primary system following refueling is 1.7 μCi/ml and increases to 2.3 μCi/ml during the subsequent fuel cycle.

At any time except during refueling, the volume of water in the primary system is approximately 165,000 gallons. This includes water in the reactor coolant system, the primary makeup water storage tank, the CVCS holdup tank, the CVCS monitor tank, and the tritiated waste holdup tank. The tanks are assumed to be partly full at normal operating levels. The refueling water volume is approximately 600,000 gallons. Amounts of water that must be removed to maintain a maximum tritium concentration of 2.5 μCi/ml are noted on the curve.

The maximum amount of tritium in storage at any time is about 8,600 Ci (both units).

Tritiated water bled from the primary system will be shipped offsite as necessary as low specific activity waste for retention at an AEC-approved disposal site.

A connection is provided in the railcar room in the auxiliary building through which water from either primary makeup water storage tank can be loaded into tank trailers or rail tank cars.

It is impossible to totally prevent release of tritium from a nuclear power plant by reasonable means. Vaporization from the refueling canal and spent fuel pit carries off significant amounts of tritium. In addition, some secondary liquids and vapors must be released from the plant, and at times these will contain small amounts of tritium which have leaked into the secondary system from the primary system. Expected sources of tritium release include purging of the containment and fuel storage areas, condenser vacuum pump effluent during periods of steam generator leaks, and any leakage which is at a tritium concentration too low to be recycled.

The amount of tritium discharged will vary depending on the concentration of tritium in the primary coolant, the primary to secondary leakage rate, and the period of operation with a primary to secondary leak. Assuming tritium recycle, if each reactor had a primary to secondary leak of 20 gallons per day which persisted for a year, the total tritium release from the secondary system would be about 140 curies.

(b) <u>Nontritiated liquid waste</u> - The essential features of the nontritiated liquid waste system are shown on figure 2.4-4. These wastes are treated for recycle to the secondary system or for discharge to Guntersville Reservoir after dilution by the cooling tower blowdown stream.

The degree of treatment given a particular batch of a liquid depends on its radioactivity concentration. As shown in figure 2.4-4, the contents of the nontritiated waste holdup tank can be treated by filtration or by evaporation. If the gross radioactivity concentration (other than tritium) of this liquid is greater than 10^{-4} μCi/ml, it will be treated by evaporation to reduce the concentration in the distillate to below 10^{-4} μCi/ml. If the gross radioactivity concentration is less than 10^{-4} μCi/ml, the liquid will be treated by filtration prior to discharge. The same radioactivity guideline will be applied to spent regenerants and chemical drains. Laundry, hot shower, and cask decontamination drains are not expected to exceed 10^{-4} μCi/ml, but they will be monitored and if they do exceed this value they can be transferred to the nontritiated waste holdup tank for processing by evaporation.

Nontritiated liquids from floor and equipment drains are collected in the nontritiated waste holdup tank. If analysis shows the radioactivity concentration to be below 10^{-4} μCi/ml, the liquid is pumped through a filter to the plant discharge. If above 10^{-4} μCi/ml, the liquid is pumped to the auxiliary waste evaporator. The concentrates from the evaporator are sent to solid waste disposal for packaging. The distillate is collected in one of two test tanks for determination of radioactivity and chemical content. It is then either pumped through a demineralizer to one of the condenser hotwells for reuse in the secondary system or it is pumped to the plant discharge. In the event that the distillate meets neither recycle or discharge standards, it is pumped to the nontritiated waste holdup tank for reprocessing.

The treatment given the liquids in the chemical drain tank depends on their chemical and radioactivity contents. If it contains chemicals that cannot be discharged or would be harmful to the evaporator, the liquid is sent to solid waste disposal for packaging. If free of harmful chemicals and below 10^{-4} µCi/ml in radioactivity, the liquid is discharged after filtration. If free of chemicals that would be harmful to the evaporator and above 10^{-4} µCi/ml, the liquid is processed in the auxiliary waste evaporator. The distillate is recycled to the secondary system or is discharged.

Laundry and hot shower drains, after sampling and analysis, are filtered prior to discharge. In the unlikely event that the radioactivity concentration exceeds 10^{-4} µCi/ml, the liquid is transferred to the nontritiated waste holdup tank for further treatment. Spent fuel cask decontamination drains are handled in a similar manner.

The Bellefonte plant uses once-through-type steam generators, which operate without blowdown. Condensate demineralizers are employed to provide water of adequate quality for the steam generators. These demineralizers are regenerated periodically with sulfuric acid, sodium hydroxide, and ammonium hydroxide. In the event of a primary to secondary leak in a steam generator, the secondary system will become contaminated with constituents of the primary system, including radioactive materials. Radioactive gases separated in the condenser will be released via the vacuum pump exhaust. Radioactive dissolved and suspended materials will accumulate in the condensate demineralizers. When the demineralizers are regenerated, these materials will be contained in the spent regenerant solutions. The solutions are collected in the spent regenerants tank, where sulfuric acid is added to neutralize excess alkali. If the solution contains less than 10^{-4} μCi/ml, it will be discharged. If above 10^{-4} μCi/ml, it will be processed. At a time when the auxiliary waste evaporator is not in use with other wastes, the contaminated spent regenerant solutions are fed to the evaporator. The distillate and concentrates will be handled as in the case of liquids from the nontritiated waste holdup tank.

The condensate demineralizers are located in the turbine building. Liquid leaks in the demineralizer area are collected in a sump and are pumped into the spent regenerants tank. Liquid leaks in the remainder of the turbine building, including those from condensate and feedwater lines, are collected in the turbine building sump. Sump liquid is sampled and analyzed for radioactivity prior to discharge. The amount of radioactivity associated with this liquid will be small, and no provision is made for processing it.

(c) Discharge of radioactive liquids - Any batch of potentially radioactive liquid released from the plant is first sampled and analyzed. Liquids from the waste disposal system are discharged through the waste discharge line which connects into the cooling tower blowdown line. The waste discharge line includes a flowmeter, a locked-closed valve, a radiation-controlled valve, an in-line radiation monitor, and a valve controlled by flow in the cooling tower blowdown line. The radiation-controlled valve is automatically closed when the monitor detects a concentration in excess of 10^{-4} μCi/ml.

The flow rate in the cooling tower blowdown line will range from zero to about 33,000 gal/min. A flowmeter in the blowdown line is interlocked with the flow-controlled valve in the waste discharge line such that the valve is closed when the blowdown flow rate is less than 15,000 gal/min.

Waste can only be pumped into the waste discharge line; flow by gravity does not take place. The radwaste operator controls the waste discharge rate to keep the concentration in the tower blowdown line below 10^{-7} μCi/ml at all times. On an annual average basis the concentrations will not exceed the limits proposed in Appendix I to 10 CFR Part 50.

(3) Gaseous waste disposal system - The radioactive noble gases krypton and xenon are dissolved in the reactor coolant. When the reactor coolant pressure is reduced to near atmospheric pressure, the gases tend to come out of solution, along with hydrogen and some radioactive iodine. This occurs when reactor coolant is let down to the reactor coolant bleed tanks. It also occurs when reactor coolant leaks from the system.

Most of the radioactive gas released from the reactor coolant system is handled in the gas decay system. Gases from the following sources are handled:

Reactor coolant bleed holdup tank

Reactor coolant bleed evaporators

Makeup tanks

Vents from pumps, filters, demineralizers, coolers in reactor coolant, makeup and purification, and chemical addition and boron recovery systems

Relief valves

Reactor coolant drain tanks

Tritiated waste holdup tank

Tritiated auxiliary building sump tank

Waste evaporator feed tank

Waste evaporator

Waste evaporator distillate test tanks

Spent resin tank

Distillate storage tanks

Boric acid storage tanks

Reactor coolant bleed evaporator feed tanks

Reactor coolant bleed evaporator test tanks

Vents from each of these sources are connected to a compressor suction header as shown on figure 2.4-5. Two gas compressors are connected to this header. The compressors discharge to one of two 3,000-cubic-foot gas decay tanks. A recycle line between the compressor discharge and suction has a pressure-controlled valve which responds to pressure in the suction header.

One compressor is normally in operation, with the other in standby. When the pressure in the suction header reaches 2.0 lb/in^2 gauge, the compressor starts and runs until the header pressure drops to 0.5 lb/in^2 gauge. When the header pressure drops below 0.5 lb/in^2 gauge, the pressure-controlled valve in the recycle line opens, recycling gas from the storage tank to the header. Typically, when a tank such as a reactor coolant bleed tank is being filled with liquid, gas above the liquid is transferred by the compressors to the gas decay tanks. When the liquid level in the tank is lowered, gas is returned from the decay tank to the holdup tank via the recycle line. This arrangement allows a maximum decay time while minimizing gas consumption.

When the decay tank in service approaches a pressure of 100 lb/in^2 gauge, the contents of the other tank are released. The tank vent line includes a radiation-controlled valve, a flow-controlled valve, a prefilter, high-efficiency particulate filter, a charcoal filter (for iodine removal), and a radiation monitor. The monitor closes the valve when a concentration of 5 μCi/ml is exceeded. Downstream of the monitor, the line branches into two lines, each of which terminates at the top of a reactor shield building. Releases are made at a time when meteorological conditions are favorable and from the vent that will provide the best dispersion for the gases.

Other gaseous releases occur for which decay storage is not provided. Tanks and equipment in the radioactive liquid waste disposal system, other than those listed above, are vented to the auxiliary building ventilation exhaust system. Radioactive gases and airborne particulates resulting from liquid leaks and spills in the auxiliary building are also picked up by the exhaust system. The exhaust is passed through HEPA and charcoal filters for particulate and iodine removal prior to discharge at the shield building vent.

During operation with primary to secondary leakage, gases from the primary system are transported with the steam to the turbine and condenser. The gases, along with air that leaks into the condenser, are removed from the condenser by vacuum pump exhausters. The vacuum pump exhaust is passed through a blower, a heater, a HEPA filter, and two charcoal filters in series before being discharged to the turbine building roof as shown on figure 2.4-5. This path is in operation except when vacuum pump flows in excess of 50 ft^3/min occur, as during unit startup. A high-flow bypass is provided which automatically opens on a high-pressure drop signal across the HEPA filter.

Radioactive gases and particulates accumulate in the containment atmosphere during normal operation as a result of small leaks in the reactor coolant system. The containment atmosphere is continuously monitored for radioactivity during operation. The containment atmosphere is purged prior to entry of personnel or in order to equalize the containment pressure with the outside atmosphere. A containment auxiliary charcoal system is operated for about 8 hours prior to purging. This system consists of three fan-filter units, each located on a separate level of the building and arranged to enhance mixing of the total containment volume. HEPA and charcoal filters are provided in each unit for reduction of airborne particulates and iodine. The three units can circulate the containment atmosphere about two times during an 8-hour period. During purging, outside air is supplied to the containment. Purged air is exhausted through two 50 percent capacity fans and filter networks in parallel (high-efficiency particulate air filter and charcoal filters) to the plant vent where it is monitored during release to the atmosphere. The containment purge system has a capacity of approximately 1.5 complete changes of air per hour. Venting capacity is controlled by variable dampers.

In addition to purge of the full containment, the instrument room is purged separately for entries made about once per 2 weeks. The air from this room is exhausted through the containment purge exhaust system.

Leakage of steam and feedwater during periods of operation with primary to secondary leakage introduces some radioactivity into the turbine building atmosphere. Airborne radioactivity is exhausted, without treatment, at the turbine building roof.

(4) Solid waste disposal system - The sources of solid wastes are spent demineralizer resins; waste and auxiliary waste evaporator concentrates; and miscellaneous solids such as filter elements, paper, rags, plastic sheeting, laboratory ware, and contaminated equipment and parts.

Spent resins are collected and stored in a spent resin tank. Periodically the spent resins are sluiced to the packaging system, where they are mixed with a solidification agent (e.g., cement or methyl methacrylate) and packaged in containers. Evaporator concentrates are also mixed with a solidification agent and packaged. Compressible wastes are packaged in drums using a baling machine. Filter elements from liquid filters are placed in drums and concrete is poured into the drums. Spent HEPA and charcoal filter elements are packaged in the containers in which new elements are received.

The quantities and shipment of solid radwaste are discussed in section 2.1.

4. Radioactivity releases - The radioactive discharges have been estimated for the principal routes of release or removal which are the liquid releases, gaseous releases, and solid radwaste disposal. For this analysis it is assumed that the reactor operates

at full load for 292 days out of the year. It is assumed that fuel which produces 0.25 percent of the core power contains small defects, allowing fission products to escape the coolant. The escape rate coefficients used to estimate this release are given in Table 2.4-2.

TVA has investigated the predicted level of failed fuel for the Bellefonte plant and has concluded (based on operation experience and predictions of fuel failure rates) that the assumption that the presence of clad defects in the fuel pins which produce 0.25 percent of the core power is a reasonable and achievable level of fuel performance over the life of the plant. Good fuel performance is enhanced by proper fuel design, good fabrication techniques, and a comprehensive quality assurance program. Inspections and tests by TVA or its consultant, as well as by the fuel fabricator, will ensure that the fuel is fabricated as designed. The design of the Bellefonte fuel will be similar to that in plants now operating or about to be operating but will have the benefit of the experience gained in operation of these plants. The radwaste systems and shielding in the plant will be designed to handle the radwaste from operation with 1 percent failed fuel in both units.

(1) Liquid releases - Table 2.4-4 summarizes the estimated annual quantities of liquid wastes from the various sources within the plant. Table 2.4-5 shows the radioactivity releases from the liquid waste disposal system, from processing condensate demineralizer regenerants and from secondary system feedwater leakage. Table 2.4-6 gives the estimated isotopic distribution of these releases.

In estimating the release from the waste disposal system, it was assumed that 20 gallons per day per unit of reactor coolant leaked into the waste disposal system, was processed by the auxiliary waste evaporator and was discharged. A decontamination factor of 1,000 was assumed for the evaporator. In addition, it was assumed that 1 gallon per day of reactor coolant was released without processing, other than by decay and filtration, in the form of nontritiated wastes, including laundry and shower wastes, cask decontamination drains, floor drains, etc.

The estimated release from the condensate demineralizer regeneration system assumes 20 gallons per day per unit of primary to secondary leakage. It is assumed that the demineralizers remove 90 percent per pass of the nongaseous radioactivity from the condensate, that the individual demineralizers are regenerated at 30-day intervals, that the spent regenerants are decayed for 3 days and processed by evaporation with a decontamination factor of 100, and that the distillate is discharged.

In estimating the secondary system feedwater leakage, it was assumed that 100 pounds per day per unit of feedwater enters the turbine building floor drain system and is discharged. It was assumed that primary to secondary leakage exists (20 gallons per day per unit), that 46 percent of the feedwater does not pass through the condensate demineralizers, and that the demineralizers remove 90 percent of the radioactivity from the remainder.

(2) Gaseous releases - Table 2.4-7 gives the estimated gaseous releases of iodines and noble gases. Table 2.4-6 gives the calculated isotopic distribution in the combined releases.

All releases are based on the reactor coolant composition given in Table 2.4-3. Other assumptions used in estimating these releases are discussed below.

(a) Containment purge - It is assumed that 50 pounds per day per unit of hot reactor coolant escapes into containment. Purges are carried out as discussed previously. Releases of radioactivity to the atmosphere are based on: (1) twelve complete containment purges per unit per year, (2) operation of the containment auxiliary charcoal filter system for 8 hours prior to purge, (3) an iodine decontamination factor (DF) of 10 in the auxiliary charcoal filters for all radioisotopes except noble gases, and (4) an iodine DF of 100 in the charcoal filters in the purge exhaust system.

(b) Instrument room purge - Releases from this source were based on 26 purges per unit. A DF of 100 for iodine in the charcoal filters of the purge exhaust system is assumed.

(c) Releases through the auxiliary building ventilation system - It is assumed that the radioactivity in 1 gallon per day per unit of reactor coolant plus 19 gallons per day per unit of liquid downstream of the purification demineralizers is released to the building atmosphere. The building atmosphere is exhausted through HEPA and charcoal filters with a DF of 100 for iodine.

It is assumed that liquid leaks from individual components in the building take place at the following rates:

3 grams per hour per valve

30 grams per hour per flange

75 grams per hour per pump seal on transfer pumps

150 grams per hour per makeup pump seal

Gas leak rates are assumed to be:

10^{-3} grams per hour per high-pressure valve or flange

10^{-4} grams per hour per low-pressure valve or flange

Specific activities of liquids are based on reactor coolant of the composition given in table 2.4-1 and on the following process DF's:

	Purification Demineralizers	Evaporator Distillate	Evaporator Concentrates
Xe and Kr	1	10^4	infinte
Cs, Y, Mo	1.22	10^2	0.1
Tritium	1	1	1
Others	10	10^2	0.1

The specific activity of gases is based on an average dissolved hydrogen concentration of 27.5 ccH_2/kg and a one-to-one dilution with nitrogen. The release process at the source of the leak is assumed to provide the following DF's:

Xe and Kr	DF = 1
Br and I	DF = 10^3
Tritium	DF = 1
Others	DF = 10^5

(d) Waste gas decay tank venting - These estimates are based on the following:

1. Load-following (push-pull) operation of both units with daily load swings from 100 percent power to 50 percent power to 100 percent power for the first 254 days of a 292-day equilibrium cycle, and base loaded thereafter.
2. A load factor, including refueling outages, of 84 percent which results in 1.05 equilibrium (292 EFPD) cycles per unit per year.
3. Coolant activities, as shown in Table 2.4-3.
4. Waste gas decay tanks operated on a 120-day cycle--60 days to fill and 60 days for decay.
5. The iodine release based on a total DF of 10^5 (10^2 for the purification demineralizer, 10^2 for vapor-liquid partitioning, and 10^1 for charcoal filters in vent line).
6. Particulate activity from primarily Sr-89 and Cs-137 resulting from the decay of Kr-89 and Xe-137, respectively. Particulate activity receives a DF of 100 due to HEPA filters in the vent line.

(e) Steam leakages - Radioactivity in steam assumes that 20 gallons per day of reactor coolant (Table 2.4-3) leaks to the secondary side of the steam generators and that all radioactivity leaves with the steam or deposits in the system.

Steam leakage of 100 pounds per day per unit is assumed. All noble gas in the leaked steam is assumed to be released. It is assumed that 90 percent of the iodine deposits in the system before reaching the leak points.

(f) Turbine gland sealing system leakage - It is assumed that 9,000 pounds per hour per unit of steam goes to the gland seals. Primary to secondary leakage of 20 gallons per day per unit is assumed. All noble gases in the steam are assumed to be released. A decontamination factor of 2,000 across the gland seal condenser is assumed for iodine.

(g) Condenser offgas - Condenser offgas release estimates are based on 20 gallons per day per unit of primary to secondary leakage (reactor coolant composition as in Table 2.4-3). It is assumed that all of the noble gases leaked to the secondary side are released as condenser offgas. Iodine releases assume a steam generator internal partition factor of 1 (once-through steam generator), a condenser air ejector partition factor of 2,000, and a decontamination factor of 100 across the air ejector after-condenser and charcoal filter.

(h) Feedwater leakage - The feedwater leakage release estimates are based on a leakage rate of 100 pounds per day per unit during operation with 20 gallons per day per unit primary to secondary leakage. For the portion of condensate that passes through the condensate demineralizers (54 percent), a decontamination factor of 10 is assumed. For all except noble gases, a decontamination factor of 10,000 is assumed from puddle to air.

5. Alternative waste treatment -

(1) Liquid waste disposal alternatives - The liquid waste disposal system, as now designed, provides treatment

which reduces releases to a level which is as low as practicable. Segregation of drains to permit recycle of tritiated liquids removes this potentially major source from the plant effluent. The added auxiliary waste evaporator provides for nontritiated liquids and makes possible the recycle of a significant fraction of such liquids.

The present design permits the treatment of detergent wastes in the event that radioactivity concentrations exceed 10^{-4} µCi/ml. However, treatment of such wastes in an evaporator could give rise to operational problems, such as foaming. Although it is understood that detergent waste treatment systems are under development, they are not commercially available at present. TVA will consider the feasibility of installing such a system if one is perfected, taking into account effectiveness, space requirements, and cost.

The present design reduces radioactive liquid discharges to a level which is considered as low as practicable.

(2) <u>Gaseous waste disposal alternatives</u> - A gas decay system which provides a minimum storage time of 60 days following a 60-day filling time has been selected to handle gases released from the reactor coolant.

The following alternatives to the gas decay system have been considered:

1. Addition of a recombiner to the gas decay system to remove hydrogen by reaction with added oxygen, thereby increasing the effective storage capacity of the gas decay system.
2. Addition of a cryogenic distillation or solvent absorption system to remove noble gases from the decay tank effluent.

(a) Addition of recombiner - The first alternative would use a recombiner installed in the gas decay system as shown in figure 2.4-6. The recombiner would remove hydrogen from the gas by reacting it with added oxygen. Since hydrogen comprises a large fraction of the total gas, the effective decay time for the noble gases would be increased from 60 days to a year or more.

Table 2.4-8 shows the effect of the added decay time on the estimated release from the gas decay system. The additional decay time has little effect on the total release because the dominant isotope, krypton-85, has a long half-life. The system would not reduce gas releases due to leakage.

The installed cost of a recombiner system would be approximately $400,00. Annual operating costs, not including depreciation, maintenance, or operating labor, could run from about $1,000 to more than $5,000, depending primarily on catalyst life, which is not known at present. A system of the type considered is not now in operation at a nuclear power station.

(b) Addition of noble gas removal system - The second alternative would add a noble gas removal system which would treat gas released from the gas decay tanks. The noble gas removal system would be a cryogenic distillation system or a solvent absorption system. Figure 2.4-7 illustrates the modification. These systems would be capable of removing more than 99 percent of the noble gases and of collecting them in containers for long-term storage. The resulting emissions from the gas decay system would be reduced to about 1 percent of the values shown in Table 2.4-8 in the 60-day decay column. Gas releases due to leakage would not be reduced.

The cryogenic distillation process is based on the differences in boiling points of the gases involved (principally nitrogen, hydrogen, xenon, and krypton). The process is now available for pressurized water reactor application from several vendors with air-liquifaction experience. Among its advantages, the equipment gives a high decontamination factor and is compact in size. On the debit side, the system is subject to mechanical failure. Care must also be taken to avoid contamination by oxygen, carbon dioxide, nitrogen oxides, and hydrocarbons, since these materials could cause operational difficulties or explosion hazards. The installed cost would be approximately $600,000. Annual operating cost, not including depreciation, maintenance, and operating labor, would be about $3,000.

The solvent absorption process utilizes the changes in gas solubilities with temperature and pressure and the differing solubilities of the gases. The process has been demonstrated on a pilot-plant scale at the Oak Ridge Gaseous Diffusion Plant. Among its advantages are the high decontamination factors obtained and the small size of the equipment. The major problems are associated with high-pressure operation and degradation of the fluorocarbon solvent. As compared to cryogenic distillation, the process does not have the benefit of long experience with comparable nonradioactive systems. The installed cost of a solvent absorption system would be about $400,000. The principal operating cost, other than for depreciation, maintenance, and operating labor, would be for solvent makeup. This is not expected to exceed a few thousand dollars per year.

(3) Conclusions - TVA considers that the liquid waste disposal system, as it is now being designed, will reduce liquid emissions to a level which is as low as practicable. The addition of facilities to process detergent wastes will be considered if operating experience shows them to be necessary.

TVA considers that the gaseous waste disposal system, as it is now being designed, will reduce gaseous emissions to a level which is as low as practicable. Alternate systems offer but minor reductions in offsite doses which with the present system are acceptably low. The amount of dose reduction offered by the alternates does not justify their cost.

6. Environmental radiological monitoring program -

(1) General - The preoperational environmental radiological monitoring program has the objective of establishing a baseline of data on the distribution of natural and manmade radioactivity in the environment near the plant site. With this background information, it will then be possible to determine, when the plant becomes operational, the earliest possible indications of the accumulation or buildup of radionuclides. The impact of accumulation will be minor even though trace accumulation may occur during the life of the plant.

Field staffs in TVA's Division of Environmental Planning and Division of Forestry, Fisheries, and Wildlife Development will carry out the sampling program outlined in Tables 2.4-9, 2.4-10, 2.4-11, and 2.4-12. Sampling locations are shown in figures 2.4-9 and 2.4-10. All of the radiochemical and instrumental analyses will be conducted in a central laboratory at Muscle Shoals, Alabama. Alpha and beta analyses will be performed on a Beckman Low Beta II low background proportional counter. A Nuclear Data Model 2200 multichannel system with 512 channels will be used to analyze the samples for specific gamma-emitting isotopes. Data will be coded and punched on IBM cards or automatically punched into paper tape for computer processing specific to the analysis conducted. A digital computer will be used to solve multimatrix problems associated with identification of gamma-emitting isotopes.

A study of environmental radiation levels will be initiated approximately 2 years before startup and will continue through low-power testing and operation of the plant.

The environmental monitoring program outlined herein is subject to change based on continued evaluation of the program now being conducted at the Browns Ferry and Sequoyah Nuclear Plant sites. The program will be coordinated closely with other agencies' programs, such as the nationwide fallout sampling and water quality networks and the radiological health program of the State of Alabama.

The program will include measurements of direct gamma radiation and sampling of airborne radioactivity, fallout particulate matter, rainfall, surface water, well and public water supplies, soil, vegetation, milk, fish, clams, bottom sediment, plankton, and river water. The extent to which various aspects of the program will be carried out takes into account data available from other sources; however, the program as outlined is self-sufficient. It will be continually evaluated to determine that the most sensitive vectors are being sampled to properly evaluate exposure of the population. Continual evaluation also allows planning an effective system with respect to sampling frequencies, locations, and laboratory analyses.

(2) Atmospheric monitoring - Ten atmospheric monitoring stations have been planned for Bellefonte Nuclear Plant. Two of these monitors will be located on the plant site in the two quadrants of greatest wind frequency. One additional station will be placed at the point of maximum predicted offsite concentration of radionuclides if this point varies significantly from present proposed locations. Six other stations will be located at perimeter areas out to 10 miles. These stations will be instrumented and data will be telemetered into the control room. Generally these stations will be located in or near the more densly populated areas within 10 miles of the plant in those quadrants having the greatest wind frequency on an annual basis (see figure 2.4-9). Two other monitors will be located at distances out to 20 miles. These remote monitors will be used as control or baseline stations. Samples of air, rainwater, and heavy particle fallout will be collected routinely as indicated in Table 2.4-9.

The atmosphere will be sampled for tritium at the Bellefonte Nuclear Plant. TVA has recently tested sampling methods, and plans have been made to incorporate the sampling apparatus into both the local and one of the remote monitoring stations.

(3) Terrestrial monitoring - Samples of milk, vegetation, soil, private well water, and public water supplies will be collected within a 20-mile radius of the plant. Environmental gamma radiation levels will be measured utilizing thermoluminescent

dosimeters on a 500-foot grid within the plant boundaries and at each offsite air monitoring station.

Milk will be sampled from dairy farms near the plant on a monthly basis. Locally processed milk will also be sampled on a monthly basis. If an increase in the I-131 content is detected in other critical vectors such as vegetation, the frequency of milk sampling will be increased.

Consideration has been given to sampling animals such as cattle raised in the vicinity of the nuclear plant. Present plans are to sample vegetation on a monthly and quarterly basis. This vector would be the first indicator in the food chain to man through animal. If an increase above the natural background established during the preoperational monitoring program is detected, the program will be expanded to include other vectors in the food chain such as beef cattle. Food crops grown by subsistence farmers in the area will be sampled during the growing season as is now being done at the Sequoyah and Browns Ferry Nuclear Plants.

(4) <u>Reservoir monitoring</u> - Sampling will be carried out quarterly at five river stations in Guntersville Reservoir. The stations will be located as indicated in figure 2.4-10 at Tennessee River miles (TRM) 396.8, 387.5, 380.4, 365.5, and at a station which will be located 500 feet below the plant discharge (approximate location TRM 392.0). Samples collected for radiological analyses include fish from three stations and plankton from five. Bottom fauna and sediment will be sampled at five stations. Aquatic macrophytes will be collected from three stations. Further sampling information can be found in Tables 2.4-10, 2.4-11, and 2.4-12 and figure 2.4-10.

Samples of water, net plankton, sediment, aquatic macrophytes, Asiatic clams, and three species of fish will be collected quarterly (plankton only during the two quarters of maximum abundance) and analyzed for radioactivity. Gamma, gross alpha, and gross beta activity will be determined in water (dissolved and suspended fractions), net plankton, aquatic macrophytes, sediment, shells and flesh of clams, flesh of two commercial and one game fish species, and the whole body of one commercial fish species. Reservoir water samples will also be analyzed for tritium. Except in the flesh of clams, white crappie, and channel catfish, Sr-89 and Sr-90 content will be determined in all samples by appropriate radiochemical techniques. The activity of at least ten gamma-emitting radionuclides will be determined with a multichannel gamma spectrometer.

At present TVA feels that it will be sampling those vectors which will give the first indication of increased radioactivity levels in the environment. If radioactivity increases are seen in those vectors being sampled, consideration will then be given to expanding the sampling program to include other biological specimens.

Consideration has been given to sampling waterfowl; however, about 95 percent of ducks hunted in northeast Alabama are migratory, moving great distances in the winter and spring. It would be impossible to make an accurate assessment of any radionuclides found in migratory waterfowl to a particular source such as Bellefonte Nuclear Plant. Therefore, it seems more logical to sample other vectors in the environment.

(a) Water - Water samples will be collected for determination of suspended and dissolved radioactivity from the five cross sections.

Effluent concentrations are determined prior to release of liquid radioactive waste from the plant. The liquid radwaste holdup tanks are sampled prior to release and the concentration of the contents determined. Knowing the dilution water discharge flow rate and the concentration of the liquid in the radwaste tank, a release rate from the tank will be established which will not exceed applicable standards in the discharge pipe prior to release to the unrestricted area. A set point will be established on a radiation monitor downstream of the tank discharge line which will cause automatic isolation if the concentration in the line exceeds the previously established value. In addition, a sequential-type sampler will continuously sample the effluent and be analyzed periodically to ensure that all other systems are functioning properly. When considering these plant safeguards, the reservoir monitoring frequency is believed to be adequate.

Buildup of radioactivity in Guntersville Reservoir is not expected; however, if it does occur it will occur slowly over a long period of time. The frequencies established in the present program will be satisfactory to detect this gradual effect. Possible leakages will be detected by the plant effluent monitoring system.

(b) Fish - Radiological monitoring of fish will be accomplished by the analysis of composite samples taken in the vicinity of the plant. Species to be analyzed will include at least one each of important sport and commercial species. Tentative choices at present are white crappie, channel catfish, and smallmouth buffalo, all of which appear to be represented by adequate numbers for sampling. Adult fish will be used, and composites will represent both flesh and whole fish. All samples will be collected quarterly and analyzed for gamma, gross alpha, and gross beta activity. Concentrations of Sr-89 and Sr-90 will be determined on the whole fish and flesh of a smallmouth buffalo only, which will be as nearly equal in size as available. The composite samples will contain approximately the same quantity of flesh from each of the fish. For each composite a subsample of material will be drawn for counting.

(c) Plankton - For radiological analyses, net plankton samples will be collected at five stations by vertical tows with a one-half meter net (pore size, 80 microns). For analytical accuracy, at least 50 grams (wet weight) of material is desirable and collection of such amounts will probably be practical only during the period April through September because of seasonal variability in plankton abundance. Samples will be analyzed for gamma, gross alpha, and gross beta activity, and Sr-89 and Sr-90 content.

(d) Sediment - Sediment samples will be collected from Ponar dredge hauls. Gamma, gross alpha, and gross beta activity, and Sr-89 and Sr-90 content will be determined in samples collected from five stations. Each sample will be a composite obtained by combining equal volumes of sediment from at least three dredge hauls collected at a point from each station.

(e) Aquatic macrophytes - Samples of at least 50 grams (wet weight) of aquatic macrophytes will be collected from both right and left overbanks at each of the three stations. Aquatic macrophytes will be analyzed for gamma, gross alpha, and gross beta activity, and Sr-89 and Sr-90.

(f) Bottom fauna - Asiatic clams will be collected from inplace biomonitoring units at five stations and analyzed for gamma, gross alpha, and gross beta activity. The Sr-89 and Sr-90 content will be determined on the shells only. A 50-gram (wet weight) flesh sample should provide sufficient activity for counting.

(5) Domestic water supplies monitoring - Domestic water supplies, such as small surface streams and wells, will be sampled and analyzed. Well water will be obtained from at least four farms located within 5 miles of the plant, and from one at some greater distance to serve as a control for laboratory analysis. Public water supplies within 10 miles downstream of the plant discharge will be sampled continuously and analyzed monthly for gross beta, tritium, and at least 10 specific gamma-emitting radionuclides.

(6) Quality control - The quality control program now in effect with the Alabama Department of Public Health Radiological Laboratory and the Eastern Environmental Radiation Laboratory, Environmental Protection Agency, Montgomery, Alabama, will be expanded to include samples from Bellefonte Nuclear Plant in order to assure the accuracy of analytical methods. Samples of air, water, milk, vegetation, and soil collected around the plant are forwarded to these laboratories for analysis. Results are exchanged for comparison.

7. Estimated increase in annual environmental radioactivity levels and potential annual radiation doses from principal radionuclides - Environmental radioactivity levels due to releases to unrestricted areas from the Bellefonte Nuclear Plant will be so low that the radiation doses to man will be less than the variations in the natural background radiation dose. However, TVA has calculated the expected increase in radioactivity levels and potential radiation doses to the population as a result of these low-level releases.

(1) Radionuclides in liquid effluents - The following doses are calculated for exposures to radionuclides routinely released in liquid effluents:

1. Doses to man
    a. From the ingestion of water
    b. From the consumption of fish
    c. From water sports
2. Doses to terrestrial vertebrates from the consumption of aquatic plants
3. Doses to aquatic plants, aquatic invertebrates, and fish

The organisms and pathways that are considered in this report are those that are judged to be the most significant because of species, habitat, diet, or patterns of living. Conservative assumptions are applied in these analyses which should result in overestimation of the doses.

Internal doses are calculated using methods outlined by the International Commission on Radiological Protection which describe international retention of radionuclides with a single-exponential model. This model is used for estimating the doses to the bone, G.I. tract, thyroid and total body of man from ingestion of water and consumption of fish and for estimating the doses to terrestrial vertebrates from the consumption of green algae. For calculating the internal doses to aquatic organisms it is assumed that an equilibrium exists between the activity concentrations in the water and those inside the organisms.

External doses are estimated using either an infinite or a semi-infinite, homogeneous-medium approximation depending on whether the organism is considered to be immersed in or floating on the water.

A more detailed discussion of the analytical methods used in calculating these doses and a detailed listing of the results are given in Appendix H.

(2) <u>Radionuclides in gaseous effluents</u> - The following doses to humans living in the vicinity of the Bellefonte Nuclear Plant are calculated for routine releases of radioactive gases:

1. External beta doses
2. External gamma doses
3. Thyroid doses due to inhalation of radioactive iodine
4. Thyroid doses due to concentration of radioactive iodine in milk produced near the site

The external beta and gamma doses to terrestrial plants and animals are considered to be of the same magnitude as the doses estimated for humans.

The gaseous effluents are released from vents located near the top of the plant buildings. Dilution of the gaseous effluents will take place due to diffusion and turbulent mixing as the gases travel downwind from the point of release. The downwind, ground-level concentrations of radionuclides are determined using a sector-averaged diffusion equation and meteorological data estimated for the Bellefonte site.

External beta and gamma doses are computed using semi-infinite cloud, immersion dose models. Iodine inhalation doses are calculated by assuming that these doses are proportional to the ground-level concentration and the receptor breathing rate. Iodine ingestion doses are calculated by assuming that they are proportional to the rate of iodine deposition on pasturage, the concentration of iodine in milk, and the milk consumption rate of the receptor. Studies[1] show that the iodine milk pathway is the principal food chain pathway for halogen and particulate releases.

A more detailed description of the analytical methods used in calculating these doses and a detailed listing of results are given in Appendix I.

(3) Summary of radiological impact - Table 2.4-13 summarizes the radiation doses calculated for releases of radionuclides in gaseous and liquid effluents during normal operation of the Bellefonte Nuclear Plant. The predicted cumulative radiological impact on the Tennessee River from operation of the Watts Bar, Sequoyah, and Bellefonte Nuclear Plants is discussed in Appendix J. The external radiation dose from outside liquid storage tanks is also shown and is discussed in Appendix K.

A comparison of doses resulting from the operation of the Bellefonte Nuclear Plant to those occurring from natural radioactivity assists in placing the doses from Bellefonte in perspective. Near the plant site the average annual dose from naturally occurring external sources of radiation is 125 mrem (Table 2.4-14). An individual receives an additional dose of approximately 20 mrem per year from naturally occurring internal sources. Therefore, the average total dose from natural radioactivity in the vicinity of the Bellefonte plant is approximately 145 mrem per year. Individual doses vary widely around this average value because of local differences in the concentrations of terrestrial radioactivity and because of variations in dose rates within different types of buildings. Large variations are also observed between different areas within the United States because of the dependence of cosmic ray dose rates on altitude and geomagnetic latitude. Due to these variations, the annual total-body doses to individuals in the United States from natural radioactivity range from approximately 110 mrem to 240 mrem.

A hypothetical individual at the site boundary would receive a maximum annual dose of about 2 mrem from the normal operation of the Bellefonte Nuclear Plant. It is assumed that this individual stands in the open at the highest dose point on the site boundary for 24 hours a day, 365 days per year. The maximum dose to the hypothetical individual is about 1 percent of the dose from natural background radiation. The maximum dose to an actual individual should be significantly less than the dose to the hypothetical individual.

The population dose within 50 miles of the Bellefonte site from naturally occurring radioactivity is estimated to be approximately 240,000 man-rem in the year 2020 (Table 2.4-14). The population dose in the year 2020 due to normal operation of the Bellefonte Nuclear Plant is calculated to be 12 man-rem (Table 2.4-13), which is less than 0.005 percent of the dose to the population within 50 miles from natural background radiation. Because population groups beyond 50 miles were considered in dose estimates for radionuclides in liquid effluents the population dose due to operation of the Bellefonte Nuclear Plant is actually less than 0.005 percent of the dose to the same population due to natural background radiation.

TVA has evaluated the potential radiation dose from a broad spectrum of possible pathways of exposure. It should be emphasized that it is possible to theoretically calculate an environmental radioactivity level or potential radiation dose that is minutely small. The dose calculated in this evaluation is only a small fraction of the dose from the natural background radiation and is, in fact, much less than the variations in natural background radiation doses. It is concluded that the Bellefonte Nuclear Plant will operate with no significant risk to the health and safety of the public.

REFERENCE

1. Atomic Energy Commission, Final Environmental Statement Related to the Operation of Oconee Units 1, 2, and 3, Duke Power Company, March 1972.

Table 2.4-1

BELLEFONTE AVERAGE REACTOR COOLANT ACTIVITY

(Based on Table 2.4-3 Assumptions)

Isotope	Average Activity (μCi/gm)
Br-84	0.841×10^{-2}
Br-85	0.111×10^{-2}
Kr-85m	0.444×10^{0}
Kr-85	0.571×10^{-1}
Kr-87	0.260×10^{0}
Kr-88	0.809×10^{0}
Rb-88	0.807×10^{0}
Sr-89	0.9638×10^{-3}
Sr-90	0.281×10^{-4}
Sr-91	0.788×10^{-2}
Sr-92	0.264×10^{-2}
Y-90	0.172×10^{-4}
Y-91	0.528×10^{-3}
Mo-93	0.412×10^{0}
Ru-106	0.373×10^{-1}
Xe-131m	0.128×10^{0}
Xe-133m	0.414×10^{0}
Xe-133	0.248×10^{-2}
Xe-135m	0.203×10^{0}
Xe-135	0.964×10^{0}
I-129	0.936×10^{-8}
I-131	0.730×10^{0}
I-132	0.393×10^{0}
I-133	0.979×10^{0}
I-134	0.122×10^{0}
I-135	0.544×10^{0}
Cs-134	0.392×10^{-1}
Cs-136	0.238×10^{-1}
Cs-137	0.903×10^{-1}
Cs-138	0.217×10^{0}
Ba-137m	0.252×10^{-1}
Ba-139	0.234×10^{-1}
Ba-140	0.126×10^{-2}
La-140	0.435×10^{-3}
Ce-144	0.101×10^{-3}

Table 2.4-2

ESCAPE RATE COEFFICIENT UTILIZED IN ESTIMATING

REACTOR COOLANT ACTIVITY OF THE BELLEFONTE NUCLEAR PLANT

Isotope	Escape Rate Coefficient (sec^{-1})
Kr	6.5×10^{-8}
Xe	6.5×10^{-8}
Bf	1.3×10^{-8}
RB	1.3×10^{-8}
I	1.3×10^{-8}
Cs	1.3×10^{-8}
Mo	2.0×10^{-9}
Te	2.0×10^{-9}
Ru	2.0×10^{-9}
Se	1.0×10^{-9}
Te	1.0×10^{-9}
Sr	1.0×10^{-11}
Ba	1.0×10^{-11}
All Others	1.6×10^{-12}

Table 2.4-3

BASES FOR THE DETERMINATION OF REACTOR COOLANT ACTIVITY

(1) Fuel which represents 0.25 percent of the core power is assumed to be defective.

(2) The activity of the core is determined by way of the model and equation presented in TID-14844.

(3) The activity is based on a load-following operation of both units with daily load swings from 100 percent power to 50 percent power to 100 percent power for the first 254 days of a 292-day equilibrium cycle, and base-loaded thereafter.

(4) A load factor of 84 percent is utilized that includes a refueling outage which results in 1.05 equilibrium cycles per unit per year.

(5) The tritium release is based on the reactor coolant concentration being limited to a maximum of 2.5 μCi/cc (assuming density = 1 gm/cc). The tritium release is essentially all HT and is based on bw equilibrium constant of 2.13 for the reaction $H_2O + HT > HTO + H_2$.

(6) The escape rate coefficients of the isotopes contained in the defective fuel are those presented in Table 2.4-2. These coefficients apply to the total activity of the isotope in the fuel pin (fuel and gap).

Table 2.4-4

RADIOACTIVE WASTE QUANTITIES

Waste Source	Quantity (dual plant), ft^3/yr	Assumptions and Comments
Liquid Wastes		
Tritiated Waste		
Miscellaneous system leakage	5,800	5 gal/h leakage
Sluicing of ion exchange resins	2,800	14 transfers/yr at 200 ft^3 each
Regeneration of deborating demineralizers	18,200	14 regenerations/yr at 1,300 ft^3 each
Sampling and laboratory drains	4,700	20 samples/day at 5 gal/sample
Filter backwash	1,200	20 backwashes/yr at 30 ft^3 each
Subtotal	32,700	All tritiated waste recycled
Nontritiated Waste		
Miscellaneous system leakage	5,800	5 gal/h leakage
Spent fuel cask decontamination	50,000	30 decontaminations/yr at 1,600 ft^3 each
Sample drains	1,100	4 samples/day at 5 gal/sample
Subtotal	56,900	
Chemical Waste		
Laboratory drains	5,800	
Decontamination drains	1,000	500 items at 2 ft^3 each
Subtotal	6,800	
Detergent Wastes		
Laundry drains	28,800	600 gal/day
Shower and sink drains	28,800	20 showers/day at 30 gal each
Subtotal	57,600	
Total Liquid Discharged	121,300	(sum of nontritiated, chemical, and detergent wastes)

Table 2.4-4
(continued)

RADIOACTIVE WASTE QUANTITIES

Waste Source	Quantity (dual plant), ft^3/yr	Assumptions and Comments
Gaseous Wastes		
Reactor coolant degassing		Degas at 30 std cc H_2 per kg water
Startup expansion and dilution	2,700	4 cold startups per fuel cycle
Lifetime shim bleed and transient xenon control	66,000	Daily load swings of 50% through 90% of fuel cycle
End of fuel cycle	4,000	Degas H_2 from reactor coolant before refueling
Start of fuel cycle	1,400	N_2 displaced with H_2 in makeup tank
Pressurizer venting	6,000	Vent once per week (primarily H_2)
System venting following refueling	12,500	N_2 displaced as system refined after refueling
Miscellaneous	1,800	Degas misc liquids such as laboratory samples or system leakage
Total Gaseous Wastes	94,400	
Solid Wastes		
Spent purification and other demineralizer resins	670	Change twice yearly and as required
Spent deborating demineralizer resin	40	Change as required
Evaporator bottoms	1,750	Liquid wastes concentrated to 20 wt % solids
Miscellaneous	900	1-1/2 55-gal drums per week plus 300 ft^3 per refueling period
Total Solid Wastes	3,360	

Table 2.4-5

ESTIMATED AMOUNTS OF RADIOACTIVITY IN LIQUID RELEASES

Origin of Release	Release, Curies/yr
Liquid waste disposal system	0.670(0)*
Processing condensate demineralizer spent regenerants	0.260(0)
Secondary system liquid leakage	0.200(-4)

$^{*}0.670 \times 10^{0}$

Table 2.4-6

ESTIMATED SOURCES OF RADIOACTIVITY RELEASED TO THE ENVIRONMENT DURING ONE YEAR'S OPERATION OF TWO UNITS

Isotope	Liquid Releases (Curies)	Gaseous Releases (Curies)
Br-84	0.1225×10^{-7}	0.9502×10^{-3}
Br-85	0.1086×10^{-8}	0.2058×10^{-7}
Kr-85m	0.0	$0.3332 \times 10^{+2}$
Kr-85	0.0	$0.1559 \times 10^{+4}$
Kr-87	0.0	$0.1275 \times 10^{+2}$
Kr-88	0.0	$0.6021 \times 10^{+2}$
Rb-88	0.7858×10^{-6}	0.5722×10^{-4}
Sr-89	0.8800×10^{-3}	0.1212×10^{-3}
Sr-90	0.9232×10^{-4}	0.3547×10^{-7}
Sr-91	0.2727×10^{-6}	0.1283×10^{-6}
Sr-92	0.4640×10^{-8}	0.4208×10^{-7}
Y-90	0.8194×10^{-5}	0.2863×10^{-9}
Y-91	0.5764×10^{-3}	0.7889×10^{-6}
Mo-99	0.3096×10^{-1}	0.5668×10^{-3}
Ru-106	0.9974×10^{-1}	0.4463×10^{-4}
Xe-131m	0.0	$0.6466 \times 10^{+2}$
Xe-133m	0.0	$0.3301 \times 10^{+2}$
Xe-133	0.0	$0.1924 \times 10^{+4}$
Xe-135m	0.0	$0.9034 \times 10^{+1}$
Xe-135	0.0	$0.7625 \times 10^{+2}$
I-129	0.3080×10^{-7}	0.5500×10^{-8}
I-131	$0.1090 \times 10^{+0}$	0.8845×10^{-1}
I-132	0.6831×10^{-6}	0.4810×10^{-1}
I-133	0.3014×10^{-1}	$0.1143 \times 10^{+0}$
I-134	0.1929×10^{-6}	0.1600×10^{-1}
I-135	0.3200×10^{-4}	0.6202×10^{-1}
Cs-134	$0.1094 \times 10^{+0}$	0.5066×10^{-4}
Cs-136	0.4859×10^{-2}	0.3439×10^{-4}
Cs-137	0.2768×10^{-0}	0.1152×10^{-3}
Cs-138	0.2304×10^{-6}	0.2921×10^{-3}
Ba-137m	$0.2547 \times 10^{+0}$	0.1151×10^{-3}
Ba-139	0.3901×10^{-7}	0.1521×10^{-5}
Ba-140	0.9061×10^{-4}	0.5373×10^{-6}
La-149	0.1980×10^{-3}	0.1217×10^{-6}
Ce-144	0.2487×10^{-3}	0.1694×10^{-8}
Cr-51	0.5828×10^{-3}	0.4987×10^{-7}
Mn-54	0.9741×10^{-4}	0.5739×10^{-8}
Fe-59	0.7817×10^{-4}	0.5737×10^{-8}
Co-58	0.4475×10^{-2}	0.2993×10^{-6}
Co-60	0.2934×10^{-2}	0.1672×10^{-6}
Zr-95	0.5848×10^{-2}	0.3991×10^{-6}
Total	$0.9300 \times 10^{+0}$	$0.3772 \times 10^{+4}$
Tritium	$0.3000 \times 10^{+3}$	$0.3000 \times 10^{+3}$

Table 2.4-7

ESTIMATED AMOUNTS OF RADIOACTIVITY IN GASEOUS RELEASES

Sources	Curies/year Iodine-131	Curies/year Noble Gases*
Containment purge	0.363(-5)	0.303(+2)
Instrument room purge	0.375(-6)	0.714(-1)
Purification and makeup system gases vented to ABVS	0.880(-3)	0.125(+4)
Waste gas decay tank venting	0.420(-3)	0.167(+4)
Steam leakages	0.135(-5)	0.454(-3)
Turbine gland sealing system leakage	0.121(-4)	0.839(-0)
Condenser offgases	0.121(-4)	0.839(+3)
Feedwater leakage	0.204(-8)	0.128(-8)

*Noble gases include: Kr-85m, Kr-85, Kr-87, Kr-88, Xe-131m, Xe-133m, Xe-133, Xe-135m, Xe-135

Table 2.4-8

ESTIMATED ANNUAL GASEOUS RELEASE FROM THE WASTE GAS DECAY TANKS

Isotope	Half-Life	Annual Release, Curies 60-Day Decay	Annual Release, Curies 1-Year Decay
Krypton-85	10.57 y	1,554	1,470
Xenon-131m	12 d	54	1.3×10^{-6}
Xenon-133	5.27 d	64	2.3×10^{-13}
Iodine-129	1.7×10^{7} y	4.4(-9)	4.4×10^{-9}
Iodine-131	8 d	4.2(-4)	1.5×10^{-15}
Strontium-89	53 d	1.2(-4)	2.3×10^{-6}
Cesium-137	37 y	3.7(-6)	3.6×10^{-6}
Tritium	12.33 y	47	45

Table 2.4-9

AIR AND TERRESTRIAL MONITORING

SAMPLING AND ANALYSIS SCHEDULE

Type Sample	Frequency	Mode	Analysis: Gross Beta	Gamma Scan[a]	$Sr^{89,90}$	Total Alpha	^{3}H
Air filter	Weekly	C[b]	x	x			
	Biweekly						x
Charcoal filter	Weekly	C[b]		x			
Rainwater	Monthly	Cp[c]	x	x	x		x
Heavy particle fallout	Monthly	Cp[c]	x				
Soil	Quarterly	Note[d]	x	x			
Vegetation	Quarterly	Note[e]	x	x	x	x	
Pasturage grass	Monthly	Note[e]	x	x	x		
Milk	Monthly	G[f]		x	x		
River water	Monthly	G[f]	x	x	x	x	x
Well water	Monthly	G[f]	x	x			
Public water	Monthly	G[f]	x	x			x
Food crops	Twice each year	Note[e]	x	x	x		

a. The gamma scan will include specific analyses for 13 isotopes.
b. C - continuous collection.
c. Cp - composite sample for period indicated.
d. Soil is collected over a 2-square-foot area 1 inch in depth.
e. Vegetation and food crops are collected such that there are 3.5 liters of sample for analysis after necessary preparation.
f. G - grab sample at time of collection.

Table 2.4-10

TYPES AND LOCATIONS OF BIOLOGICAL SAMPLES COLLECTED FOR PREOPERATIONAL AND OPERATIONAL RAD ANALYSIS IN GUNTERSVILLE RESERVOIR IN RELATION TO THE BELLEFONTE NUCLEAR PLANT

TRM Station	Plankton[a,b]	Benthic Fauna[c]	Aquatic Macrophytes[d]	Sediment	Fish[e]
396.8	2	2	2	2	G/E
392±	2				
to be determined	2	2	2	2	G/E
387.5	2	2	2	2	G/E[f]
380.4	2	2		2	G/E[f]
365.5	2	2		2	

a. Vertical tows.
b. Replicate samples.
c. Replicate samples of Asiatic clam flesh taken from inplace biomonitoring units.
d. Aquatic macrophytes will be collected on both overbanks.
e. G/E - Gill net and/or electroshocker.
f. Alternate site--only one will be chosen after initial field testing.

Table 2.4-11

RESERVOIR WATER SAMPLES COLLECTED TO MONITOR PREOPERATIONAL AND OPERATIONAL RADIOLOGICAL CONDITIONS IN GUNTERSVILLE RESERVIOR IN RELATION TO THE BELLEFONTE NUCLEAR PLANT

TRM Station	Distance from Left Bank (Normal Full Pool Elev.) Feet	Percent	Depths for Water meters
396.8	2,000	71	1
	2,400	86	1, 8
392± [a]	(To be determined)		4, 8
397.5	1,300	34	1, 4, 8
	3,400	88	1
380.4	500	12	1
	2,900	72	1, 9
365.5	4,400	50	1, 11

a. This station will be located 500 feet downstream from the point of release.

Table 2.4-12

RESERVOIR MONITORING RADIOLOGICAL ANALYSES

Type Sample	Analyses[a]
Fish	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90} [b]
Sediment	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90}
Water	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90}, and tritium
Plankton	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90} [c]
Macrophytes	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90}
Benthos	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90} will be determined on shells only

All samples will be collected and analyzed on a quarterly frequency.

a. The activity of 13 gamma-emitting radionuclides will be determined with a multichannel gamma spectrometer. Sr^{89} and Sr^{90} will be determined by appropriate radiochemical techniques.

b. Sr^{89} and Sr^{90} concentrations will be determined on the whole fish and flesh of smallmouth buffalo only, which will be composed of individuals as nearly equal in size as possible. The composite samples will contain an equal quantity (approximately) of flesh from each of the six fish of the species. From each composite a subsample of at least 50 to 100 grams (net weight) will be drawn for counting.

c. Sr^{89} and Sr^{90} will be determined if there is adequate sample. At least 50 grams must be obtained for analytical accuracy. Samples will be collected twice annually during periods of greatest abundance.

Table 2.4-13

SUMMARY OF RADIOLOGICAL IMPACT ON ANNUAL BASIS[a,b]

	Normal Operation	Proposed 10 CFR 50 Appendix I Guides
A. Liquid Effluents		
Activity released	0.93 Ci	10 Ci
Average concentration before dilution in the Tennessee River	1.5 (-8)[c] μCi/Cm^3	2.0 (-8) μCi/cm^3
Maximum human organ doses		
1. bone	2.1 (-2) mrem	5 mrem
2. G.I. tract	1.4 (-2) mrem	5 mrem
3. thyroid	3.3 (-2) mrem	5 mrem
4. skin	1.3 (-2) mrem	5 mrem
5. total body	1.3 (-2) mrem	5 mrem
Human population doses within the Tennessee Valley region		
1. bone	6.6 man-rem	
2. G.I. tract	4.7 man-rem	
3. thyroid	7.4 man-rem	
4. skin	4.2 man-rem	
5. total body	4.2 man-rem	
Maximum dose to terrestrial vertebrates	160 mrad	
Maximum doses to aquatic organisms		
1. plants	8.5 mrad	
2. invertebrates	3.5 mrad suspended 12.0 mrad benthic	
3. fish	0.4 mrad	

a. Table excludes tritium. Doses due to release of tritium in liquid effluents are 3.0 x 10^{-3} mrem and 0.68 man-rem. Doses due to releases of tritium in gaseous effluents are 0.16 mrem and 1.0 man-rem.

b. Releases for two units operating at full power with 0.25 percent failed fuel.

c. 1.5 x 10^{-8}.

Table 2.4-13 (continued)

	Normal Operation	Proposed 10 CFR 50 Appendix I Guides
B. Gaseous Effluents		
I-131 concentration at site boundary	4.4 (-16) $\frac{\mu Ci}{cc}$	1.0 (-15) $\frac{\mu Ci}{cc}$
Maximum individual doses		
1. inhalation at site boundary (thyroid)	1.7 (-2) mrem	5 mrem
2. consumption of milk from nearest dairy farm (thyroid)	4.5 (-2) mrem	5 mrem
3. external exposure at site boundary (β&γ)	1.7 mrem	10 mrem
Population doses within a 50-mile radius		
1. inhalation (thyroid)	4.2 (-2) man-rem	
2. consumption of milk (thyroid)	3.3 (-1) man-rem	
3. external exposure (β&γ)	7.9 man-rem	
C. Direct Gamma Radiation from Liquid Storage Tanks	2.8 (-2) mrem	
D. Maximum Annual Dose to Any Individual[d]	1.7 mrem	
E. Maximum Population Dose[d]	1.2 (+1) man-rem	

d. Skin dose. Thyroid dose is of about the same magnitude as skin dose.

Table 2.4-14

DOSES FROM NATURALLY-OCCURRING BACKGROUND RADIATION

Individual Doses (mrem)

External[a]	125
Internal[b]	20
Total	145 mrem

Population Dose (man-rem)

0.145 rem x 1,650,000[c] people = 240,000 man-rem

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a. Measured by TVA personnel

b. Principles of Radiation Protection. K. Z. Morgan and J. E. Turner, eds. New York: John Wiley and Sons, Inc., 1967, p. 10.

c. Estimated population within a 50-mile radius of the Bellefonte Nuclear Plant in the year 2020.

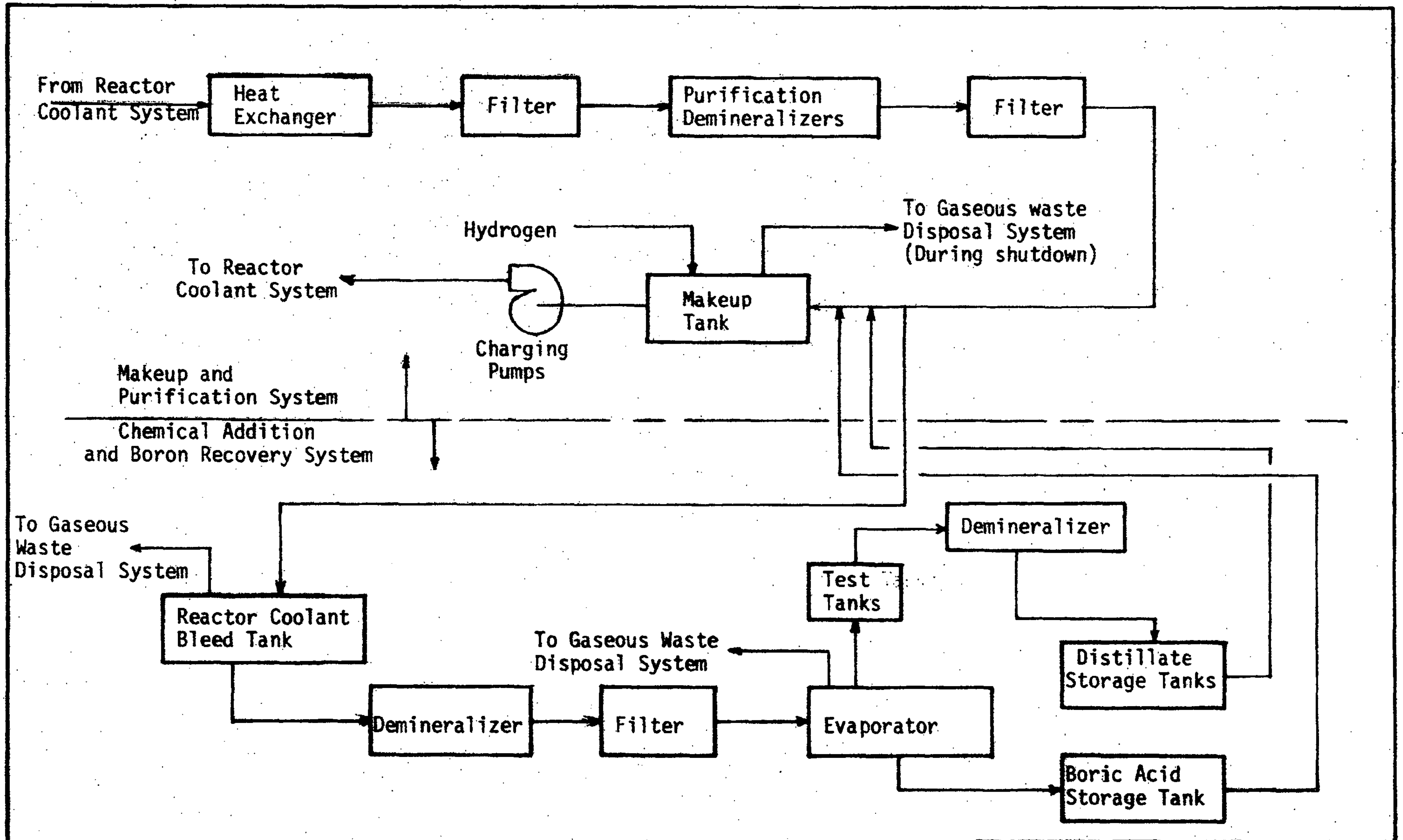

Figure 2.4-1

MAKEUP AND PURIFICATION; CHEMICAL ADDITION AND BORON RECOVERY SYSTEMS

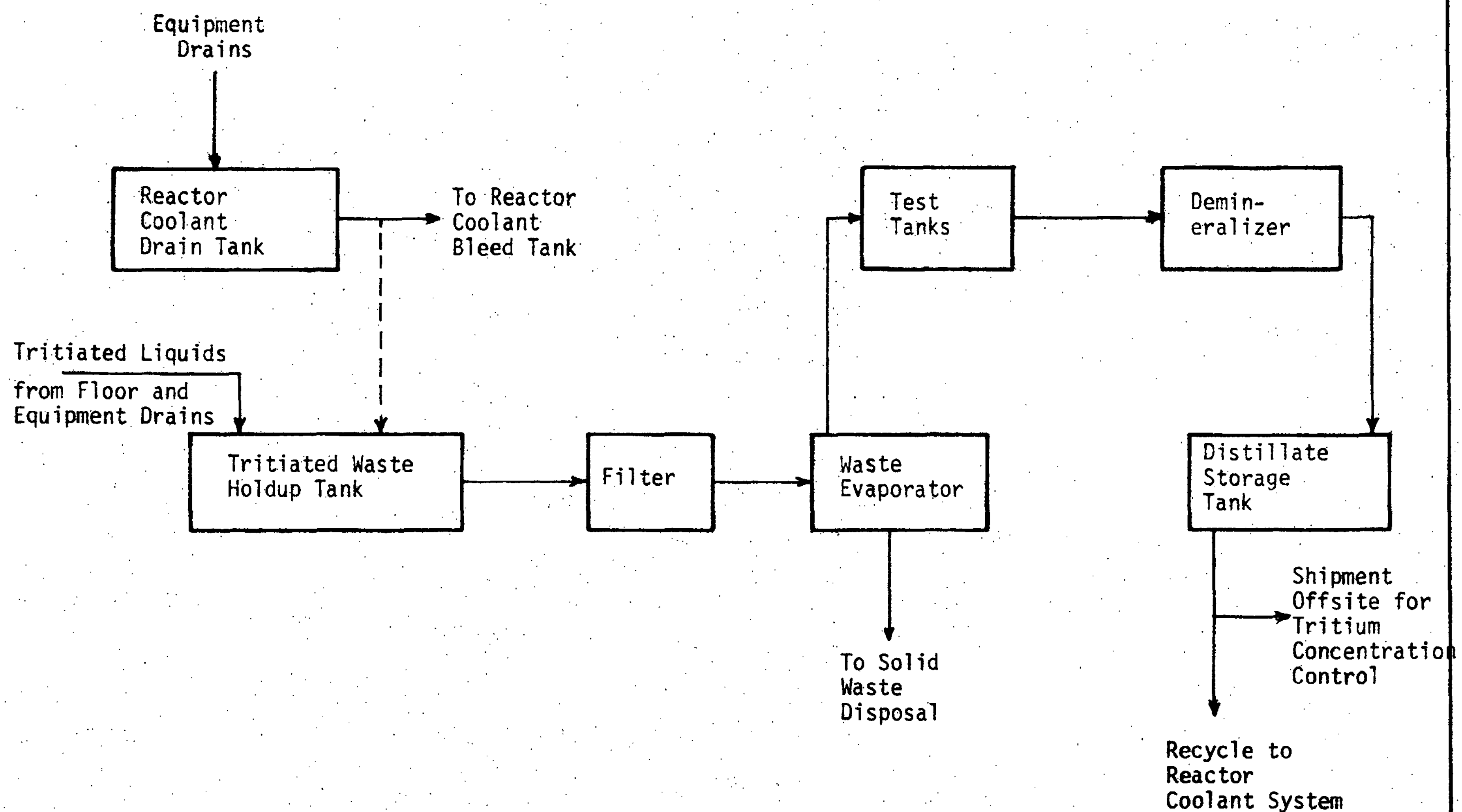

Figure 2.4-2

TRITIATED LIQUID WASTE TREATMENT SYSTEM

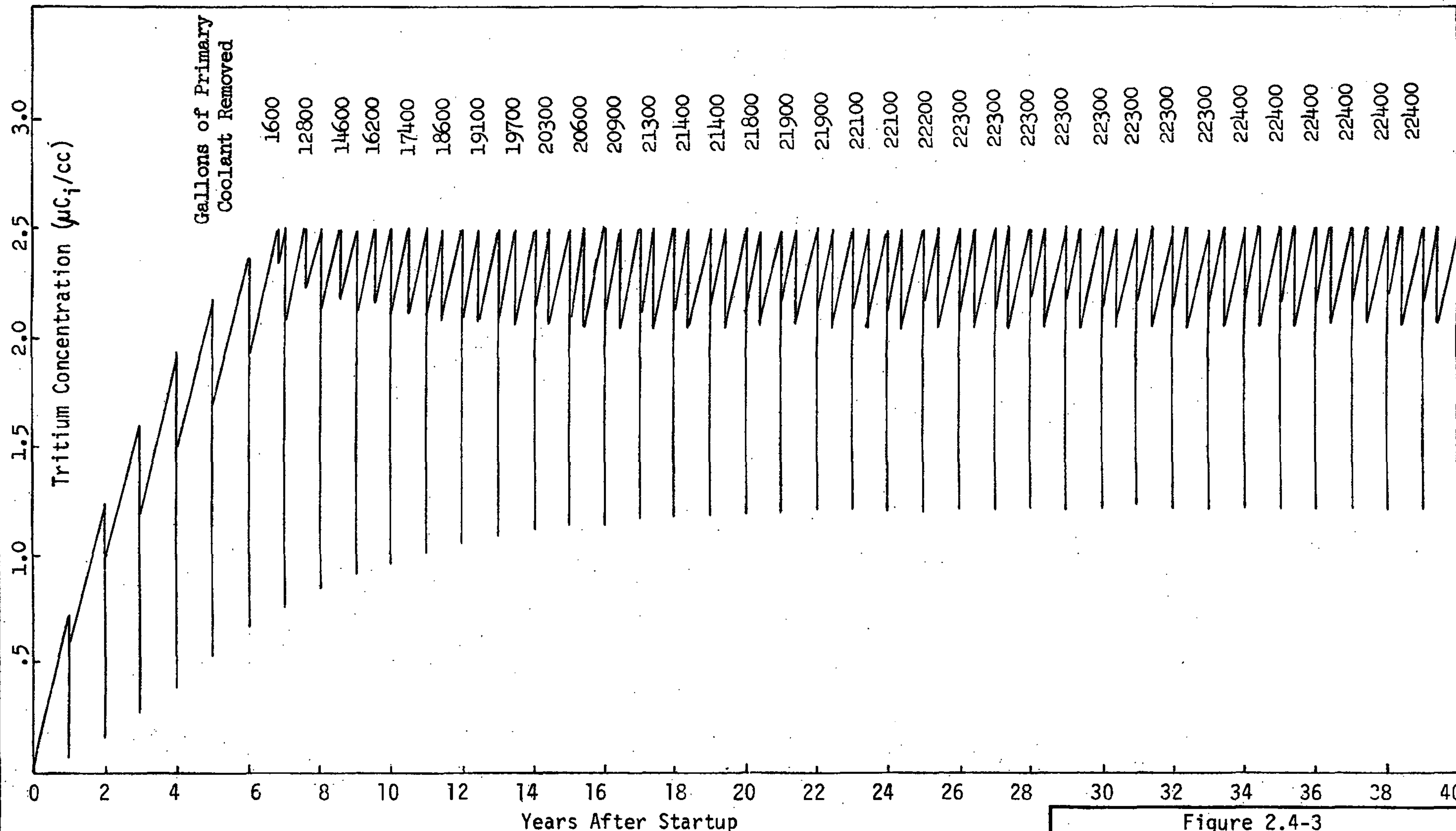

Figure 2.4-3
TRITIUM BUILDUP IN PRIMARY AND REFUELING VOLUMES WITH 2.5 μCi/CC LIMIT IN PRIMARY VOLUME

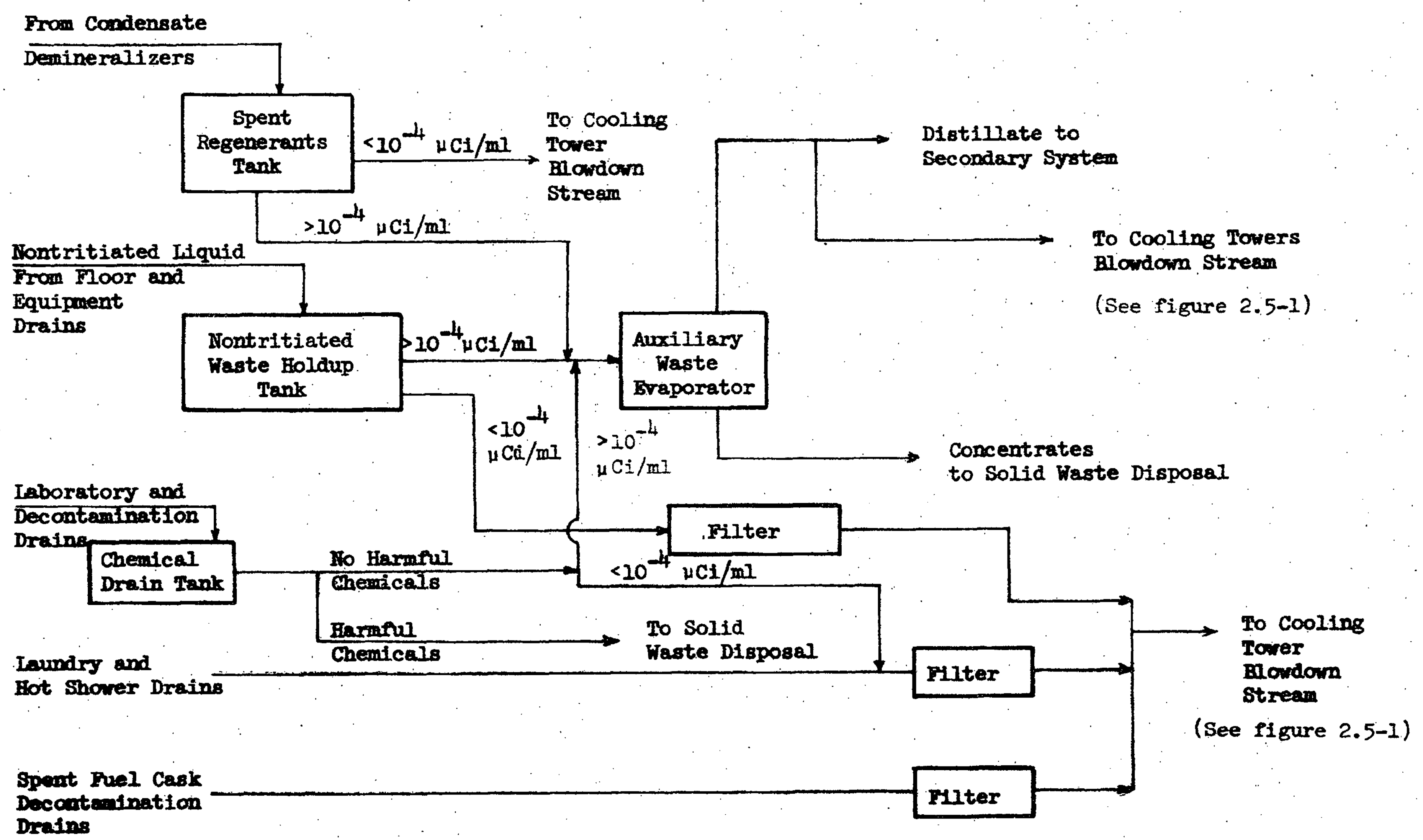

Figure 2.4-4

NONTRITIATED LIQUID WASTE DISPOSAL SYSTEM

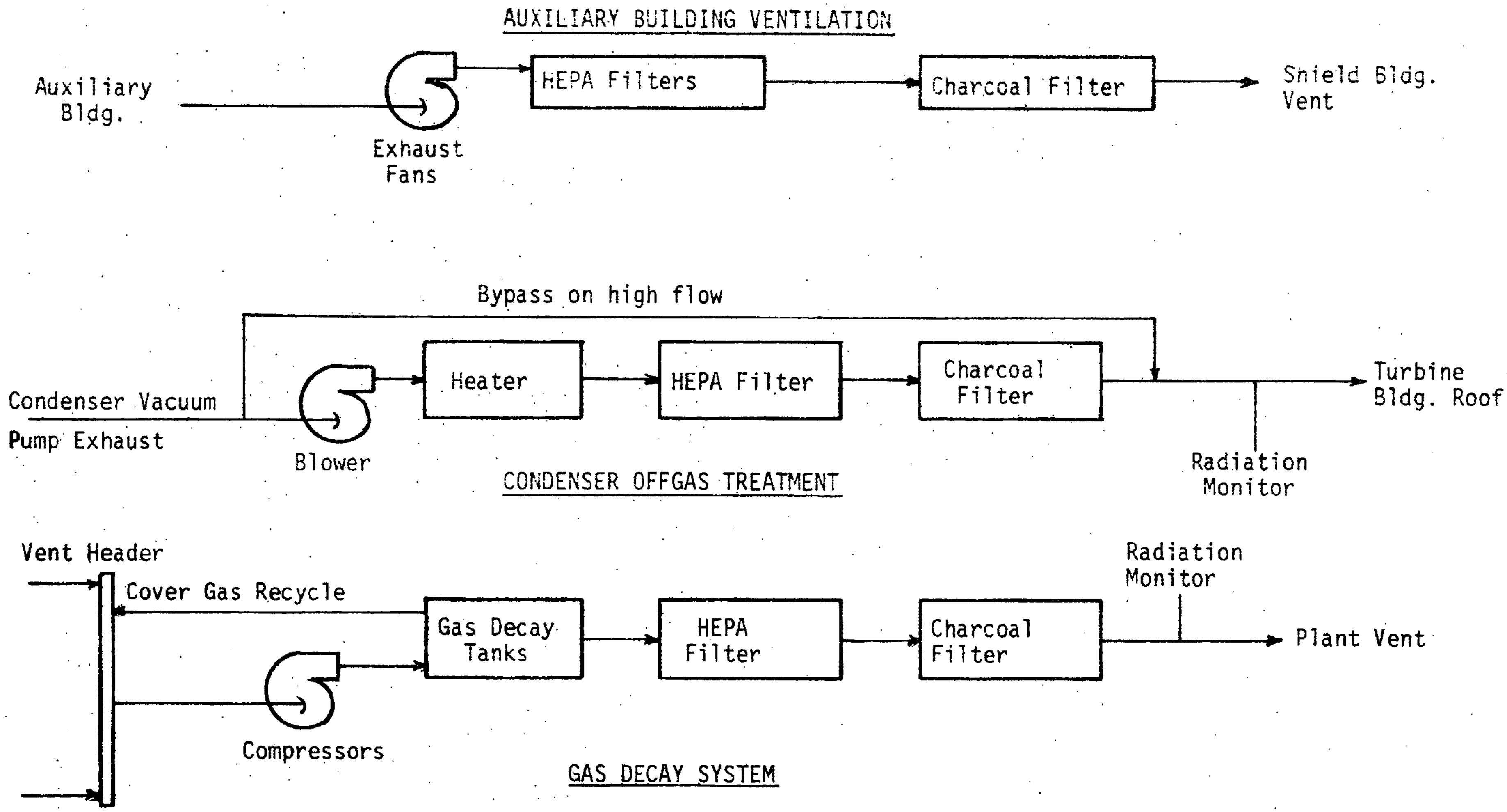

Figure 2.4-5

GASEOUS EXHAUST SYSTEMS

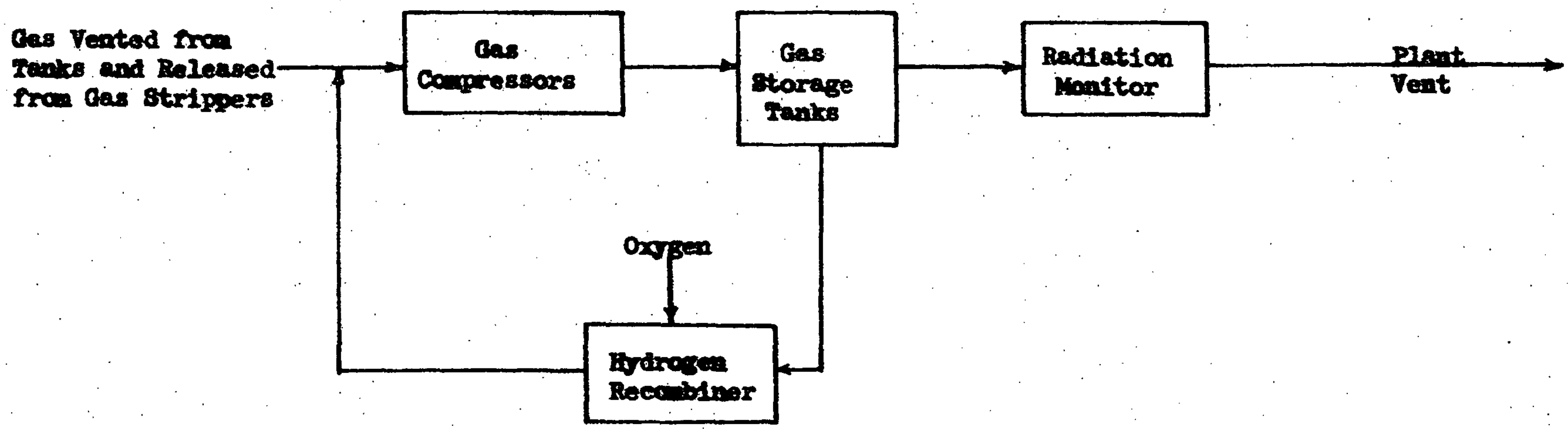

Figure 2.4-6
GASEOUS RADWASTE
ALTERNATIVE 1
ADDITION OF A
HYDROGEN RECOMBINER

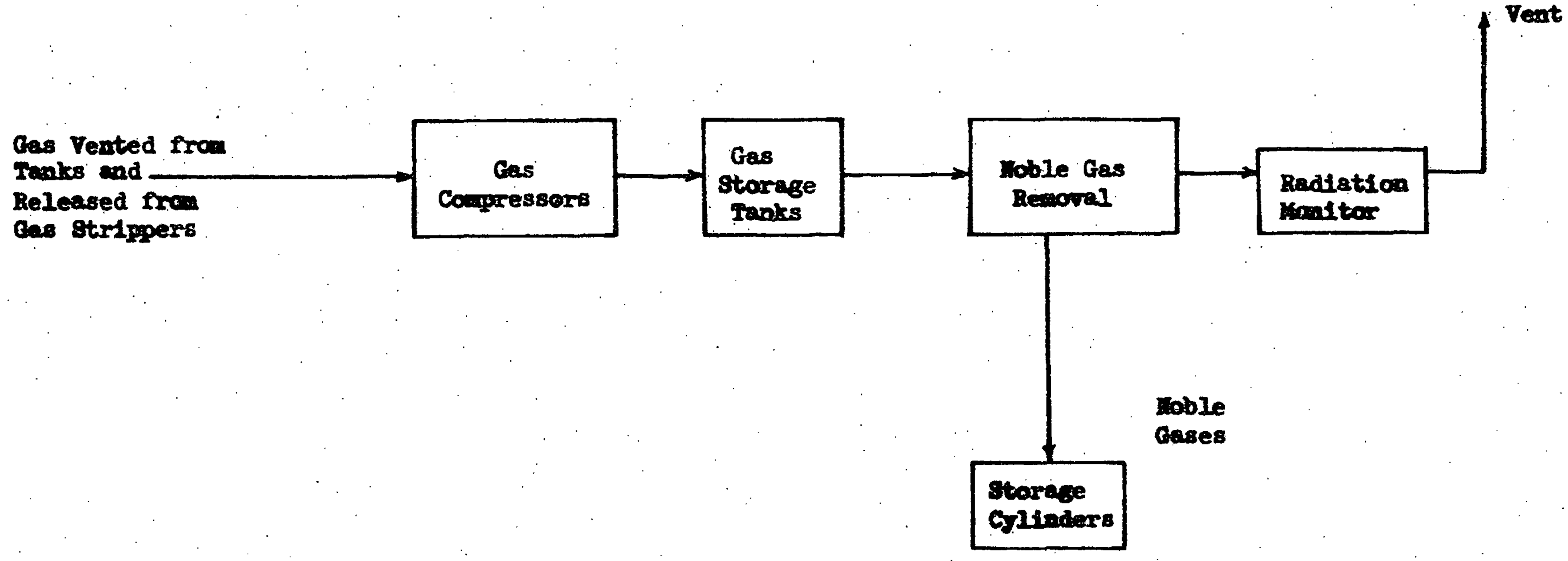

Figure 2.4-7
GASEOUS RADWASTE
ALTERNATIVE 2
ADDITION OF
NOBLE GAS REMOVAL SYSTEM

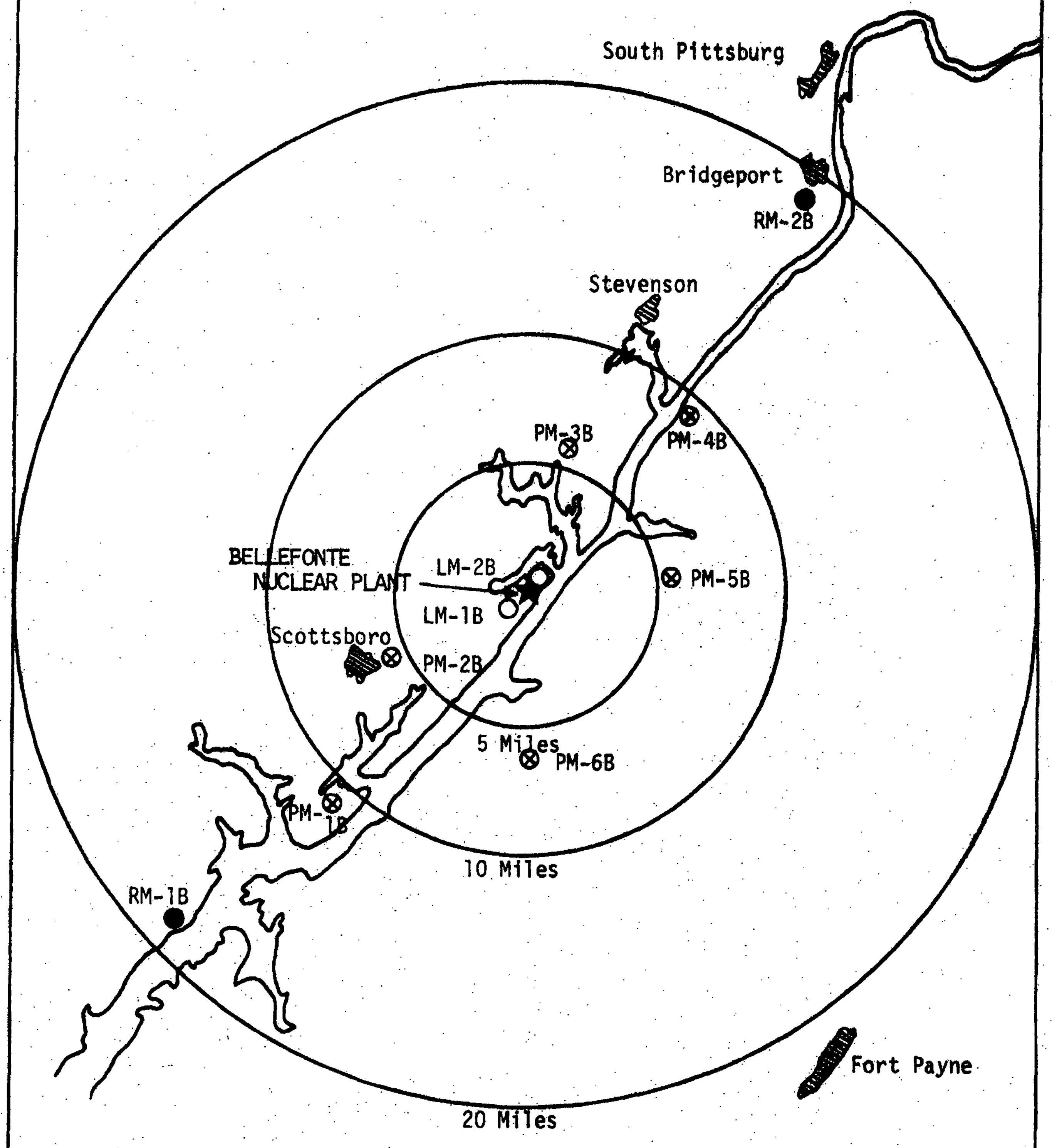

Figure 2.4-8

ATMOSPHERIC AND TERRESTRIAL MONITORING NETWORK

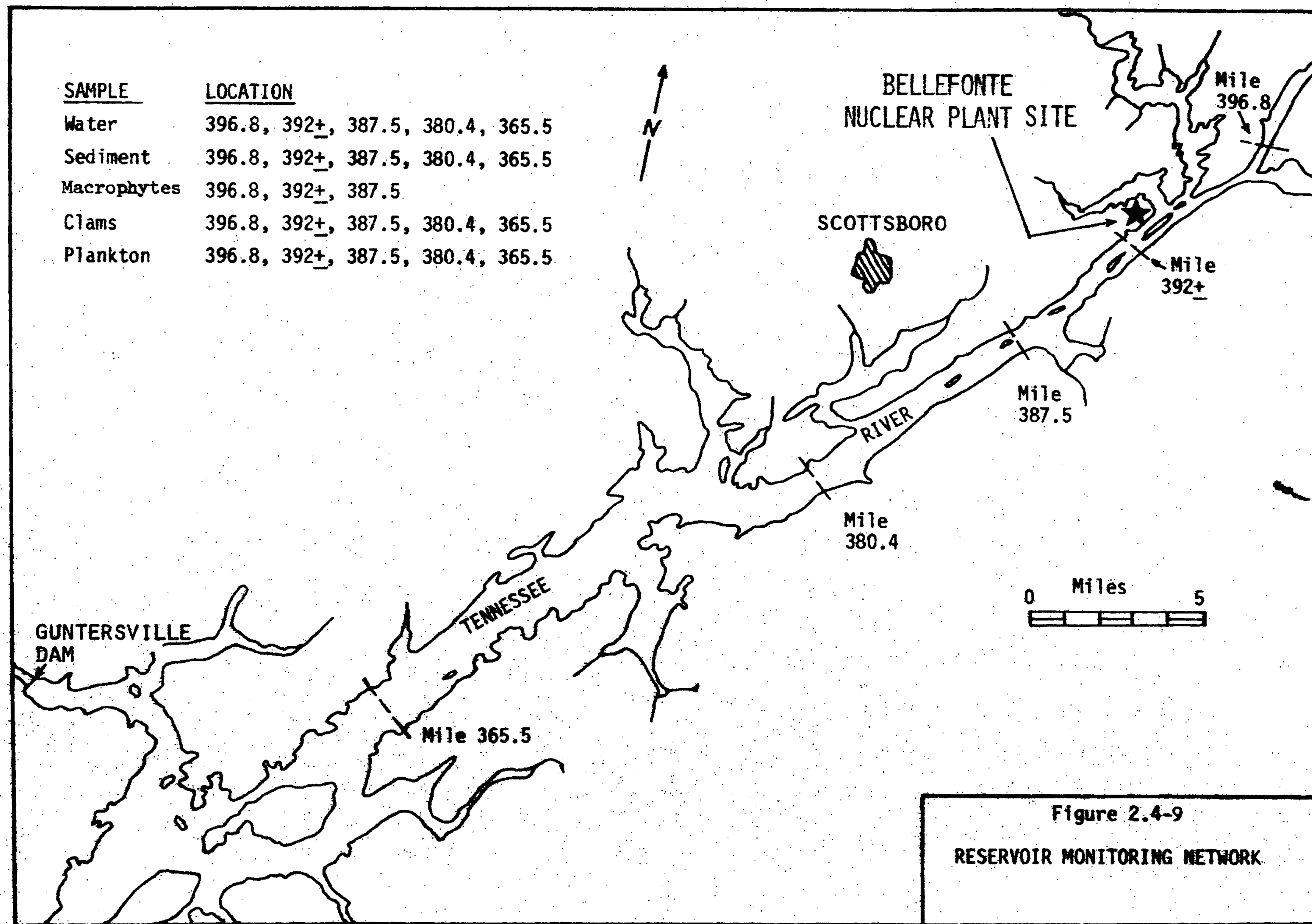

Figure 2.4-9

RESERVOIR MONITORING NETWORK

2.5 Nonradioactive Discharges - It is TVA's policy to keep the discharge of all wastes from its facilities at the lowest practicable level by using the best and highest degree of waste treatment available with existing technology, within reasonable economic limits.

A description of the potential sources and amounts of nonradioactive discharges which have been identified is given in this section, along with a description of the specific treatment of these potential sources.

1. Chemical discharges - The Bellefonte Nuclear Plant chemical discharge system is shown in schematic representation in figure 2.5-1. The sources of these chemicals and the maximum expected quantity of resulting chemical end products that could be discharged are summarized in Table 2.5-1. The proposed blowdown diffuser will be designed to mix the blowdown with 9 equal parts of reservoir water. On this basis the average and maximum expected chemical concentrations in the discharge pipe and in the reservoir after initial jet mixing are shown in Table 2.5-2. The tables were generated using conservative assumptions for chemical usage and solids concentrations in the cooling towers. The computations show that even under adverse conditions and using conservative assumptions, chemical discharges to the environment will be very small.

(1) Cooling tower blowdown and drift - The normal blowdown rate from the cooling towers will be approximately 74 ft^3/s during periods of high evaporation. This will maintain a condenser cooling system solids concentration of about twice the reservoir solids concentration. Blowdown will be returned to the river through a diffuser system designed to (1) provide good diffusion and (2) to minimize environmental impacts due to disturbance of aquatic life during construction and operation of the plant.

As described in Section 2.6, Heat Dissipation, short periods of no flow at the Bellefonte site occur rather often, but the duration of no flow is relatively short. As also discussed in section 2.6, the blowdown diffuser will continue to entrain river water for some portion of this low flow period and cooling tower blowdown will be discontinued when there is insufficient riverflow to provide proper dilution of the blowdown. If the blowdown is discontinued during a 5-hour period, dissolved solids concentrations in the cooling water circuit will rise, but are not expected to exceed three times their reservoir concentrations.

If blowdown is discontinued for about 5 hours, the chemical concentration factor of the cooling system would increase from about 2 to 3. Resumption of blowdown at 74 ft^3/s will gradually reduce the concentration factor back to about 2. The trace metal concentrations calculated to occur in (1) the cooling tower blowdown and (2) in Guntersville Reservoir at the edge of the jet mixing zone are presented in Table 2.5-5. Also shown in the table are the applicable effluent guidelines.

In the trace metal analysis, no distinction has been made of element state or form. For conservatism, all forms are considered as being available to the biota which would not be the case in nature as discriminatory limits are determined by the state or form of the element as presented to an organism. Data on trace metals are limited. Water quality data from EPA for 1962 to 1967 are shown in Table 2.5-5. Data on trace metals in sediment for

1972 are shown in Appendix B as part of the sediment analyses for ecological baseline information on fish and other aquatic life.

These trace metal concentrations, or higher concentrations in the future, are not expected to have more than a local impact that may or may not be reflected in the biota. The degree of impact will depend on the organic content, the suspended solids concentration, and the turbidity of the water. It also depends on the type of sediment the organisms inhabit.

It is anticipated that a biological control method might have to be used at the plant to control growth of fauna or flora in the main condenser cooling system. The selected method of treatment would be injection of chlorine. If chlorine is used, it will be fed for one hour per day to maintain a maximum of 0.5 mg/l residual at the condenser outlet during feed periods.

The National Water Quality Laboratory has stated that intermittent (2 hours per day) discharges not exceeding a concentration of 0.05 mg/l residual chlorine in the receiving water "should not result in significant kills of aquatic organisms nor adversely affect the aquatic ecology."[1] With the diffuser system at Bellefonte, a 9 to 1 dilution will insure that the residual chlorine concentration will not exceed 0.05 mg/l.

Cooling tower drift is not expected to exceed .25 ft^3/s. This amount of drift would result in an average discharge of solids of about 230 lb/d. Essentially all of the drift is expected to fall within 1,000 yards of the towers.[2] No significant environmental impacts will occur since no area outside the plant area would receive significant quantities of drift.

(2) Cooling tower makeup and essential raw cooling water systems - If faunal or floral populations develop in either the condenser cooling system or the essential raw cooling water system a biocide will probably be used. The upstream Widows Creek Steam Plant, however, has had no fouling problems with any biological forms and does not treat its cooling systems. Acrolein, an unsaturated aldehyde, would probably be fed into the cooling tower makeup stream and into the essential raw cooling water system should a problem exist.

The principal organism that creates fouling problems in cooling systems in the Tennessee Valley is the invasion species, *Corbicula manilensis*, the Asiatic clam. Experience at operating plants indicates a maximum annual problem period of about 120 days in the spring and summer when the veliger larvae are in the water. If a problem develops, acrolein will be fed into the cooling tower makeup and into the essential raw cooling water system one-half hour each day to maintain a concentration within the influent streams of approximately 0.2 to 0.3 mg/l during feed periods. The two systems' flows will be added as makeup water to the main condenser cooling system upstream of the condensers.

An acrolein demand of the main condenser cooling water of only 0.1 mg/l in one hour[3] would be sufficient to deplete all the residual acrolein contained in the cooling tower makeup and essential raw cooling systems. Since acrolein is volatile, much of it would also be readily scrubbed from the cooling system water during its first pass through the cooling tower fill.

Considering only dilution, the maximum concentration that would be expected in the main condenser system during periods when acrolein is fed simultaneously to both the cooling tower makeup and essential raw cooling water systems, would be about 0.02 mg/l. This concentration in the cooling tower blowdown discharged through the diffuser would result in an acrolein concentration in the river, at the edge of the jet mixing zone, of 0.002 mg/l. The 96-hour TLM for fathead minnows is reported to be 0.06 mg/l[4]; for juvenile top minnows the 48-hour TLM was 0.24 mg/l[5]. The concentration in the river resulting from dilution alone (within the main condenser cooling system and by the diffuser) is about 3 percent of the lowest 96-hour TLM.

An anticipated acrolein demand in the main condenser cooling water and the probability of acrolein scrubbing in the cooling towers would add to the conservativeness of the described dilution; thus the use of acrolein or an equivalent biocide should have no significant wide area adverse impact on the reservoir.

(3) <u>Water filtration plant</u> - Raw water will be processed through a filtration plant for providing water to the steam systems makeup demineralizers and other plant uses. The plant will have a maximum capacity of 502 gallons per minute for a daily net output of 635,000 gallons. This rate will be utilized only prior to unit startup and at times of unit outage which will be for a period of about 12 weeks annually. Annual operational requirements will be about 40 percent of the maximum capacity.

Operation of the water filtration plant will require the use of alum, soda ash, and chlorine. Chlorine will be fed only to meet the initial raw water demand. The resultant chlorides will be removed by the steam systems makeup demineralizers and will be retained as combined chlorides in the demineralizer regenerant solutions. Filter backwash water and clarifier sludge will contain aluminum hydroxide floc and settled solids. These wastes will be diverted to a settling area which will consist of two basins for use at alternate times for storage and settling. Each basin will be sized for maximum plant output to allow a settling time of 2 days for normal backwash rates and four weeks storage of anticipated sludge. The supernatant water from the lagoon area will be decanted and returned to the inlet of the water filtration plant. As necessary, the sludge will be removed and disposed of by burial in compliance with applicable standards. Burial or landfill is a commonly accepted method of ultimate disposal of waste sludge used by municipal or other industrial plants. All disposal will be done in such a manner that environmental impacts will be minimal.

The addition of a coagulation aid may be necessary for more efficient operation of the filter plant. Any coagulation aid used will be chosen from those approved by the Environmental Protection Agency [6] and will be used in accordance with manufacturer's recommendations. Since a coagulation aid is used to improve the efficiency of the sedimentation, its use should result in less use of alum and soda ash with an overall result of less environmental impact.

(4) Steam systems makeup demineralizers - Two demineralizer trains, each with a capacity of 150 gallons per minute, will be installed for the purpose of supplying demineralized water for primary and secondary steam systems makeup and other minor plant uses such as

equipment decontamination, etc. The two trains will be operated only prior to unit startup and at times of unit outage which will be for a period of about 12 weeks annually. Normal annual operational requirements should be about 25 percent of maximum treatment capability. Based on maximum capacity operation for 12 weeks during refueling and reduced capacity operation for the remaining 40 weeks, the expected annual chemical additives would be approximately 126,200 pounds of sulfuric acid and 103,100 pounds of sodium hydroxide.

Normal procedure for treatment of demineralizer wastes is to hold the acid and caustic wastes in a tank, monitor pH, and adjust pH by addition of acid or caustic as required, and when neutralized the waste is discharged from the plant. At Bellefonte the regeneration waste will be passed through a weak cation-anion exchanger which will neutralize the waste. It will then be collected in a sump and, after pH monitoring and any further pH adjustment required, will be pumped to the cooling tower blowdown stream.

The weak cation-anion exchanger is charged initially with a weakly acidic cation resin which has a negligible salt splitting capacity. The neutral salts present do not consume ion exchange capacity, but pass through the column unchanged. Typical chemical reactions with the weakly acid cation exchanger are as follows:

Reactions with acid:

$$2RNa + H_2SO_4 \rightarrow 2RH + Na_2SO_4$$

Reactions with alkali:

$$RH + NaOH \rightarrow RNa + HOH$$

The unit is self-regenerating as long as the process is in balance.

Backwash for the demineralizer and neutralizer will be diverted to the filter plant backwash settling area.

(5) Main steam system - The main steam system utilizes once-through steam generators. Condensate polishing demineralizers are employed to control secondary system solids concentrations. There will be no steam generator blowdown. Currently it is expected that the condensate polishing demineralizers will utilize an ammonium-form cation resin. Regeneration of the condensate demineralizers will require the use of sulfuric acid, sodium hydroxide, and ammonium hydroxide. Regenerant wastes will normally be given the same treatment as the steam systems makeup demineralizers regeneration wastes. However, during periods of operation with steam generator leaks the condensate demineralizers may be radioactive. Under these circumstances, the condensate demineralizer regeneration wastes will be treated by evaporation and the evaporator distillate recycled for use in the secondary system (See section 2.4). The evaporator bottoms will be treated as solid radwaste.

Only hydrazine and ammonia are expected to be added to the steam generator feedwater. Feed concentrations will be about 15 μg/l hydrazine and 100 μg/l ammonia. (Feedwater pH will be maintained near 9.4 for system corrosion protection.) The only releases of ammonia or hydrazine will be trace amounts by way of the condenser vacuum pump air ejectors. These releases will not constitute a significant environmental impact.

(6) Alternative Treatment of Wastes from Makeup and Condensate Demineralizers - The spent regenerant solutions from the makeup and condensate demineralizers are the source of more than 90 percent of the "added" nonradioactive inorganic chemical wastes which will originate from the plant. The proposed method for disposing of these

wastes is to neutralize the regenerant solutions and then discharge them to the reservoir through the cooling tower blowdown. This is an accepted and widely used method of handling nonradioactive inorganic chemical wastes of this type. The expected chemical concentrations in the cooling tower blowdown and in the reservoir after mixing are summarized in Table 2.5-2. Discharge in this manner will not significantly alter the chemical quality of the river nor have significant environmental impacts that would affect other water uses.

As part of its environmental review, TVA investigated alternative methods of treating these wastes to determine if there were feasible and economically available methods to further reduce the already insignificant environmental impact of the proposed method of treatment and discharge of these wastes. Basically the alternatives considered would treat the spent regenerant solutions from the makeup and/or condensate demineralizers by evaporation. The evaporator distillate would be recycled within the plant and the evaporator bottoms would be disposed of by burial. The alternatives considered would achieve two different levels of reduction in discharges. However, because two different disposal methods were considered for each level of reduction, there were four alternatives considered. The alternatives considered are as follows:

1. The spent makeup demineralizer regenerants, after neutralization, would be released through the cooling tower blowdown in the same manner as the proposed method. The spent condensate demineralizer regenerants would be neutralized then evaporated. The evaporator bottoms would be disposed of with radioactive wastes in a licensed repository.

2. Both the spent makeup and condensate demineralizer regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of with radioactive wastes in a licensed repository.
3. The spent makeup demineralizer regenerants, after neutralization, would be released through the cooling tower blowdown in the same manner as the proposed method. The spent condensate demineralizer regenerants would be neutralized then evaporated. The evaporator bottoms would be disposed of by burial in accordance with applicable standards.
4. Both the spent makeup and condensate demineralizers regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of by burial in accordance with applicable standards.

The performance of alternatives 1 and 3 and of alternatives 2 and 4 are the same in regard to their impact on the aquatic environment. The performance of these two alternative groups are summarized and compared with the proposed method of treating and discharging these wastes in Table 2.5-3. Alternatives 2 and 4 when compared with the proposed method would result in the maximum reduction in discharge of the water quality parameters that would be affected by the implementation of the alternatives. The resulting reductions, in all cases, are less than the variations between the average and maximum concentrations observed to naturally occur at TRM 385.9. When compared with the proposed method of treatment and discharge of these wastes, no beneficial impacts on the aquatic environment can be identified as resulting from the implementation of either of the alternative treatment methods. In addition, there would be increased impacts in other areas; such as land use, transportation, and resource commitments.

The economic costs of adding the treatment alternatives are summarized in Table 2.5-4. These costs include only the costs of evaporator operation, bottoms solidifications (as required), transportation, and burial. No capital costs for evaporators and related equipment were included in these economic evaluations. Assuming all evaporator bottoms to be nonradioactive, then Alternative No. 4 having an added annual cost of about $81,000 is the lowest cost alternative considered that would provide the maximum reduction in the discharge of these wastes. Correspondingly, if all the bottoms were assumed to be radioactive, then Alternative No. 2 having an added annual cost of $342,000 would be the lowest cost alternative. The actual annual cost that would be expected with the implementation of either alternative 2 or 4 would be somewhere between $81,000 and $342,000 depending on the relative portion of the bottoms that would be disposed of as either nonradioactive or radioactive wastes.

Since there are no environmental benefits that can be identified with the addition of either of the alternatives considered, it is concluded that the additional economic costs associated with the implementation of any of the alternatives considered cannot be justified.

(7) Component cooling water system - The cooling water system, used to cool the components of the primary reactor system during reactor shutdown, is closed forming a double barrier between the radioactive primary cooling system and the raw water cooling system. Corrosion inhibitors must be used in this intermediate cooling

system. Tentative plans are to use an amine form inhibitor such as ammonia, morpholine, or cyclohexylamine, The concentration within the component cooling water system is expected to be about 5 ppm ammonia or an equivalent concentration of morpholine or cyclohexylamine. Hydrazine will be used as an oxygen scavenger. Its concentration will be about 5-10 ppm.

When necessary for maintenance purposes, the component cooling water will be drained from portions of the system. If possible, the water will be returned to the component cooling water system. Otherwise, the water will be processed through the radwaste system for recycle or discharge.

(8) Reactor coolant system - Boric acid, lithium hydroxide, and hydrazine will be used in the reactor coolant system. Hydrazine will be used only during startup. Letdown from this system will be processed as tritium-containing waste and recycled for reuse in the plant.

(9) Auxiliary steam generator blowdown - Two 100,000-pound-per-hour oil-fired steam generators will be supplied. One steam generator will operate continuously and one will operate during the heating season and intermittently during the remainder of the year. Hydrazine will be added continuously to the feedwater as a dissolved oxygen scavenger. The hydrazine concentration in the feedwater will be about 10-15 μg/l and within the system is expected to be at less than detectable concentrations. Ammonia will be intermittently added to the feedwater for pH control. Blowdown rate will vary from about 5,000 to about 11,000 gallons per day for both steam generators and will result in an annual discharge of ammonia of only about 33 pounds. The blowdown, which will have a residual ammonia concentration of about

0.3 mg/l, will be discharged to the sewage system subsurface filter dosing tank which discharges to the condenser cooling system makeup supply. Much of the ammonia will be scrubbed from the cooling water in the cooling towers.

(10) Chemical cleaning during construction - Chemical cleaning operations prior to unit startup will be conducted in such a way as to minimize releases to the reservoir and to ensure that any chemicals released have been neutralized and diluted to meet applicable standards. These operations are described in Section 2.7, Construction Effects.

(11) Miscellaneous - Most equipment cleaning and decontamination operations will be performed with high-pressure water and with detergent solutions. A minimum amount of detergent will also be used for laundry and similar uses. These liquids will be treated in the radwaste system by filtration and will be released to the cooling tower blowdown discharge line. Treatment and discharge of these detergent solutions in this manner are not anticipated to result in any significant environmental impacts.

Some decontamination operations will involve the use of chemicals such as sodium phosphate, sodium permanganate, ammonium citrate, alkaline potassium permanganate, and nitric, critic, oxalic, acetic, and hydrofluoric acids. Although the amounts of such chemicals have not been determined at this time, they will not be discharged to the reservoir but will be drained to the chemical tank in the radwaste system. The solutions will be neutralized and either drummed directly or processed by evaporation and the concentrates drummed.

Inputs to the chemical drain tank in the radwaste system will consist of laboratory drains and decontamination wastes. The principal chemical reagents used in the laboratory will include sodium and ammonium hydroxides; hydrochloric, nitric, and sulfuric acids; ammonium acetate; and sodium carbonate.

Before the chemical drain tank is emptied, its contents will be analyzed. If the liquid does not contain chemicals that would be harmful to evaporator equipment (principally, chlorides and sulfides) it will be processed by evaporation. The concentrates will be drummed and the distillate discharged to the reservoir. If the chemical drain tank should contain chemicals that would be harmful to the evaporator, the contents will be drummed without further processing. The contents of the tank will be released to the reservoir only when analysis shows that chemical and/or radioactivity levels are within acceptable limits. It is expected that release would be an infrequent event.

2. Yard drainage system - An area of approximately 10 acres will be diked to provide a yard drainage pond. Any debris or oil which may be spilled and enter the yard drainage system will flow to this pond. A deep-level skimming type outflow will be provided so that floating debris and oil cannot escape from the pond. This material will be periodically removed from the pond for disposal. Depending on the character of the wastes, disposal will be by such methods as reclamation, burial, landfill, or burning. Oil will be reclaimed for reuse when practicable. If not suitable for reuse, it will be drummed and held onsite for later disposal. One possible disposal method under consideration is for fuel in one of TVA's fossil-fueled plants.

3. Transformers and electrical machinery - Some oil leakage may occur from bearings and other parts of certain machinery inside buildings. The oil will be drained to an oil sump that will have adequate capacity to contain all spillage which will be recovered for reclamation or disposal.

In the event of an outside oil spill from the main stepup transformer or insulating oil storage tank, the oil spillage will be routed to the storm drains and then to the drainage pond. At the drainage pond the oil will be recovered for reclamation or disposal.

Diesel fuel oil for auxiliary boilers and lube oil will be stored in tanks in an area which will be depressed below the surrounding ground to form a basin of sufficient capacity to retain the contents of the enclosed tanks. During periods of rainfall, some runoff water may accumulate in the basin. A valved low-level discharge pipe will be provided for periodic removal of precipitation collected within this area and basin contents will be inspected prior to discharge to assure that oil will not be released by this mechanism. The valve will be maintained in a closed position at all other times to provide for retention of oil should the tanks rupture.

In the interest of fire prevention, indoor transformer installations will be either Askarel-filled or dry-type transformers. When the former is used, the transformer will be located within a concrete basin to contain any possible spillage of this liquid. This will isolate this liquid (which contains polychlorinated biphenyls) from the common floor drainage system. Either a separate drain will be provided for routing any spillage to a separate storage sump or else the basin will be made high enough to hold the entire liquid content of the transformer. In either case, spilled liquid will subsequently be drummed for proper disposal if not suitable for reuse. Plans are to return the liquid to the manufacturer for ultimate disposal.

4. <u>Sanitary wastes</u> - Extended aeration sewage treatment facilities will be provided during the construction period to treat the domestic wastes from a peak construction force of approximately 2,500

persons. Effluent from the plant will be chlorinated before discharge to the river. These treatment facilities will be complemented during construction by portable-type chemical toilets for use in isolated or remote areas of the project site. At the end of construction, these initially installed facilities will be removed.

Secondary treatment facilities with provision for chlorination will be provided for the permanent plant. The treatment facility will be designed to handle the sewage load for approximately 300 persons which should be satisfactory for the 170 permanent employees, temporary employees, and visitors. During periods when a large temporary maintenance force is working at the plant, the permanent waste treatment system will be supplemented by portable-type chemical toilets.

Both construction and permanent sewage systems will be operated to prevent untreated effluents from entering the river. The effluent from the permanent plant will be discharged to the cooling tower makeup system. The design will be in accordance with approved sanitation standards applicable to TVA facilities and the waste treatment regulations of the Alabama Water Improvement Commission.

TVA routinely sends plans of its sanitary waste treatment facilities to the appropriate state pollution control organization for their information and files.

5. <u>Gaseous emissions</u> - The oil-fired auxiliary steam generators are expected to burn a total of about 4.8×10^6 gallons per year of No. 2 fuel oil, having a maximum sulfur content of 0.5 percent.

The boilers are each rated at 100,000 lb/h steamflow with an input rating of about 145×10^6 Btu/h.

Emissions resulting from boiler operation were used to calculate the annual average ambient pollutant concentrations. For shorter averaging times (24 hours and less) both units were assumed to operate at full capacity, which results in burning 1,815 gallons/h of fuel.

The following emission rates were used to calculate ambient pollutant concentrations:

Particulates	14.6 lb/h
Sulfur Oxides	14.3 lb/h
Carbon Monoxide	0.073 lb/h
Hydrocarbons	3.68 lb/h
Nitrogen Oxides	251.98 ton/yr

The emission will be released through a stack which is approximately 125 feet above ground level.

Calculated maximum ambient pollutant concentrations resulting from these emissions, together with the applicable ambient standards, are given below.

Pollutant	Averaging Time	Calculated Concentrations	Secondary Ambient Standards
Particulates	24-hour	0.57 ug/m^3	150 ug/m^3
Sulfur Oxides	24-hour	2.23×10^{-4} ppm	0.14 ppm
Carbon Monoxide	1-hour	1.27×10^{-5} ppm	35 ppm
Hydrocarbons	3-hour	7.43×10^{-4} ppm	0.24 ppm
Nitrogen Oxides	1-year	7.13×10^{-5} ppm	0.05 ppm

This evaluation of the emissions from the auxiliary boilers indicates that these emissions will cause a negligible environmental impact.

6. Normal Solid Waste Disposal - The nonradioactive solid waste, including sludge from the water treatment plant filters and demineralizers, generated at Bellefonte Nuclear Plant will be disposed of in a sanitary landfill located on TVA land and operated by TVA in

accordance with EPA guidelines or in a state-approved sanitary landfill on non-TVA land and operated by a municipality, county, or private contractor.

The characteristics of the nonradioactive solid waste generated at this installation will be paper, soft-drink cans, glass, wood, and garbage. The garbage portion will be relatively small in comparison to the quantity of paper present; thus, the moisture content of the solid waste will be low. The sludge from the filter plant and demineralizers will contain aluminum hydroxide which may be toxic to some plants if spread over land; therefore, the sludge will be dewatered, mixed with the other nonradioactive solid waste, and disposed of in a sanitary landfill. It is estimated that the quantity of nonradioactive solid waste will be 30 cubic yards per week plus about an additional 20 cubic yards of sludge per year. EPA's draft guidelines permit the disposal of sludge in a sanitary landfill provided it has been dewatered. The scrap metals (other than cans) will be salvaged and sold. Scrap lumber will be salvaged for reuse and made available to scavengers when it no longer can be used by TVA. Residue from the scavenged scrap lumber will be mixed with the other solid waste for disposal in a sanitary landfill. This system will be used during construction and operation of the completed plant. Used oil will be collected and transported to the nearest fossil-fueled plant for disposal.

Private contractual service for handling solid waste is available and some installations on Guntersville Reservoir are being served by a private contractor. Economics will determine whether TVA or a private contractor operates the collection and disposal systems. Adequate storage facilities, based on a minimum collection frequency of twice a week, will be provided and transport will be in a closed vehicle or container regardless of which method is utilized. The service provided will be continually monitored by TVA to assure conformance to applicable Federal and state regulations.

7. Nonradiological Environmental Monitoring Program - The preoperational environmental monitoring program will be initiated to establish a baseline of biological and water quality conditions in the vicinity of the plant site. As now planned quarterly monitoring will be started about two years prior to scheduled plant operation. The design of the operational monitoring program will be based on results from the preoperational monitoring program and from experience acquired during operation of similar programs at other plant sites.

The proposed biological and water quality monitoring programs are shown in Tables 2.5-6 and 2.5-7 respectively.

Since many of the details of the environmental monitoring programs are closely related to the final plant design, the monitoring programs are necessarily tentative. As details of the final plant design are completed, the respective environmental monitoring programs will be reevaluated and modified as needed to insure adequate environmental monitoring programs. The resulting proposed monitoring programs will be reviewed and coordinated with the appropriate agencies.

REFERENCES FOR SECTION 2.5

1. Water Quality Criteria Recommendations for Residual Chlorine in Receiving Waters for the Protection of Aquatic Life. Letter to Francis T. Mayo from W. A. Brungs. EPA National Water Quality Laboratory, Duluth, Minnesota, dated December 30, 1971.

2. McKelvey, K. K. and Maxey Brooke, The Industrial Cooling Tower. Elsevier Publishing Company, Amsterdam, London, New York, Princeton, 1959 pp. 206.

3. "Biological Control in Cooling Systems - New Developments and Pollution Considerations," Special Report 506 of the Biological Control in Cooling Systems.

4. Butler, P. A. 1965 "Effects of Herbicides on Estuarine Fauna," Proceedings of Southern Weed Conference, 18:576-580.

5. Oberton, A. C. E. and V. T. Stack. 1957 "Biochemical Oxygen Demand of Organic Chemicals," Sewage Industrial Wastes 29 (11): 1267-1272.

6. "Coagulant Aids for Water Treatment," Journal of American Water Works Association, Volume 63, pp. 388-389.

Table 2.5-1

<u>SUMMARY OF "ADDED" CHEMICALS AND RESULTING END PRODUCTS</u>

System	Chemical Treatment Source Chemical	Maximum Annual Use lbs	Waste End Product Chemical	Resulting End Product - lbs Maximum Annual	Mean Daily	Maximum Daily
Steam System Water Filtration Plant[a]	Alum	43,232	$Al(OH)_3$ [b]	9,860	27	60
	$Al_2(SO_4)_3 \cdot 18 H_2O$		SO_4^{--}	18,700	51	110
	Soda Ash Na_2CO_3	15,596	Na^+	6,800	19	42
			Settled Solids[b,c]	21,800	60	151
	Chlorine Cl_2	5,250	OCl^- and Cl^-	5,250	14	30
Steam System Makeup Water Demineralizers[a]	Sulfuric Acid H_2SO_4 (100%)	126,200	SO_4^{--}	123,600	339	1,410
	Sodium Hydroxide NaOH (100%)	103,087	Na^+	59,300	162	1,150
Natural Minerals Removed by Demineralizers[a,c]	Sodium Na^+	2,500	Na^+	2,500	7	28
	Chloride Cl^-	4,810	Cl^-	4,810	13	55
	Sulfate SO_4^{--}	5,760	SO_4^{--}	5,760	16	65
	Total Dissolved Solids	30,900	Total Dissolved Solids	30,900	85	340
Main Steam System Condensate Polishing Demineralizers[d]	Sulfuric Acid H_2SO_4 (100%)	160,000	SO_4^{--}	157,000	430	1,602
	Sodium Hydroxide NaOH (100%)	52,500	Na^+	30,200	83	308
	Ammonia Hydroxide NH_4OH (100%)	33,000	NH_3	17,000	47	173
Main Steam Generator System[d]	Ammonia NH_3 [e]	13,000	NH_3 [f]	13,000	36	36
	Hydrazine H_2NNH_2 [g]	1,900	NH_3 [f]	1,900	5	5
Auxiliary Steam Generator System[d]	Ammonia NH_3 [e]	175	NH_3	175	0.5	0.5
	Hydrazine H_2NNH_2 [g]	26	NH_3	26	0.1	0.1
RCW and ERCW[d]	Acrolein ($CH_2 = CHCHO$) [h]	600	Acrolein	-	-	-
Main Condenser Cooling H_2O [d]	Chlorine (Cl_2) [i]	149,800	OCl^- and Cl^-	149,800	410	410

a. Based on operation at rated capacity 12 weeks per year and less than rated capacity 40 weeks per year.
b. Precipitated material that will make up the water treatment sludge on a dry weight basis.
c. Estimates based on mean water quality data observed at TRM 385.9.
d. Based on 24-hour operation 365 days per year at rated capacity.
e. Ammonia will be added as needed to maintain a pH of approximately 9.4 in the system.
f. Ammonia will be released to the atmosphere through the air vapor outlet.
g. Hydrazine will be added as needed as a "DO" scavenger. Hydrazine assumed to decompose to ammonia.
h. Acrolein will be added to the system for 120 days for one-half hour each day. The acrolein demand of the main condenser water system and cooling tower stripping will prevent acrolein from being discharged to the aquatic environment.
i. Chlorine will be added to maintain a 0.5 mg/l chlorine residual at condenser outlet for one hour each day.

Table 2.5-2

SUMMARY OF "ADDED" INORGANIC CHEMICAL DISCHARGES TO GUNTERSVILLE RESERVOIR

USING THE PROPOSED METHOD OF TREATMENT[a] AND DISCHARGE

BELLEFONTE NUCLEAR PLANT

Waste Product Chemical	Maximum Daily Discharge of Product Chemical - lbs	Maximum Daily Contribution to Cooling Tower Blowdown - mg/l[b]	Observed Chemical Concentrations in Reservoir Water at TRM 385.9 mg/l		Blowdown Concentration Factor[c]	Concentration During Period of Added Chemical Discharge				
						Blowdown[d] mg/l		River After Jet Mixing[e] mg/l		Allowable Concentration in Reservoir[f] mg/l
			Average	Maximum		Average	Maximum	Average	Maximum	
Sulfates (SO_4^{--})	3,187	47.9	17.7	23.0	2	83.3	93.9	24.3	30.1	250
					3	101.0	116.9	26.0	32.4	
Sodium (Na^+)	1,528	23.0	7.7	12.4	2	38.4	47.8	10.8	15.9	g
					3	46.1	60.2	11.5	17.2	
Chlorides[h] (Cl^-)	495	7.4	14.8	22.0	2	37.0	51.4	17.0	24.9	250
					3	51.8	73.4	18.5	27.1	
Ammonia[i] (NH_3)	0.6	.009	0.026	0.09	2	.061	.189	.031	0.10	g
					3	.087	.279	.032	0.11	
Total Dissolved Solids	5,402	81.1	95.0	140.0	2	271.1	361.1	112.6	162.1	500
					3	366.1	501.1	122.1	176.1	

a. Assume all maximum daily waste streams are retained in a holding tank and discharged within a 4-hour period each day. The makeup demineralizer spent regenerants and condensate demineralizer spent regenerants will be retained in separate tanks. However, when discharged to blowdown, the tanks could be emptied simultaneously. This will constitute the maximum discharge during a specific 4-hour period.

b. Based on maximum daily contributions in blowdown stream for a 2-unit plant with a 74 ft^3/s continuous blowdown rate.

c. Normal blowdown concentration factor = 2; blowdown concentration factor = 3 following periods when blowdown was discontinued.

d. Based on concentrations occurring only when the cooling tower blowdown is being released.

e. Assumes jet mixing diffuser will be provided to mix 9 volumes reservoir water with one volume of blowdown.

f. Alabama Water Improvement Commission, Water Quality Criteria for Waters of Alabama, July 17, 1972. Note: TVA code requires observance of 150 mg/l for SO_4^{--} instead of the given 250 mg/l

g. No specific standard has been identified, but contribution to dissolved solids is included.

h. Computation is for chlorides.

i. Ammonia and hydrazine added to the auxiliary steam system for pH control and dissolved oxygen control, respectively. Hydrazine assumed to decompose to ammonia.

Table 2.5-3

PERFORMANCE SUMMARY OF ALTERNATIVES FOR THE TREATMENT OF "ADDED" INORGANIC CHEMICAL WASTES AND COMPARISON WITH THE PROPOSED METHOD

				Alternates 1 and 3[a]							Alternates 2 and 4[b]						
	Observed Chemical Concentrations in Reservoir Water at TRM 385.9 mg/l				Total Chemical Concentrations During Periods of Chemical Release				Reduction in Concentration as Compared to Proposed Method[d]			Total Chemical Concentrations During Periods of Chemical Release				Reduction in Concentration as Compared to Proposed Method[d]	
					Blowdown mg/l		River After[c] Jet Mixing mg/l					Blowdown mg/l		River After[c] Jet Mixing mg/l			
Parameter	Average	Maximum	Blowdown Concentration Factor	Maximum Daily Contribution to Cooling Tower Blowdown mg/l	Average	Maximum	Average	Maximum	Blowdown mg/l	River After[c] Jet Mixing mg/l	Maximum Daily Contribution to Cooling Tower Blowdown mg/l	Average	Maximum	Average	Maximum	Blowdown mg/l	River After[c] Jet Mixing mg/l
Sulfates SO_4^{--}	17.7	23.0	2 3	23.8	59.2 76.9	69.8 92.8	21.9 23.6	27.7 30.0	24.1	2.4	0	35.4 53.1	46.0 69.0	19.5 21.2	25.3 27.6	47.9	4.8
Sodium Na^+	7.7	12.4	2 3	18.4	33.8 41.5	43.2 55.6	10.3 11.0	15.4 16.7	4.6	0.5	0	15.4 23.1	24.8 37.2	8.5 9.2	13.6 14.9	23.0	2.3
Chlorides Cl^-, OCl^-	14.8	22.0	2 3	7.4	37.0 51.8	51.4 73.4	17.0 18.5	24.9 27.1	0	0	6.1	35.7 50.5	50.1 72.1	16.9 18.4	24.8 27.0	1.3	0.1
Ammonia NH_4	0.026	0.09	2 3	.009	.061 .087	.189 .279	.031 .032	0.10 0.11	0	0	.009	.061 .087	.189 .279	.031 .032	0.10 0.11	0	0
Total Dissolved Solids	95	140	2 3	52.4	242.4 337.4	332.4 472.4	109.7 119.2	159.2 173.2	28.7	2.9	6.1	196.1 291.1	286.1 426.1	105.1 114.6	154.6 168.6	75	7.5

a. Neutralization and discharge of spent makeup demineralizer wastes on the same manner as the proposed method with evaporation of the condensate demineralizer spent regenerant wastes.
b. Neutralization and evaporation of both the makeup and condensate demineralizer spent regenerant wastes.
c. Assumes jet diffuser will be designed to mix nine volumes of river water with one volume of blowdown.
d. Reduction for average and maximum reservoir conditions are the same.

Table 2.5-4

SUMMARY OF ADDITIONAL AVERAGE ANNUAL COSTS OF ALTERNATIVE METHODS OF TREATING INORGANIC CHEMICAL DISCHARGES AS COMPARED TO THE PROPOSED METHOD

	Additional Annual[a] Cost
Proposed System Neutralization of spent makeup and condensate polishing demineralizer wastes followed by discharge to the cooling tower blowdown.	Base
Alternative No. 1 The spent makeup demineralizer regenerants, after neturalization, would be released through the cooling tower blowdown in the same manner as the proposed method. The spent condensate demineralizer regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of with radioactive wastes in a licensed repository.	$197,000
Alternative No. 2 Both the spent makeup and condensate demineralizer regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of with radioactive wastes in a licensed repository.	$342,000
Alternative No. 3 The spent makeup demineralizer regenerants, after neutralization, would be released through the cooling towers blowdown in the same manner as the proposed method. The spent condensate demineralizer regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of by burial in accordance with applicable standards.	$ 50,000
Alternative No. 4 Both the spent makeup and condensate demineralizers regenerants would be neutralized, then evaporated. The evaporator bottoms would be disposed of by burial in accordance with applicable standards.	$ 81,000

a. Includes evaporator operation, bottoms solidification (as required), transportation, and burial. Does not include capital cost of evaporators and related equipment.

Table 2.5-5

SUMMARY OF OBSERVED TRACE METAL CONCENTRATIONS AND EXPECTED MAXIMUM TRACE METAL CONCENTRATIONS

IN THE DISCHARGE STREAM AND AT THE EDGE OF THE JET MIXING ZONE

BELLEFONTE NUCLEAR PLANT

Parameter (Dissolved)	Number of Times Observed in Nine Samples[a]	Statistics for Observed Values[a] ug/l Minimum	Maximum	Mean	Concentration Factor[b]	Maximum Expected Trace Metal Concentrations Closed-Cycle Cooling Operation[c] ug/l In Blowdown	Edge of Jet Mixing Zone[d]	Effluent Guidelines[e] ug/l	
Zinc	5	6	23	12	2	46	25.3	800	(Zn)
					3	69	27.6		
Boron	9	7	45	24	2	90	49.5		
					3	135	54.0		
Iron	9	4	52	21	2	104	57.2	3,000	(Fe)
					3	156	62.4		
Manganese	3	0.6	1.9	1.4	2	3.8	2.1		
					3	5.7	2.3		
Copper	9	2	9	4	2	18	9.9	500	(Cu)
					3	27	10.8		
Barium	9	11	36	24	2	72	39.6		
					3	108	43.2		
Strontium	9	20	118	54	2	236	129.8		
					3	354	141.6		
Aluminum	6	16	53	28	2	106	58.3		
					3	159	63.6		
Chromium	3	3	13	6	2	26	14.3	500	(Cr)
					3	39	15.6		
Lead	2	11	14	12.5	2	28	15.4		
					3	42	16.8		
Molybdenum	1	12	12	12	2	24	13.2		
					3	36	14.4		
Cadmium[f]	0	-	-	-				<100	(Cd)
Arsenic[f]	0	-	-	-					
Beryllium[f]	0	-	-	-					
Silver[f]	0	-	-	-					
Nickel[f]	0	-	-	-				500	(Ni)

a. From Trace Metals in Waters of the United States: A Five Year Summary of Trace Metals in Rivers and Lakes of the United States, (October 1, 1962 through September 30, 1967), U.S. Department of the Interior, FWPCA, Division of Pollution Surveillance, Cincinnati, Ohio. Weekly samples were composited for 3-month periods twice a year during the period. Data collected at Widows Creek Steam Plant TRM 408.

b. Normal blowdown concentration factor = 2; blowdown concentration factor = 3 when blowdown is resumed following periods when blowdown had been discontinued for up to 5 hours because of low streamflows.

c. Assumes maximum observed concentrations occur.

d. Assumes jet diffuser will be designed to mix nine volumes of river water with one volume of blowdown.

e. Alabama Water Improvement Commission, Tentative Guidelines for Heavy Metal Effluent Limitations, received by letter, October 30, 1972.

f. Not detected in any sample.

Table 2.5-6

TYPES AND LOCATIONS OF BIOLOGICAL SAMPLES COLLECTED QUARTERLY TO MONITOR NON-RADIOLOGICAL PREOPERATIONAL AND OPERATIONAL CONDITIONS IN GUNTERSVILLE RESERVOIR IN RELATION TO THE BELLEFONTE NUCLEAR PLANT

TRM Station	Sample Location[a]	Depths for Zooplankton, Chlorophyll a and Phytoplankton (Random, Replicate Composite Samples)	Depths for Productivity[b]	Benthic Fauna-Grabs	Benthic Fauna - Artificial Substrates	Periphyton Substrate
		(meters)	(meters)	(number)	(number)	(number)
396.8	R-L	0, 3, 5	0, 1, 3, 5	10	3	2
392± to be determined	R-L	0, 3, 5	0, 1, 3, 5	10	3	2
387.5	R-L	0, 3, 5	0, 1, 3, 5	10	3	2
380.4	R-L	0, 3, 5	0, 1, 3, 5	10	3	2
365.5	R-L	0, 3, 5	0, 1, 3, 5	10	3	2

a. R-L - Area 0.1 mile either side of TRM designation and from the extreme right overbank to the extreme left of main channel. Samples will be from a quadrant in this area selected randomly for each quarterly sampling.
b. Location of lower depths depends on depth of the photic zone.

Table 2.5-7

TYPES AND LOCATIONS OF WATER SAMPLES COLLECTED TO MONITOR PREOPERATIONAL AND OPERATIONAL CONDITIONS IN GUNTERSVILLE RESERVOIR IN RELATION TO THE BELLEFONTE NUCLEAR PLANT

TRM Station	Distance From Left Bank (Normal Full Pool Elev.)		Depths for Water[1]
	feet	percent	meters
396.8	2,000	71	1, 4, 8
	2,400	86	(1)*, 4, (8)
392±[2]	(to be determined)		1, 4, 8*
387.5	300	8	1
	1,300	34	(1)*, 4, (8)
	3,400	88	1
380.4	500	12	1, 4
	2,900	72	1*, 4, 9
365.5	2,600	30	1, 4
	4,400	50	1*, 4, 11

1. Temperature observed throughout each vertical to limit differences between successive observations to 2° F. Dissolved oxygen measured at all depths listed, additional samples collected if an appreciable change is found.

2. This station will be located 500 feet downstream from the point of release.

( ) Indicates location at which samples are to be collected for analysis of a larger series of selected parameters.

* Indicates samples for analysis of metals (iron, copper, zinc, nickel, and chromium).

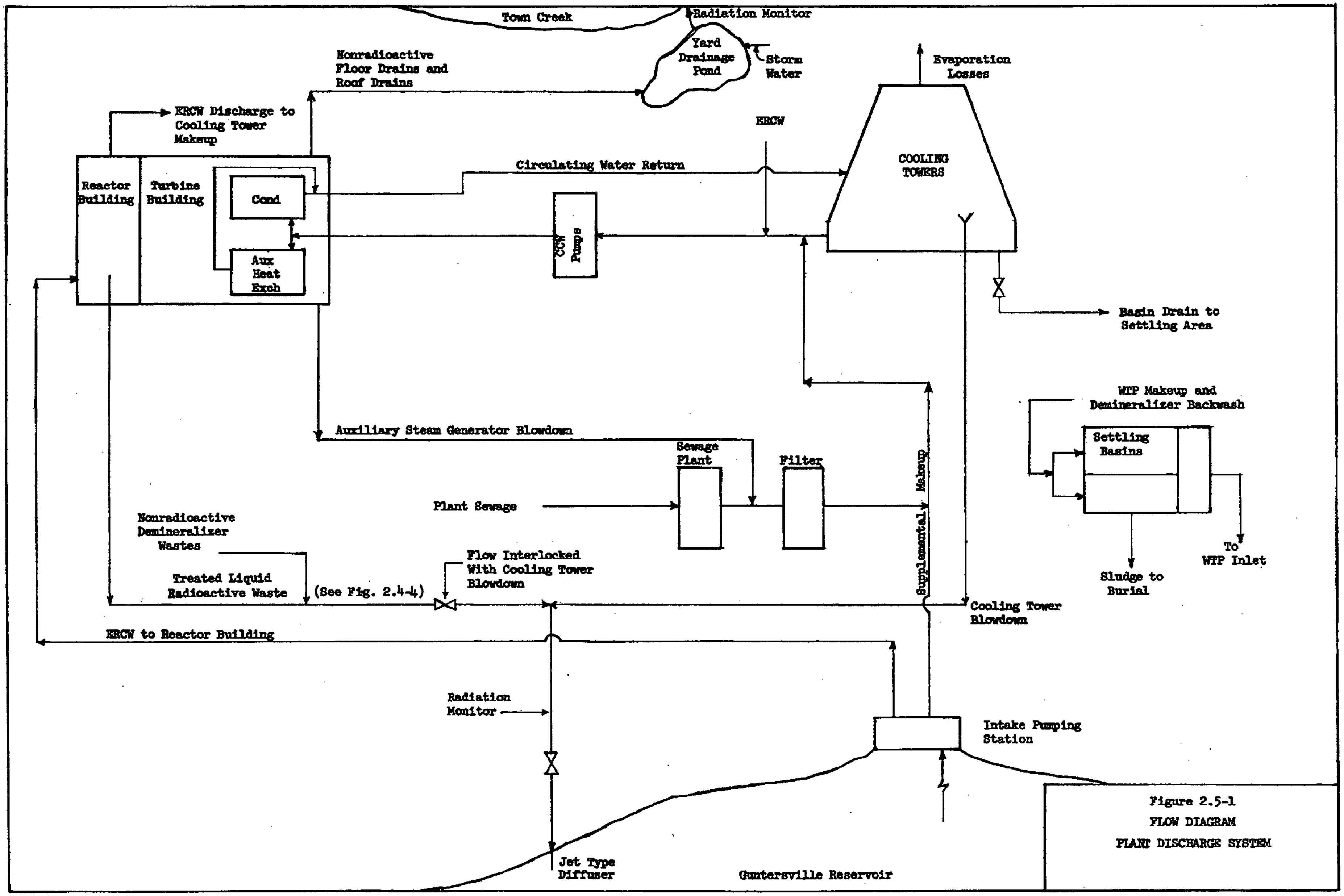

Figure 2.5-1
FLOW DIAGRAM
PLANT DISCHARGE SYSTEM

2.6 Heat Dissipation - All steam-electric generating plants must release heat to the environment. A portion of the thermal energy produced in the reactor will be converted to electrical energy through the turbine and generator, while the remainder is absorbed by cooling water flowing through the condenser. In the current state of technological development in nuclear plants, approximately two-thirds of the heat produced in the reactor is released to the environment.

1. Water temperature standards - The applicable water temperature standards within the State of Alabama for the protection of fish and aquatic life are as follows:

> The maximum temperature rise above natural temperatures before the addition of artificial heat shall not exceed 5°F. in streams, lakes, and reservoirs nor shall the maximum water temperature exceed 90°F., except that in the Tennessee River Basin and portions of the Tallapoosa River Basin which have been designated by the Alabama Department of Conservation as supporting smallmouth bass, sauger, and walleye, the temperature shall not exceed 86°F. In lakes and reservoirs, there shall be no withdrawals from or discharge of heated waters to the hypolimnion unless it can be shown that such discharge will be beneficial to water quality. In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained.

These standards were adopted by the Alabama Water Improvement Commission on July 18, 1972, and approved by EPA on September 18, 1972.

2. Thermal regime of Guntersville Reservoir - Guntersville Reservoir exhibits weak thermal stratification during the summer months due primarily to the relatively short detention time within the reservoir and the fact that the power intakes withdraw water from the entire depth of the reservoir. The dissolved oxygen and temperature profiles of Guntersville Reservoir observed in 1963-64 and the dissolved oxygen and temperature observed in the releases from Guntersville Dam

and Hales Bar Dam (replaced in 1967 by Nickajack Dam) for calendar years 1963 and 1964 have been previously discussed in Section 1.2, General Information, and are shown in figures 1.2-9 and 1.2-10, respectively.

Temperature data collected in the tailrace of Guntersville Dam for the period 1960 through 1971 show a maximum temperature of 88.7°F and also show that temperatures exceeding 82°F occurred frequently during the summer months. Similar data collected at Nickajack for the period 1968 through 1971 show a maximum water temperature of 82.4°F. These data show that the outflow temperature from Nickajack (inflow to Guntersville) is slightly cooler than the outflow from Guntersville. The temperatures of the releases from Guntersville and Nickajack Dams are summarized in Table 1.2-15.

3. Description of the cooling system - To meet cooling requirements at Bellefonte Nuclear Plant and at the same time provide environmental protection for the waters of Guntersville Reservoir, TVA proposes to install closed-cycle natural draft hyperbolic cooling towers. This type of condenser cooling water system would enable the plant to operate with a minimum thermal effect on the Tennessee River since the condenser cooling water system will cycle cool water from the cooling towers through the condensers and discharge the warmed water back to the cooling towers in a closed system rather than discharging to the river.

The plant will be designed for two towers which will be approximately 500 feet in diameter and 500 feet high. Figure 2.6-1 shows the tower arrangement. The use of natural draft towers will not require additional land.

For each unit approximately 466,000 gal/min of cooling water from the cooling towers would circulate through the condensers. The temperature of the water flowing through the condensers will be raised by approximately 36°F in removing 7.8×10^9 Btu/h from each unit when operating at normal full load. In the operation of cooling towers a certain portion of the circulating water is continuously lost as a result of evaporation, small leaks, drift, and blowdown. Therefore, makeup water must be continuously added to the system. To provide this makeup, an estimated maximum of 66,600 gal/min, or 148.5 ft^3/s, will be withdrawn at the head of the channel feeding from the Guntersville Reservoir at TRM 392.25. Normally about 26,000 gal/min, or 57.9 ft^3/s, of this withdrawal will supply water for the essential raw cooling water system. This flow, which may be warmed as much as 13°F in passing through the heat exchangers, will be discharged to the cold water channel of the towers, thus supplying a portion of the water required for use as cooling tower makeup. Since the normal flow from the essential raw cooling water system will not meet cooling tower makeup requirements in all cases, which at a maximum are about 148.5 ft^3/s, additional (supplemental) intake pumps will be provided. The raw cooling water for the plant will be taken from and returned to the cooling tower system.

Normal water surface of the Guntersville Reservoir varies between elevations about 595 (summer) and 593 (winter). The water intake pump structure will be located at the end of an intake channel in which the maximum water velocity of the cross section will be less than 0.2 foot per second even for a water surface elevation of

593. The intake structure will have four openings slightly over 8 feet wide and 15 feet high. The top of the opening will be at elevation 572 and the bottom at elevation 557. The maximum velocity of flow will be less than 0.42 foot per second through each of the openings. The openings will be followed by vertical traveling screens which have 3/8-inch opening mesh. The maximum velocities through clean screens are estimated to be about 0.24 foot per second during summer high-water level and about 0.25 foot per second during winter low-water level. All intake water taken from the river will pass through 1/8-inch strainers after passing through the traveling screens.

The intake channel which connects the intake structure to the reservoir will have side slopes 4 feet horizontally to 1 foot vertically with the side slopes intersecting the surface of rock. The distance between the toes of the slopes at the rock surface will be 40 feet. To provide assurance that water will always be available to the essential raw cooling water system, a 20-foot-wide trench will be excavated 20.5 feet below the surface of the rock to connect to the original river channel. The depth of water in the intake channel will vary from 10 to 12 feet measured to the surface of the rock and 30.5 feet to 32.5 feet to the bottom of the trench. The intake structure will be located some 1,200 feet from the existing shoreline (at elevation 595).

An alternative location of the intake structure at the reservoir shoreline is precluded by the requirement for nuclear safety that water be available to the essential raw cooling water system under all conceivable conditions. A location at the reservoir shoreline makes the structure vulnerable to damage from runaway barges resulting from extreme flood conditions with the resultant blockage of the intake openings in the structure.

Normal blowdown from the natural draft towers will be discharged into Guntersville Reservoir at a rate of about 74 ft^3/s. Studies will be made to determine the proper type and the best location for a blowdown diffuser to provide good dilution with the streamflow, consistent with the need to protect the aquatic biota of the reservoir. The temperature of the blowdown will be the same as the cooling tower effluent which will vary with the meteorological conditions. It is now believed that a nozzle-type diffuser will be the best diffuser design for this site and that it can be designed to mix the blowdown with 9 equal parts of reservoir water and thus limit the temperature rise after mixing to less than 5°F. For cost estimating purposes such a design was assumed to consist of an approach pipe approximately 4 feet in diameter. Mixing would be achieved by means of two 2-foot diameter nozzles spaced approximately 50 feet apart and oriented to discharge perpendicular to the reservoir current. The blowdown diffuser will continue to entrain ambient river water even during periods of zero or low flow. The length of time that the blowdown diffuser can operate in these low-flow situations without exceeding a 5°F rise after mixing will depend on the final design of the diffuser.

The diffuser will be designed and located in the stream so as to minimize the disturbance of the aquatic organisms on the bottom of the reservoir, and it will be located to take advantage of flow in the reservoir to provide mixing to reduce the thermal impact.

An exact estimate of the mixing zone for the heated discharge can only be determined after the design of the diffuser is finalized.

Alternatives to the multiple-nozzle jet diffuser include a multiport diffuser, an open pipe with headwall, and a single buoyant jet. The least costly alternative to construct and operate would be the open-end pipe to discharge back to the reservoir. However, the open-pipe discharge and the buoyant jet would not achieve the required degree of mixing to meet the State water quality standards. Thus TVA proposes to use some type of diffuser system for discharging the blowdown to the reservoir.

A multiport diffuser could be designed to achieve the required dilution, but preliminary investigations indicate that there would be no economic or environmental advantage over the jet diffuser.

4. Impact of heat dissipation facilities - After considering several alternative heat dissipation facilities, including once-through cooling, mechanical draft and natural draft cooling towers, spray canal, and a cooling lake (the details of which are discussed in section 2.6.6), TVA proposes to install closed-cycle natural draft hyperbolic cooling towers. This section describes the environmental impacts which are anticipated as a result of installing and operating this system.

(1) Physical and chemical characteristics of the tower effluent - Tower makeup will be taken from the Tennessee River at the plant site. The quantity of makeup will be dependent on (1) the amount of blowdown necessary, (2) the amount of evaporation, and (3) drift and other small losses. The maximum amount of makeup required for operation with natural draft cooling towers is estimated to be about **148.5 ft^3/s.**

Operation of the two natural draft cooling towers of the condenser circulating water system will evaporate approximately 37 ft^3/s of the flow for each tower during periods of high evaporation. Since water is continuously evaporated from the towers, the concentrations of dissolved solids in the circulating water of a closed system will increase. To limit the dissolved solids concentrations and water chemistry changes which would result from chemical additives, a certain amount of blowdown from the towers and makeup to the towers must be provided. The amount of blowdown is dependent on the amount of evaporation, the concentration of dissolved solids in the circulating water, and the water quality standards imposed for the receiving waters. This blowdown will be removed from the tower effluent (cold-water side) and normally will be discharged into Guntersville Reservoir through a diffuser at a rate of 74 ft^3/s. The dissolved solids at TRM 385.9 for 1963-64 averaged approximately 95 mg/l with a peak of 140 mg/l. It is expected that concentrations of dissolved solids in the circulating water system will not normally exceed 2 (see section 2.5.1), and the applicable stream standards for dissolved solids will not be exceeded.

Because the plant site is located between the Nickajack and Guntersville Dams, the flows by the site will depend on the releases TVA schedules from these two projects, the primary influence being the release from Nickajack. All cooling tower blowdown will be stopped when there is insufficient water available to provide dilution of the cooling tower blowdown. Short periods of no flow at the site probably occur rather frequently, as shown by the flow frequency curves for Nickajack and Guntersville Dams (see figures 2.6-2 and 2.6-3). However, the duration of no-flow periods is relatively short, as shown by the following table:

DURATION OF ZERO-FLOW PERIODS
AT NICKAJACK DAM FROM MAY 1968 TO OCTOBER 1971

Duration (hours)	No. of Occurrences from 5/68 to 10/71
1	32
2	27
3	41
4	62
5	90
6	112
7	89
8	57
9	33
10	21
11	6
12	4
13	0
14	1
15	0
16	1

There were no occasions during this period when the duration of no releases was 24 hours or more. These shutdowns were controlled by TVA and were planned operations. After Bellefonte Nuclear Plant becomes operational, the blowdown requirements of Bellefonte Nuclear Plant will be considered before the releases of the hydro project are restricted.

When streamflows are restored following shutdowns, the normal blowdown rate will be resumed. After some period, depending on the length of time blowdown was withheld, the concentrations of solids will return to normal levels.

The temperature of this blowdown water will be approximately 67°F under average winter conditions, 74°F under average fall and spring conditions, and 84°F under average summer conditions. A peak summer condition could produce temperatures near 90°F for a few hours a day on the hottest summer days.

As shown by the data of Table 1.2-15, there will be times when the water temperatures of Guntersville already equal or exceed the maximum temperature standard of 86°F. During such times TVA will operate Bellefonte so as to hold up blowdown to the extent considered practicable. This holdup capability can be used to restrict heated discharges to the periods of the day when wet-bulb temperature is most favorable. This will result in discharges of blowdown at the lowest possible temperature. Nevertheless, there will be very limited times when the reservoir water temperatures are 86°F or more and blowdown will have to be discharged. The quantity of heat will be small and will be well dispersed within the receiving waters by the mixing device.

A detailed thermal monitoring program for the Bellefonte Nuclear Plant will be available at the operating license stage.

The amount of drift is estimated to be approximately 0.01 percent of the circulating waterflow, or about 0.25 ft^3/s total for the two towers.

(2) Local fogging and icing -

(a) General conditions - Potential environmental effects from thermal dissipation alternatives at the Bellefonte Nuclear Plant may include some modification of the local environment by increased frequency of fog formation, increased fog density, reduced visibility, increased precipitation, alteration of ambient moisture content, and icing on nearby surfaces when temperatures are below freezing.

Local atmospheric conditions indicate that dense, naturally occurring fogs (visibility less than 1,000 feet) can be expected about 35 days per year in the vicinity of the Bellefonte Nuclear Plant.

Fogs occurring in the Bellefonte area are mainly radiation and radiation-advection types resulting primarily from nocturnal cooling and subsequent saturation of the air within the lower few hundred feet of the surface. These fogs normally occur during late evening through midmorning hours when weak winds and optimum radiational cooling conditions prevail. On a seasonal basis, heavy natural fogs occur in the Bellefonte area with the highest frequency during late fall through winter and the lowest frequency during late spring through late summer.

(b) Method of analysis - Evaluations of the potential environmental effects from operation of mechanical draft and natural draft cooling towers, spray canal, and cooling lake alternatives were based partly on field observations from August 1, 1970, through August 31, 1971, at the TVA Paradise Steam Plant in Kentucky. During this period one or more of the three natural draft cooling towers at the Paradise plant were in operation on 122 days during all seasons in the year. Observations were made by the resident meteorologist* usually between 0730 and 0900 hours local time. These observations were augmented by data from the Paradise meteorological station, the National Weather Service Upper Air Section (rawinsonde) in Nashville, and the Widows Creek valley and Widows Creek Sand Mountain autometer stations located 19 and 15 miles, respectively, upvalley from the Bellefonte plant site.

Since the length of the visible vapor plumes depends primarily on the moisture content of the ambient air, observed plume lengths at the Paradise Steam Plant were correlated with the absolute humidity deficit determined from the mean ambient dry-bulb and dew-point temperatures of the layer of air in which the plume was observed. Absolute humidity deficit is defined as the amount of moisture a parcel of air can contain at saturation for a specific dry-bulb temperature, minus the actual amount of moisture present. The observed plume lengths and humidity deficits were fitted by least squares to obtain an expression to estimate plume lengths.

The absolute humidity deficit was determined for the vertical layers, 0 to 1,000 feet and 500 to 3,000 feet, and correlated with corresponding mean wind directions to identify the mean meteorological conditions applicable for mechanical draft and

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*On permanent assignment at the Paradise Steam Plant for support of the plant's SO_2 emission limitation program.

natural draft tower operations, respectively. This information, which is based on the 0600 local time Nashville rawinsonde data, was extrapolated to the Bellefonte area and used to estimate plume lengths for the mechanical draft and natural draft towers. Early morning data from the two Widows Creek Steam Plant meteorological stations were used to evaluate the environmental effects of the proposed spray canal and cooling lake. Data from these stations provided surface information for evaluating the environmental effects of low-level moisture additions from the spray canal and cooling lake.

Since the generating capacity of the Bellefonte Nuclear Plant is larger than that of the Paradise Steam Plant, more moisture would be evaporated into the atmosphere at Bellefonte; therefore, it is necessary to adjust the observed Paradise evaporation rates upward. This adjustment of observations resulted in longer vapor plume estimates for the Bellefonte Nuclear Plant heat dissipation alternatives.

This data analysis was used to construct radial graphs illustrating directional frequency, by compass sector, of the expected plume lengths during the early morning hours, 0600-0900 local time, the time of day when the maximum plume lengths are expected. Two graphs were prepared for each heat dissipation method--one for all days regardless of the early morning average ambient temperature and one for those days when the 0600-0900 average ambient temperature was below freezing. The plume length data from which the graphs were drawn were separated by direction into the sixteen 22-1/2-degree compass point sectors. Radial distances on the graphs represent plume lengths up to 5 miles; numbers on the lines dividing the compass sectors represent percentages of days when sometime during the period, 0600-0900 local time, the vapor plume will be equal to or greater than the indicated length. It is emphasized that these numbers represent the percentage of days the plume lengths could reach these distances and do not indicate necessarily whether or not the vapor plume would exist at ground level for a particular alternative. These radial graphs were overlayed on a scaled map showing the highways, population centers, and the terrain elevations for the Bellefonte area.

(c) Effects of natural draft towers - Observations of the natural draft cooling tower plumes at the TVA Paradise Steam Plant indicate that with the average plume rise ranging from 500 to 1,000 feet above the cooling towers, the visible portion of the elevated plumes seldom, if ever, reaches ground level and causes localized surface fogging. However, in the Bellefonte area the nearby Sand Mountain Plateau is approximately 400 feet higher than the natural draft cooling tower. The plateau lies within 1-1/2 to 2-1/2 miles from the plant site in the northeast through south sectors. The radial graph illustrating directional frequency of expected plume lengths, figure 2.6-4, indicates that plumes of sufficient length to reach the plateau will occur as often as 6 percent of the time (22 days per year) in some of these sectors. Subsequently, there may be a fogging potential associated with the roadways on Sand Mountain. The approximate population of this area is 880. Traffic volume data are not available for the county roads of the area where increased fogging could occur. However, Alabama Highway 40 in the south sector could have the plume reach it 1 percent of the time. The 1970 average daily traffic at this point was 2,200 vehicles.

Review of the daily early morning temperatures indicated that freezing temperatures can normally be expected about 70 days during the 5-month period, November through March. As indicated by figure 2.6-5, plumes of sufficient length to reach the nearby Sand Mountain Plateau during potential icing conditions could occur as often as 2 percent of the time (7 days per year) in some of the sectors. Highway 40 in the south sector could have potential icing conditions about 0.5 percent of the time. Observations at the Paradise Steam Plant indicate that light fallout of freezing precipitation from the bottom of the plume should be no problem.

(3) <u>Aesthetics</u> - The hyperbolic form and concrete materials will be compatible with the architecture of the main plant and should not require any special aesthetics treatment.

The natural draft cooling towers being about 500 feet high will most certainly become a landmark on the surrounding terrain. The vapor plumes will create an aesthetic impact on the towns of Pisgah (population, 519), Hollywood (population, 865), and Scottsboro (population, 9,324), as well as for traffic on U.S. Highway 72, which is within 5 miles of the plant in the north-northeast through west-southwest sectors.

(4) <u>Noise</u> - Based on TVA's experience with the three natural draft towers installed at its Paradise Steam Plant, only slight increases in noise levels at the site boundary would be expected from the natural draft towers.

5. Applicability of water quality certification - Under the provisions of Section 401(a)(6) of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), TVA as a Federal agency is not required to obtain the certification of compliance with applicable state water quality standards required by Section 401(a) of that Act. TVA is, however, required by Section 313 to meet state water quality requirements and is subject to Executive Order 11507, "Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities."

The thermal discharge from this plant will not affect the quality of the waters of any other state.

6. Alternative heat dissipation facilities - The following discussion describes the alternative heat dissipation methods and facilities considered by TVA. The methods investigated were: once-through cooling using a large diffuser system, dry cooling towers, mechanical draft cooling towers (wet), natural draft cooling towers (wet), spray canal system, and cooling lake system.

Analyses were performed using the following factors as a basis: feasibility, environmental considerations, and economic considerations. The analyses were carried to the extent required to determine the acceptability of each alternative when considering these factors and the capability of meeting water quality standards.

(1) Once-through cooling - Once-through cooling utilizing a diffuser discharge to the reservoir has been a practical consideration at other plant sites in order to benefit the plant with cooler water for lower turbine backpressure and attendant increased plant capability. Because of the adopted thermal standards

of 5°F rise and 86°F maximum, the completely open system was not considered feasible for this plant. Assuming the heated effluent is mixed with 75 percent of the riverflow, there would have been insufficient flows available in the reservoir to meet thermal standards about 30 percent of the days based on analysis of the daily flows for 1966-71. In a low-flow year with a relatively hot summer, plant generation might have to be curtailed as much as 43 percent of the days to comply with the thermal standards if the plant utilized once-through cooling only. Therefore, the temperature rise after mixing could not meet the criteria a sufficient amount of time to justify the once-through cooling system. Some form of auxiliary cooling with a combined- or closed-cycle system is therefore required to assure that the thermal criteria are complied with and that a reliable source of power is provided.

(2) Dry cooling towers - The use of dry cooling towers for power plants is a relatively recent development in the United States. The largest unit in the United States employing this type of cooling is less than 50 MW. While European units have used dry cooling towers for years, the largest such unit is believed to be less than 250 MW in size.[1]

Dry cooling tower systems for use in heat dissipation for power plants are today being discussed more and more because of the potential environmental advantages this method has over the once-through and the evaporative (wet) or conventional cooling systems. The dry system requires almost no consumptive use of water, and since there is no evaporation of water, there are no vapor plumes, no drift, and therefore no fogging and icing. Losses to the aquatic life from impingement and entrainment are limited to the initial filling of the system and to the occasional replacement for leaks and other losses. There is no cooling tower blowdown, and thermal discharges to surface waters are not required.

The dry cooling tower system which would most likely be used for generating units in the size range now installed in the U.S. is the indirect or Heller system.[2] In this system the cool water coming from the tower is sprayed directly into the turbine exhaust steam in a jet-spray condenser. The water from the condenser is collected and a portion is returned to the boiler in the steam cycle; the remainder circulates in a closed system to the cooling tower to be cooled and again sprayed into the condenser. Since the cooling water and the steam are mixed, the cooling water must be of condensate purity. Both mechanical draft and natural draft towers can be used in the dry system to reject the heat to the ambient air by convection rather than evaporation. This is an inherently less efficient process and requires an extensive heat transfer surface area of metal fin tubing within the tower, which could be either mechanical or natural draft. In this system the temperature of the water leaving the tower can only approach the dry-bulb temperature of air which is invariably higher than the wet-bulb temperature approached by the wet towers.

Because of the high circulating water temperatures, expensive supplemental cooling must be provided for plant auxiliaries.[1] Dry cooling systems dictate severe performance requirements on the turbines which may have to operate over a wide range of backpressures with a maximum of from 10 to 14 inches Hg Absolute compared to a maximum backpressure of conventionally cooled plants of about 5 inches of Hg Abs.[1,3]

Turbine manufacturers have recently indicated it should be feasible to develop 700 to 800 MW turbines with backpressures as high as 15 inches Hg Abs. for delivery by 1976. There are, however, substantial associated problems which would have to be resolved before these turbines can be made available. In a June 28, 1971, Marketing Information Letter the General Electric Company stated:

> Our studies show that there are substantial turbine design challenges associated with the higher than normal exhaust pressure of dry cooling tower applications. These include: possible overheating of the last-stage bucket; possible flutter damage to the last-stage bucket at high exhaust pressures and low loads; possible water damage due to recirculation from the direct condenser; rapid exhaust temperature changes due to load changes which cause cycling thermal stresses; distortion of the exhaust hood and bearing supports; and difficulties in providing adequate clearance control.

Regarding turbines of the size required for large units as are to be installed at Bellefonte, the GE letter said, "We believe it is premature to speculate on the cost or earliest shipment of any nuclear turbine design suitable for operation at exhaust pressures up to 15 inches Hg absolute."

In a followup letter of November 29, 1971, GE offered a turbine for fossil reheat application suitable for operation at exhaust pressures up to 15 inches Hg Abs. The maximum rating for a 4-flow turbine-generator of this design is approximately 750,000 kW. GE announced that they were proceeding with the design and development of this new turbine in order to support shipment by early 1976.

A report, Plant Design Alternatives for Controlling Thermal Discharge, Chemical Effluents, and Intake Entrapment, which was prepared by Sargent & Lundy Engineers and presented at the Atomic Industrial Forum Seminar, January 23, 1973, stated regarding dry towers:

Dry towers are not feasible on large nuclear units at the present time for many reasons. These include engineering problems, condenser problems, lack of experience, and unfavorable economics.

Indications are that progress is being made in the area of power plant design for dry tower application and that more serious consideration will be given in the future to such towers. However, at present TVA believes that dry cooling towers are not a viable alternative heat dissipation method for nuclear units of the size to be installed at Bellefonte.

(3) Alternative systems of operation - Two systems of operation were considered for the several heat dissipation alternatives: (1) closed-cycle system, in which the cooling water is circulated in a closed-loop system, and (2) combined-cycle system, in which the system can be operated in any of three modes as required.

The three modes in which the combined-cycle system can operate are:

1. Open mode. Operates as a once-through system with heat dissipated to the river.
2. Helper or topping mode. Heated condenser water is circulated through a supplemental cooling facility for initial cooling and then discharged to the river.
3. Closed mode. Operates in a closed loop with heat dissipated to atmosphere by, for example, a tower.

The closed-cycle system is adaptable to either mechanical or natural draft cooling towers, cooling lake, or spray canal. The only water discharged to Guntersville Reservoir would be the required blowdown from the cooling system. The closed system would essentially exclude the use of Guntersville Reservoir for heat dissipation but would result in reduction of plant net electrical output and therefore reduced plant efficiency. Figure 2.6-6 shows the schematic arrangement for a closed system.

The combined-cycle system provides the flexibility of using the Guntersville Reservoir for heat dissipation. The open mode would utilize diffusers alone, which increases plant efficiency due to lower condenser cooling water temperature. The helper mode also would allow use of the lower temperature condenser cooling water from the reservoir and would divide the heat dissipation between the reservoir and the heat dissipation device. The combined-cycle system would employ cooling facilities designed for less cooling capability than the facilities selected for a closed system since a closed system requires supplemental cooling 100 percent of the time, and therefore higher cost, more efficient heat dissipation facilities can be justified. Figure 2.6-7 shows the schematic arrangement and operation of the various gates required in the cooling water circuit to accomplish the three modes of combined-cycle operation.

The design of the intake as a skimmer wall for combined-cycle system is not considered feasible because of the shallow water depths at the site and the small temperature difference between the upper and lower layer of water which will exist when meeting the 5°F rise standard. With 2-unit open or helper mode operation and a maximum temperature rise in the reservoir of 5°F, the width of the skimmer wall necessary to withdraw water from a 12-foot-deep lower layer (out of a total depth of 20-25 feet) would be at least 2,000 feet.

The location of the intake would be expected to be on the river bank upstream from the discharge which has been shown by model studies for the Browns Ferry plant to result in negligible intake temperature rise as long as the criterion of a 5°F rise in the river is being met by diffuser dilution.

Analysis shows that a diffuser system is feasible for those schemes employing a combined cooling system. Although sufficient design information is not available for a final design, a preliminary design has been developed.

The proposed design consists of two conduits having cross-sectional areas equivalent to a 19-foot diameter circular section. Because of the shallow depths and the large hydrodynamic loading that would act on an exposed diffuser pipe as a result of navigation above it, it is believed that the diffuser would have to be almost completely buried. The length of the upstream conduit would be about 1,100 feet excluding approach pipe. Diffusion would be achieved by means of 43 two-foot diameter nozzles evenly spaced along the last 550 feet of the pipe. The nozzles should be oriented to discharge in the downstream direction, parallel to the reservoir current. The downstream diffuser would be 550 feet long excluding approach pipe and would also have 43 two-foot diameter nozzles evenly spaced along the length of the conduit. Nozzle orientation would be the same as for the upstream diffuser. The nozzle jet velocity would be approximately 10 ft/s. The velocity of the flow over the diffusers which would be induced by the jets would be about 1 ft/s.

Based on available design criteria, it is estimated that this diffuser would be capable of entraining up to 10 times the condenser flow. The diffuser would occupy about 75-80 percent of the width of the section; hence, at large reservoir flows, the condenser flow may mix with as much as 75-80 percent of the reservoir flow. Based on experience with the Browns Ferry 3-dimensional model, three types of thermal regimes could occur depending on the total reservoir flow.

For reservoir flows less than or equal to 10 times the condenser flow, the diffuser would entrain the entire reservoir flow, and the resulting temperature rise in the reservoir, ΔT_R, would be

$$\Delta T_R = \frac{Q_C \Delta T_C}{Q_R}$$

where Q_C = Condenser flow rate

Q_R = Reservoir flow rate

ΔT_C = Temperature differential between the reservoir and the condenser water

A second type of thermal regime would occur when the total reservoir flow is greater than 10 times the condenser flow but less than about 12.5-13.5 times the condenser flow. The upper limit on flow for this regime represents the reservoir flow at which the jet entrainment is satisfied without deflecting the stream lines of the upstream flow. For this regime, the temperature rise of the reservoir is given by

$$\Delta T_R = \frac{\Delta T_C}{10}$$

Some of the reservoir flow would pass the diffuser without being entrained by the jets. The cooler, unmixed water would flow beneath the heated water forming a 2-layered system downstream. A surface eddy is expected to form in the area between the end of the diffuser and the left bank. Heated water would move upstream from the diffuser.

A third thermal regime would form at reservoir flows greater than about 12.5-13.5 times the condenser flow. For this regime, the temperature rise of the reservoir is given by:

$$\Delta T_R = \frac{Q_C \Delta T_C}{P Q_R}$$

where: P = the percent of the total reservoir flow passing over the diffuser which would be about 75-80 percent.

The length of the conduits could be decreased and still maintain the same dilution; however, the velocity over the diffusers will be increased and might create a navigation problem. The quantity of flow intercepted by the diffuser would also be reduced below the 75-80 percent used in the preceding discussion.

The cooling tower, spray canal, or cooling lake may be utilized as the supplemental heat dissipation device for a combined-cycle system.

The alternative systems investigated for this plant are the schemes as designated below:

Scheme	Heat Dissipation Device	Type System
1	Cooling lake	Closed
2A	Spray canal	Combined (Intake from reservoir)
2B	Spray canal	Combined (Intake from Town Creek)
3	Spray canal	Closed
4	Mechanical draft towers	Combined
5	Mechanical draft towers	Closed
6	Natural draft towers	Combined
7	Natural draft towers	Closed

Scheme 7 is the proposed system discussed previously and was used as a base case for economic comparison of the alternatives which follows.

(4) Cooling lake (scheme 1) -

(a) Feasibility - The use of a cooling lake as an alternative closed-cycle heat dissipation method would require about 3,900 acres of effective water surface based on a rule of thumb of 1.5 acres per MW of nuclear capacity. The approximate lake size feasible at this site is 5,650 acres, which would be achieved by impounding the Dry Creek basin and flooding it to elevation 630 feet (See figure 2.6-8). This is 35 feet above normal reservoir elevation. The area to be flooded is sparsely populated except for areas near Scottsboro and Hollywood, Alabama, which are moderately populated. Additional land would be required for flood control and other management functions. Some 6,100 acres would have to be cleared. A 29,000 foot-long dike dividing the lake and directing the flow into a circuitous route, a 1,000-foot dike separating the Dry Creek and Evans Creek drainage areas, a 4,000-foot dike separating the Dry Creek and Town Creek drainage areas, and a 6,000-foot dike dividing the impounded lake from the main river channel would be required. The shoreline of the cooling lake would come within 10,000 feet of the plant site, and the water circulated to and from the plant would be through open channels. A lift station with pumps would be required.

The acceptability of this type of cooling facility has been explored with the Alabama Water Improvement Commission. By letter dated October 18, 1972, the Acting Chief Administrative Officer, AWIC, notified TVA that the Commission had previously approved a cooling pond for another power generating facility located in Alabama. However, it was emphasized that prior approval of cooling ponds did not constitute a general policy action by the Commission. If TVA studies showed the cooling lake to be the most feasible cooling alternative at Bellefonte Nuclear Plant, then TVA would need to further explore the possibility with the Commission.

The performance of the proposed cooling lake has been evaluated from the point of view of its hydraulic and heat transfer behavior.

The topography of the lake would promote a slug-type flow from the discharge to the intake without any significant short circuiting. This is particularly important as it reduces the impacts of the discharge and intake design on the performance. It is expected that neither the intake nor the discharge design would have a significant effect on the lake performance except for a small benefit in the form of slightly lower (<.5°F) intake temperatures which might possibly be achieved by designing the intake to withdraw from the lower portion of the lake depth.

The lake depth is estimated to be about 20 feet on the average and would result in the following beneficial heat transfer behavior:

1. Surface layers of water slightly warmer than the underlying waters would move as density currents into the many small coves and embayments along the perimeter of the lake. This would promote highly efficient use of the full surface area for heat transfer.
2. The net heat transfer through the surface of the lake would determine: (1) the average temperature of the lake as a whole and (2) its cooling performance, i.e., the decrease in temperature between the discharge and intake points. The proposed lake would have sufficient depth so that its "thermal inertia" would be large enough to prevent daily variations in the solar and atmospheric radiation inputs from causing significant changes to the average lake temperature. Specifically, the response time of the average lake temperature to changes in natural heat inputs would be on the order of 1 week. The total volume of the lake is such that the 2-unit flow-through time would be about 7 days, thus ensuring that the cooling performance would not be affected by hourly or daily variations in wind speed,

dry-bulb temperature, or wet-bulb temperature. The protection of the intake temperature from short-term excursions of natural meteorological conditions is an important advantage of a cooling lake over mechanical cooling devices.

The thermal loading of the surface area of the lake would be low, about 2.5 acres per MW. Assuming typical heat loss coefficients for summer and winter conditions, the extremes of the cooling lake performance have been evaluated. The intake temperature rise above "ambient" would range from about 0.5° in the summer to 4° in the winter. This is very adequate because the intake temperature rise would be lowest in the summer when the efficiency of the plant is more sensitive to the condenser intake temperature. The average surface temperature rise would range from 7°F to 14°F above "ambient."

A cooling lake is an established method of heat rejection which would be feasible at this site.

(b) Environmental considerations -

Physical and chemical characteristics of lake effluents - Heat dissipation by the cooling lake is largely by evaporation, although a significant portion is by convection and radiation. The forced evaporation caused by the plant heat load plus the natural evaporation due to heat gain from solar radiation causes the average makeup to be approximately 140 ft^3/s, which is essentially the same as that required for other alternatives. The average inflow to Dry Creek is only 31 ft^3/s; therefore, additional makeup from Guntersville Reservoir would normally be required. There would be no drift associated with a cooling lake.

Cooling lake makeup water for the closed-loop system would consist of the auxiliary and essential raw cooling water discharges plus natural inflows. Blowdown would be taken from the lake return channel.

The amount of makeup required for continuous operation of the cycle would depend on the amount of blowdown necessary and evaporation. With a blowdown concentration factor of 2, the total makeup required would be approximately 5.8 percent of the circulating flow, or 140 ft^3/s. The flow required from Guntersville Reservoir would vary since the natural inflow to Dry Creek Basin influences the concentration of the blowdown. Blowdown would vary, but the normal rate is estimated to be 2.9 percent of the circulating waterflow, or 70 ft^3/s.

Temperature of the blowdown for the closed cooling lake system would be approximately 64°F under average winter conditions, 75°F under average fall and spring conditions, and 88°F under average summer conditions. Peak summer conditions could produce blowdown temperatures near 95°F. During periods of high temperature and no flow by the discharge point (approximately 5 hours maximum) the blowdown could be withheld without significantly affecting the concentrations in the lake due to the large inventory of water in the lake. The cooling lake offers additional time for settling of solids and dilution of plant effluents during periods of high inflow.

Ecological considerations - The cooling lake alternative would represent an initial one-time demand for water. The location of the lake would avoid infringement on existing embayments. Effects on biota owing to thermal discharges would be avoided. Entrainment would, after the initial filling stage, be limited to that associated with the withdrawal of makeup water. Studies of larval fish at the Browns Ferry Nuclear Plant site (Wheeler Reservoir) in 1971 indicated that at least 90 percent of larval fish produced annually is present in the 91-day period between April 27 and July 27.[4] Estimated losses of larval fish based on this 91-day period of vulnerability would be 1.1×10^8; losses of larval and young fish would be irretrievable. A cooling lake would have the potential for providing additional habitat for sport fish or aquaculture, provided the design of the lake and the temperature of the water are favorable.

The change in land use to a limited-use or nearly single-purpose reservoir would constitute a significant effect on aquatic life of impounded streams and terrestrial life of the area. A cooling lake would present to invading aquatic life areas of extreme thermal conditions. The areas of greatest temperature would be within the heated water discharge plume. Some aquatic life forms present in the Guntersville Reservoir, however, can live in high-temperature zones and could pass through the nuclear plant cooling systems into the cooling lake. Such organisms include midges, Asiatic clams, a number of higher aquatic plants, and many algal forms.

A small number of fragments of Eurasian watermilfoil would be expected to pass through the intake screens. Such fragments have been found to have a threshold of damage by short-term high-temperature treatment of 45°C (113°F) for 5 minutes. Lower temperature (40°C), even for 15 minutes, was barely detrimental; higher temperature (50°C) for only 2 minutes was very detrimental. Some fragments subjected to 45°C for 5 minutes could survive and be able to establish new colonies creating a potential problem in the cooling lake.

The colonization of the lake by Eurasian watermilfoil and possibly by Asiatic clams would require control measures such as herbicides or biocides. Additionally, concentrations of trace metals and scaling elements would increase within the cooling lake, its sediments, and biota.

Atmospheric impact - Evaluations of the atmospheric effects of cooling lakes are very limited to date. A review of the literature and discussions with other investigators[5] indicate that if the cooling lake is of adequate size for the thermal discharge, the effects are limited to within 1/4 mile from the lake border and to bridges over the lake. "Adequate size" is determined using a rule-of-thumb estimation as 1-1/2 acres of cooling lake for one megawatt plant size rating for nuclear power plants and a one-to-one requirement for fossil-fired power plants, i.e., one acre for one megawatt. The cooling lake would affect the local environment in a manner similar to that of any natural body of water. However, some environmental effects would be expected in the area where the thermal discharge enters the lake to include that area where the water temperature is above the temperature of a natural body of water. These effects are expected only out to within 1/4 mile downwind from the lake edge in the areas of warm water.

The affected peripheral area was determined by the annual wind direction frequency distribution in the plant area. The wind data from the Widows Creek valley meteorological station indicated the area most affected will be south-southwest of the cooling lake, figure 2.6-9. This sector will experience potential fogging about 23 percent of the time (83 days per year). A high percentage, i.e., 23.01 percent, of "calms" is the result of using only early morning, 0600 local time, readings, which is the critical period for potential dense fogging. The south-southwest sector is also more frequently affected during freezing temperatures when rime icing could form on structures and vegetation up to 1/4 mile downwind. As indicated by figure 2.6-10, this sector will be affected during freezing temperatures about 12 percent of the time (43 days per year).

Particularly in the winter months, "steam fogs" would occasionally develop over the lake. This type of fog has been observed on a plant access road over a cooling pond at Commonwealth Edison Company's Dresden Nuclear Power Station. Therefore, it is believed that a cooling lake of this size (figure 2.6-8) at the Bellefonte Nuclear Plant would frequently create a serious hazard to travel on U.S. Highway 72 and the Southern Railroad, both of which would cross the lake, as well as on the proposed plant access road.

<u>Aesthetics</u> - Since the lake would be created by impounding a natural basin, the approaches to the lake would be natural, and the lake would be aesthetically pleasing.

<u>Noise</u> - Noise levels at the plant site would not be increased.

(c) <u>Land</u> - The cooling lake would require about 7,000 acres of land beyond that now proposed for the plant site. Successful management of the land surrounding the lake to minimize the environmental impact of the lake on wildlife and to control flooding would require the purchase of approximately 1,350 acres in addition to the lake area of 5,650 acres. Approximately 140 occupied structures would have to be removed. The value of the impounded waters may be enhanced by providing a habitat for aquatic species not naturally occurring in that locale.

Dikes between the cooling lake and adjoining drainage areas and between the cooling lake and Guntersville Reservoir would be provided with an impermeable compacted earthfill to minimize seepage and resist erosion. However, extensive soil sampling and rock core drilling would be required to accurately predict the total seepage from the lake.

Construction excavation and diking would be performed in a manner to minimize land damage.

(d) <u>Economic considerations</u> - The initial investment required to install a cooling lake system is preliminarily estimated to be $8,940,000 more than for scheme 7.

The comparative capability and the required present worth cost to provide the replacement capacity for a cooling lake compared to scheme 7 are as follows:

Scheme	7	1
Type system	Closed ND	Closed CL
Comparative capacity loss, kW	Base	(-)6,200
Comparative replacement cost, $10^6$$	Base	(-)1.75

The availability of a large cooling lake and the lower cost of circulating water pumping power due to the lower head requirements results in a lower main condenser back pressure for the cooling lake scheme versus scheme 7. As a result the plant utilizing a cooling lake would produce more power and reject less heat than with natural draft towers.

The present worth (1979-80 dollars) comparative operation and maintenance costs of a cooling lake compared to scheme 7 are shown below:

Scheme	7	1
Type system	Closed ND	Closed CL
Heat rate, Btu/kWh	9534.4	9510.0
Efficiency loss, 10^6\$	Base	(-) 0.82
Pump power cost, 10^6\$	Base	(-) 2.64
Total operation cost, 10^6\$	Base	(-) 3.46
Maintenance cost, 10^6\$	Base	(-) 0.69
Total operation and maintenance cost, 10^6\$	Base	(-) 4.15

(5) Spray canal system (schemes 2A, 2B, and 3) -

(a) Feasibility - The use of a spray canal system as an alternative combined-cycle heat dissipation method would require a canal approximately 12,800 feet in total length and 200 feet wide with 320 power spray modules spaced four abreast in 80 rows. The use of a spray canal system as an alternative heat dissipation method is considered feasible for this site, and three arrangements were evaluated. Figures 2.6-11, 2.6-12, and 2.6-13 show possible locations and arrangements on the plant site.

The use of a spray canal for power plant cooling is a relatively new concept and only in recent months has a large installation been put into operation. Typical among units adopting this method for heat dispersal are:

User	Location	Heat Rejection Millions, Btu/h	Purpose
Commonwealth Edison	Dresden	5,466	Temporary startup, Units 2 and 3
Gulf States Utilities	Beaumont, Texas	-	Salt water test
Detroit Edison	Fermi	261	Testing
Virginia Electric & Power	Chesterfield	2,067	Topping
Public Service of New Hampshire	Merrimack	429	Topping

The largest installation, Dresden, has been in operation for over one year in conjunction with units of 809-MW capacity and a heat rejection rate of 5,466 million Btu/h. By comparison, the heat rejected from the proposed Bellefonte plant is 15,600 million Btu/h.

Spray canal systems have demonstrated heat dispersal capability for the above installations, and as experience is being obtained, this method is being adopted for larger installations.

The performance of the proposed spray canal systems has not been evaluated quantitatively since design details have not been determined. In any case there is a lack of a good general model for spray canal performance, and most designs must proceed on the basis of manufacturers' specifications. It is possible, however, to make some general comments about spray canals.

1. Wind speed has far less effect on heat and mass transfer in a spray pond in comparison with a cooling lake. This helps to reduce the hourly variations in spray pond performance which might otherwise be caused by changing wind speeds.
2. The efficiency of a spray pond is a very strong function of the wet-bulb temperature alone. Heat and mass transfer coefficients may vary as much as 50 percent for wet-bulb variations between 40°F and 80°F. If the spray system is to be used in the winter months, it must be designed large enough to reflect the low wet-bulb temperatures common at that time.
3. The overall heat transfer rate of the spray system is directly proportional to the difference between the average temperature of the spray (the average of the plant condenser intake and discharge temperatures) and the natural wet-bulb temperature. The wet-bulb temperature is known to vary widely on an hourly basis. These variations will be reflected in the condenser intake temperature, and thus in the power production efficiency, because the water in the system has very little thermal inertia and will respond to the hourly wet-bulb behavior.

The preceding discussion on the performance of spray ponds was based on reference number 6.

Location of the intake in Town Creek for scheme 2B would have to be evaluated in light of the possibility that Town Creek may undergo significant diurnal fluctuations in temperature and may be generally warmer than the water in Guntersville Reservoir proper.

(b) Environmental considerations -

Physical and chemical characteristics of canal effluents - Water necessary for operation of the spray canal in the closed mode would be obtained from the Tennessee River at the plant site. With a blowdown concentration factor of 2, the total makeup required would be approximately 5.4 percent of the circulating flow, or 146 ft^3/s.

The water for makeup for spray canal schemes 2A (combined) and 3 (closed) is taken directly from Guntersville Reservoir; the water for makeup for spray canal scheme 2B (combined) is taken from the Town Creek Embayment of Guntersville Reservoir.

The amount of blowdown and its dissolved solids concentration required for continuous operation with spray canal is estimated to be approximately 2.7 percent of the circulating waterflow, or 73 ft^3/s. With a concentration factor of 2, the dissolved solids in the blowdown should not exceed acceptable levels.

Temperature of the blowdown for the spray canal closed-cycle system would be approximately 72°F under average winter conditions, 83°F under average fall and spring conditions, and 91°F under average summer conditions. Peak summer conditions can produce temperatures near 97°F a few hours a day on the hottest summer days. Corresponding temperatures for closed mode of a combined-cycle system are 80°F, 86°F, 93°F, and 98°F, respectively. Holdup time on blowdown would be longer for the spray canal system than for cooling towers due to the larger quantity of water in the system.

Drift, the water blown from the spray canal by wind, is estimated to involve quantities of approximately 0.007 percent of the circulating waterflow, or 0.2 ft^3/s. Although the water is sprayed into the air by the spraying modules and is subject to being carried away, the droplets are large and should be carried only a short distance. Furthermore, the channel edge would be approximately 20 feet from the side spray modules and the edge would be sloped back to the channel so that a large percentage of water which may be blown by the wind would return to the canal.

Ecological considerations - Under schemes 2A and 2B operation of the spray canal would require more water than other alternatives considered. The location of the canal as indicated on figure 2.6-12 suggests the possibility of some disturbance of the upper end of Town Creek Embayment. Alternative location B appears to have more potential for disturbance of the embayment than does alternative A. Care would have to be taken to avoid disturbance of the shoreline during all phases of site preparation and construction for either of the spray canal alternatives. For combined-cycle systems, thermal effects on biota owing to discharge of heated water would occur; the extent and significance of the impact would be determined primarily by the design and location of the discharge structure. In this regard, a discharge diffuser located in the channel would be preferable to a shallow-water, point-source discharge. In open-cycle operation, estimated losses of larval and young fish would be 2.3×10^9 for a 91-day period of vulnerability; in closed cycle, losses would be 1.1×10^8. Losses under combined-mode operation would vary within this range depending on the operating schedule. Losses of plankton, larval fish, and young fish due to entrainment and condenser passage would be irretrievable under either mode. Assuming that numbers of organisms entrained would be roughly proportional to the amount of water withdrawn, the spray canal alternative under combined-mode operation is the worst alternative in this regard.

The location of the intake in Town Creek and the operation of the cooling system in a helper or open mode would induce a flushing flow in Town Creek many times its natural flow. Water would enter Town Creek from the river upstream from the plant, pass through the creek, and be withdrawn by the intake structure to be discharged eventually back into the river. This constant movement of the water in Town Creek and the introduction of river water may produce changes in the aquatic environment which have not been evaluated.

<u>Atmospheric impacts</u> - Effects from the use of a spray canal system in the Bellefonte area would involve some fogging and icing. These effects are largely dependent on the quantity of evaporation of the spray effluent and the absolute humidity deficit of the atmosphere. Therefore, the expected plume

lengths should be somewhat greater than those estimated for cooling towers because of the usually lower ambient temperature and greater amount of moisture within the near-surface layer where most of the effluent will be dispersed. (Water is sprayed upward at a low level, 15 to 20 feet, as compared to plume release heights of 60 feet and 400 to 500 feet for mechanical and natural draft cooling towers, respectively.)

In many cases visible plumes generated by the spray canals would move downwind near ground level with intensifying effects on natural fogging. Such conditions should occur about 35 days per year with most fogging between 3 a.m. and 8 a.m. Most fogging will probably occur south-southwest of the plant--the highest frequency of plume occurrence. Figure 2.6-14 indicates that for 13 percent of the time (47 days per year) the plume would be 2 miles or more in length in this sector. In the south and south-southwest sectors from 4 to 8 percent of the time fogging could be encountered by traffic on Alabama State Highway 40. Average daily traffic on Highway 40 in 1970 at this point was 2,200 vehicles. U.S. Highway 72 would experience fogging in several sectors, and plume-induced fogging would reach Hollywood (population 865) about 2.5 percent of the time (9 days per year). Average daily traffic on U.S. 72 in 1970 at this point was estimated at 3,660 vehicles.

Periods of potential canal-induced icing when the ambient temperature is below freezing are expected about 70 days per year during the 5-month period, November through March, with the highest frequency in January and February.

Duration of heaviest icing would depend on the persistency of the below-freezing temperatures. Most severe conditions are expected between midnight and 7 a.m. Icing could be experienced on Alabama State Highway 40 about 4 percent of the time (15 days per year), on U.S. Highway 72 about 1 percent of the time (3.5 days per year), and possibly as a very rare occurrence on Alabama Highway 35 (figure 2.6-15).

<u>Aesthetics</u> - Plume-induced fogging would create an aesthetic impact to the Hollywood populace and to travelers of the highways in the area. However, the aesthetic impact from a spray canal system should be not significantly adverse.

<u>Noise</u> - The operation of a spray canal would increase noise levels at the plant site by a small amount. This increase would be due to motors and the falling water. Normally acceptable noise levels would be expected at site boundary.

(c) <u>Land</u> - Based on a preliminary investigation of site conditions, it is estimated that spray canal scheme 2A (combined) would require the acquisition of 480 acres of land in addition to that required for the plant. Spray canal scheme 2B (combined) and scheme 3 (closed) would not require the purchase of additional land.

(d) <u>Economic considerations</u> - The initial investment to install a spray canal system is estimated to require $16,510,000 more for scheme 2A, $16,250,000 more for scheme 2B, and $5,540,000 more for scheme 3 than for the proposed scheme 7.

Due to the location of base rock relatively close to the surface at this site, construction of the 12,800-foot spray canal would be particularly expensive.

The comparative capability and the associated replacement cost of a spray canal versus scheme 7 are as follows:

Scheme	7	2A	2B	3
Type system	Closed ND	Combined SC	Combined SC	Closed SC
Comparative capacity loss, kW	Base	(-)14,880	(-)14,880	4,940
Comparative replacement cost, 10^6\$	Base	(-)4.16	(-)4.16	1.39

The savings realized in capability by the combined spray canal scheme over scheme 7 is a result of the lower backpressure caused by operation in the open mode a large portion of the time. The present worth (1979-80 dollars) comparative operation and maintenance costs of a spray canal compared to scheme 7 are as follows:

Scheme	7	2A	2B	3
Type system	Closed ND	Combined SC	Combined SC	Closed SC
Heat rate, Btu/kWh	9534.4	9477.0	9477.0	9553.6
Efficiency loss, 10^6\$	Base	(-) 1.94	(-) 1.94	.64
Pump power cost, 10^6\$	Base	(-) 2.77	(-) 2.77	2.47
Total operation cost, 10^6\$	Base	(-) 4.71	(-) 4.71	3.11
Maintenance cost, 10^6\$	Base	.99	.99	.99
Total operation and maintenance cost, 10^6\$	Base	(-) 3.72	(-) 3.72	4.10

Since the combined-cycle spray canal system operates in the open or helper mode a large part of the time, the turbine efficiency is better and the required auxiliary power is less than for scheme 7.

(6) Mechanical draft cooling towers (schemes 4 and 5) - The use of crossflow mechanical draft cooling towers as an alternative cooling method would require four wood-filled cooling tower sections, each approximately 50 feet wide by 60 feet high by 640 feet long with 14 cells per section for the combined-cycle system (scheme 4) and four tower sections, each approximately 50 feet wide by 60 feet high by 720 feet long with 18 cells per section for the closed-cycle system (scheme 5).

(a) Feasibility - Mechanical draft cooling towers are suitable for application to a closed or combined system at the Bellefonte Nuclear Plant site. Figure 2.6-16 and 2.6-17 show possible locations and arrangements of the mechanical draft towers on the plant site.

(b) Environmental considerations -

Physical and chemical characteristics of effluents - For a closed-loop tower system, the main circulating water pumps would circulate water through the condenser and to the towers where the heat is transferred to the air, the flow of which is induced by large fans. Water returning from the towers would flow by gravity back to the circulating water pumps. Tower makeup water and tower blowdown would be the only intake and discharge from and to Guntersville Reservoir.

With a blowdown concentration factor of 2, the total makeup required would be approximately 6 percent of the circulating flow, or 147 ft^3/s.

The blowdown is estimated to be 3 percent of the circulating waterflow, or 71 ft^3/s. Concentrations of dissolved solids in the circulating water system of a closed system or closed mode of operation will not normally exceed 2 and blowdown would meet stream standards.

Slightly increasing the quantity of blowdown and makeup would further reduce the dissolved solids concentration. The temperature of this blowdown for the mechanical draft tower closed-cycle system (scheme 5) would be approximately 74°F under average winter conditions, 77°F under average fall and spring conditions, and 84°F under average summer conditions. Peak summer conditions could produce temperatures near 89°F a few hours a day on the hottest summer days. Corresponding temperatures for closed mode on a combined mechanical draft tower system (scheme 4) are 81°F, 85°F, 91°F, and 95°F respectively. Under peak temperature conditions and during periods when there is no flow by the discharge point, blowdown could be withheld. During periods of no flow (approximately 5 hours maximum) the concentrations in the tower system are not expected to exceed 3. Discharge to the reservoir with this concentration would not exceed stream standards.

Drift, which is water that is blown out of the towers, has been estimated by the cooling tower manufacturers to involve quantities of approximately 0.1 percent of the circulating waterflow, or 2.5 ft^3/s.

<u>Ecological considerations</u> - Mechanical draft towers rank intermediately in water demand of the

alternatives considered. The principal advantages of this alternative, under either scheme, over the spray canal alternative are the absence of infringement on Town Creek Embayment and reduced entrainment losses; the latter being solely a function of the relatively smaller water demand. Estimated losses of larval and young fish would be 2.0×10^9 under open-cycle operation and 1.1×10^8 under closed-cycle operation. Losses would be irretrievable under closed-cycle operation; irretrievable losses under open-cycle operation are more difficult to predict but would probably approach 100 percent. Thermal discharge effects would be approximately the same as for the spray canal (scheme 3), given the same considerations regarding design and location of the discharge device.

The closed-cycle scheme would be preferable in terms of avoiding losses due to entrainment. No significant differences in entrainment losses would be expected for mechanical versus natural draft towers.

Thermal discharges under combined cycle would be made in compliance with the applicable thermal standards, and therefore no significant adverse effects would be expected to occur.

Atmospheric impacts - Atmospheric effects from the operation of the mechanical draft cooling towers at the Bellefonte Nuclear Plant would include considerable fogging and possibly some icing within about 4 to 5 miles of the cooling towers. The potential effects will be more significant than those from the higher plumes of the natural draft cooling towers because of their lower emission height. In some cases the visible plumes from the mechanical draft towers should move downwind at near ground level. Of particular interest would be the intensifying effects of these low-level plumes during periods of natural fog. Such fogging conditions would likely occur on about 35 days per year with optimum conditions for fogging occurring between 3 a.m. and 8 a.m.

Most fogging would probably occur south-southwest of the plant in the direction of the highest frequency of long-plume occurrence (figure 2.6-18). About 17 percent of the time (61 days per year) the plumes will be transported in the south through the southwest sectors with lengths greater than 4 miles. Alabama Highway 40 could experience fogging from 4 to 8 percent of the time. The model used indicated no expected plume lengths beyond 5 miles. However, the trend of results in these sectors indicated that a fogging potential exists a small percentage of the time in the vicinity of Alabama Highway 35 which is about 5.2 miles' distance. Also of significance is potential fogging to the town of Hollywood 2.5 percent of the time (9 days per year) and to U.S. Highway 72 in the north-northeast sector 7 percent of the time (26 days per year).

The data indicate that cooling tower-induced icing could occur on about 70 days per year during the 5-month period, November through March, with the highest frequency expected in January and February. Duration of heaviest icing would depend on persistency of the below-freezing temperatures with the optimum periods from midnight to 7 a.m. The direction with the maximum frequency of plume travel is the south-southwest sector. As indicated in figure 2.6-19, the ice-inducing plume could reach Alabama Highway 40 from 1.5 to 3 percent of the time. It is unlikely that a plume of length sufficient to affect Alabama Highway 35 would occur any more often than one day per year. Light-to-moderate icing would occasionally occur on any nearby structures located north-northeast through west-southwest of the cooling towers.

Aesthetics - The materials of mechanical draft towers would not be compatible with the architecture of the powerhouse; therefore design features would be incorporated to achieve architectural compatibility with the main plant. The relatively low profile of the mechanical draft towers would not present a very large vertical barrier or landmark on the terrain.

Noise - The use of mechanical draft towers would increase noise levels at the plant site. This increase would be due to (1) the fans, and (2) the falling water with fan noise being dominant. Predicted sound pressure levels from one manufacturer[7] of cooling towers are 62 dB at 250 Hz, 57 dB at 2,000 Hz, and 59 dB at 8,000 Hz—all 200 feet from the louvered face (ref 0.0002 microbar). Predicted noise levels for Browns Ferry plant, at which six 600-foot sections of mechanical draft cooling towers are being installed, were judged to be "normally acceptable." On the basis of these predicted levels, it is expected that mechanical draft towers for the Bellefonte site would also be judged "normally acceptable."

(c) Land - The use of mechanical draft towers as an alternative means of cooling would not require the acquisition of additional land beyond that now required for the plant. The towers would occupy about 50 to 100 acres of the site.

(d) Economic considerations - The initial investment required to adapt and install the mechanical draft tower system for combined-cycle is estimated to be $17,390,000 more than the proposed natural draft tower system, and the closed-cycle mechanical draft tower system is estimated to require an investment of $1,510,000 less than the proposed tower system.

The combined-cycle system dictates lower efficiency, less costly towers; however, the additional return channels, gates, and diffusers make the initial cost greater than the closed-cycle system. Less expensive mechanical draft towers make their initial investment less than a natural draft tower for a closed-cycle system. However, due to the longer conduits and greater excavation required and the more extensive site preparation needed for the mechanical draft towers this difference in cost is narrowed considerably.

The loss in capacity and associated replacement cost to assure the same reliability of power supply as compared to scheme 7 are as follows:

Scheme	7	4	5
Type system	Closed ND	Combined MD	Closed MD
Comparative capacity loss, kW	Base	(-)13,140	120
Comparative replacement cost, 10^6 \$	Base	(-)3.68	.05

The cooling towers for closed-cycle systems have optimum economic selection points at lower approaches than those for combined-cycle systems. Also, the combined-cycle system would benefit from the lower reservoir temperatures for condenser cooling water when sufficient flow is available. The loss in capacity and efficiency is therefore less for a combined-cycle system.

The use of mechanical draft cooling towers is estimated to have the following operating and maintenance costs as compared to scheme 7 (costs are present worth differences in 1979-80 dollars):

	Comparative Costs		
Scheme	1	4	5
Type System	Closed ND	Combined MD	Closed MD
Heat rate, Btu/kWh	9534.4	9483.2	9534.9
Efficiency loss, $10^6$$	Base	(-) 1.72	.02
Fan and pump, power cost, $10^6$$	Base	(-) 1.77	3.69
Total operation cost, $10^6$$	Base	(-) 3.49	3.71
Maintenance cost, $10^6$$	Base	3.16	3.70
Total operation and maintenance cost, $10^6$$	Base	(-) 0.33	7.41

Average efficiency is greater and auxiliary power requirements are less for a combined-cycle tower system than for a closed-cycle system due to the benefit from lower reservoir temperatures when on helper- or open-mode and because the towers are operated less. The mechanical draft tower closed-cycle system, however, requires greater auxiliary power than a closed natural draft tower system due to the additional fan power requirements. Efficiency loss for the closed-cycle mechanical draft tower and for the closed-cycle natural draft tower systems is nearly equal since the optimum selection point was at about the same approach. Maintenance cost for the mechanical draft tower system is understandably higher due to the additional mechanical equipment involved.

(7) Natural draft cooling towers (schemes 6 and 7) - The use of two closed-cycle natural draft towers is proposed as the method of heat dissipation for the Bellefonte Nuclear Plant. Considerations for this alternative are discussed in detail in sections 2.6.3 and 2.6.4. The discussion in this subsection is limited primarily to the differences in considerations associated with the combined-cycle natural draft system alternative (scheme 6).

The use of natural draft cooling towers as an alternative cooling method would require two impervious-fill towers approximately 480 feet in diameter and 400 feet high for the combined-cycle system and 500 feet in diameter and 500 feet high for the closed-cycle system.

(a) Feasibility - Natural draft cooling towers have been used for many years; however, the first unit in the United States, Big Sandy, commenced operation in 1962. The following counterflow towers, similar to those required for Bellefonte, are under construction or were recently placed in operation:

American Electric Power, Amos Plant - 400' diameter x 492' high

Portland General Electric, Trojan Plant - 385' diameter x 492' high

Toledo Edison and Cleveland Electric, Davis-Besse Plant - 411' diameter x 492' high

Cincinnati Gas & Electric, Zimmer Plant - 383' diameter x 479' high

Natural draft cooling towers are suitable for application to a closed- or combined-cycle system at the Bellefonte Nuclear Plant site. Figures 2.6-1 and 2.6-20 show possible locations and arrangements of the two towers on the plant site.

(b) <u>Environmental considerations</u> - <u>Physical and chemical characteristics of effluents</u> - The temperature of the blowdown for the combined-cycle system operated in the closed mode would be approximately 71°F under average winter conditions, 78°F under average fall and spring conditions, and 88°F under average summer conditions. Peak summer conditions can produce temperatures near 94°F a few hours a day on the hottest summer days; however, blowdown could be withheld under peak temperature conditions and during periods when there is no flow by the discharge point. Drift has been estimated to be 0.01 percent of the circulating waterflow, or 0.25 ft^3/s.

<u>Ecological considerations</u> - Combined-cycle natural draft towers have advantages over the mechanical draft towers and spray canals in terms of total water demand and the concomitant entrainment losses. Estimated losses of larval fish would be 1.8×10^9 under open-cycle operation and 1.1×10^8 under closed-cycle operation. Natural draft towers would also avoid disturbance of Town Creek embayment. Thermal discharge effects would be similar to those of mechanical draft towers. The closed-cycle scheme would be preferable in terms of avoiding losses due to entrainment.

Land disturbance would be less than for any of the other heat dissipation schemes since less total area and excavation would be necessary.

Thermal discharges under combined cycle would be made in compliance with the applicable thermal standards, and therefore no significant adverse effects would be expected to occur.

(c) Economic considerations - The initial investment required to install combined-cycle natural draft towers is estimated to be $17,140,000 more than closed-cycle natural draft towers, which for the 2-unit plant are estimated to cost about $58 million, including conduits, condensers, and site preparation. The combined-cycle tower system dictates lower efficiency, less costly towers; however, the additional channels, gates, and diffusers make the initial cost greater than the closed tower system.

The loss in capability and the associated replacement cost (1979-80 dollars) to assure the same reliability of power supply with scheme 7 as the base are as follows:

Scheme	7	6
Type System	Closed ND	Combined ND
Comparative capacity loss, kW	Base	(-)8,540
Comparative replacement cost, 10^6 $	Base	(-) 2.36

As was the case for mechanical draft towers, the natural draft towers for closed-cycle systems have optimum economic selection points at a lower approach than that for combined systems because the combined system benefits from lower condenser cooling water when operating on helper and open modes. The average loss in capacity and efficiency is therefore less for a combined system.

The use of natural draft cooling towers would have the following operating and maintenance cost differentials (1979-80 dollars) compared with scheme 7 as base:

	Comparative Costs	
Scheme	7	6
System type	Closed ND	Combined ND
Heat rate, Btu/kWh	9534.4	9501.3
Efficiency loss, 10^6\$	Base	(-) 1.12
Fan and pump power cost, 10^6\$	Base	(-) 2.62
Total operation cost, 10^6\$	Base	(-) 3.74
Maintenance cost, 10^6\$	Base	(-) .19
Total operation and maintenance cost, 10^6\$	Base	(-) 3.93

As was the case for mechanical draft tower systems, average efficiency is greater and auxiliary power requirements are less for a combined-cycle tower system than for a closed-cycle system due to the benefits from lower reservoir temperature when on helper or open mode. Maintenance costs are slightly lower for the combined-cycle systems due to the smaller towers required.

(8) Evaluation of alternative heat dissipation facilities - Table 2.6-1 summarizes the present worth cost comparison in 1979-80 dollars and other differences of the feasible alternatives.

The comparison of feasible alternatives shown in Table 2.6-1 indicates the relative economic differences in present worth evaluated costs (1979-80 dollars) which include the capital cost of installing the facilities and the present worth of the operation and maintenance costs. The natural draft closed-cycle cooling tower scheme is used as the base since it is the scheme with the lowest total evaluated cost. Scheme 1, closed-cycle cooling lake, has the next lowest evaluated cost, and scheme 5, closed-cycle mechanical draft cooling tower system, is the third lowest.

All alternatives are estimated to be compatible with the construction schedule for the remainder of the plant, except the cooling lake which may not be compatible because of possible problems in acquiring needed land.

The mechanical draft closed system (scheme 5), in addition to having an evaluated cost of some $6 million more than the natural draft towers, would create considerable fogging and icing, the effects of which would be more significant than the potential effects from the higher plumes of the natural draft towers. Mechanical draft towers are also noisier than any of the other alternatives.

The cooling lake system would cost some $3 million more than the natural draft towers and would require the use of considerably more land and the acquisition of about 7,000 acres of additional land. Ground fogging and icing would also be a problem more frequently with a cooling lake than with the towers.

In conclusion, TVA has investigated numerous feasible alternatives for heat dissipation for the Bellefonte

Nuclear Plant, and each alternative costs more and offers no significant advantages over the natural draft towers. Therefore, due to the economic advantage and the smaller overall potential for environmental impacts, TVA proposes to include the closed-cycle natural draft cooling tower installation for heat dissipation at the Bellefonte Nuclear Plant. The initial investment in facilities for the base natural draft closed-cycle system, including towers, conduits, condensers, site preparation, etc., is estimated at $58 million for the 2-unit plant.

REFERENCES FOR SECTION 2.6

1. Rossie, J. P., and W. A. Williams, Jr. "The Cost of Energy from Nuclear Power Plants Equipped with Dry Cooling Systems." ASME. 1972.

2. Leung, P., and R. E. Moore. "Thermal Cycle Arrangements for Power Plants Employing Dry Cooling Towers." ASME. 1970.

3. Leung, P., G. R. Reti, and J. R. Schilling. "Dry Cooling Tower Plant Thermodynamic and Economic Optimization." ASME. 1972.

4. Tennessee Valley Authority. Browns Ferry Nuclear Plant Units 1, 2, and 3 Environmental Statement, Section 2.7, Volume 1. 1972.

5. Communications with James E. Carson, Argonne National Laboratory, 10/1/71, and Donald Portman, University of Michigan, 9/29/71, by W. C. Colbaugh, TVA.

6. Ryan, P. J. "Temperature Prediction and Design of Cooling Ponds," Engineering Aspects of Heat Disposal from Power Generation, (D.R.F. Harleman, Ed.), R. M. Parsons Laboratory for Water Resources and Hydrodynamics. Department of Civil Engineering, M.I.T. June 1972.

7. Letter to R. S. Rainey, TVA, from I. F. Kuharic, Engineering Division, The Marley Company, Mission, Kansas. February 10, 1972.

Table 2.6-1

PRESENT WORTH COST COMPARISONS OF ALTERNATIVE HEAT DISSIPATION FACILITIES[a]
(1979-80 Dollars)

Scheme	1	2A	2B	3	4	5	6	7
Heat Dissipation Device	Cooling Lake	Spray Canal	Spray Canal	Spray Canal	Mechanical Draft Towers	Mechanical Draft Towers	Natural Draft Towers	Natural Draft Towers
Type	Closed	Combined	Combined	Closed	Combined	Closed	Combined	Closed
Average Annual Net Turbine Heat Rate - Btu/kWh	9510.0	9477.0	9477.0	9553.6	9483.2	9534.9	9501.3	9534.4
Percent of Time Operating in Various Modes								
Open	0	71.6	71.6	0	71.6	0	71.5	0
Helper	0	25.5	25.5	0	24.9	0	25.1	0
Closed	100	2.9	2.9	100	3.6	100	3.4	100
Facilities Cost, $ Million	8.94	16.51	16.25	5.54	17.39	(-) 1.51	17.14	Base
Capability Cost, $ Million	(-)1.75	(-) 4.16	(-) 4.16	1.39	(-) 3.68	0.05	(-) 2.36	Base
Operation Cost, $ Million	(-)3.46	(-) 4.71	(-) 4.71	3.11	(-) 3.49	3.71	(-) 3.74	Base
Maintenance Cost, $ Million	(-)0.69	0.99	0.99	0.99	3.16	3.70	(-) 0.19	Base
Total, $ Million	3.04	8.63	8.37	11.03	13.38	5.95	10.85	Base

a. All costs shown are present worth cost differences in 1979-80 dollars using scheme 7 as a base.

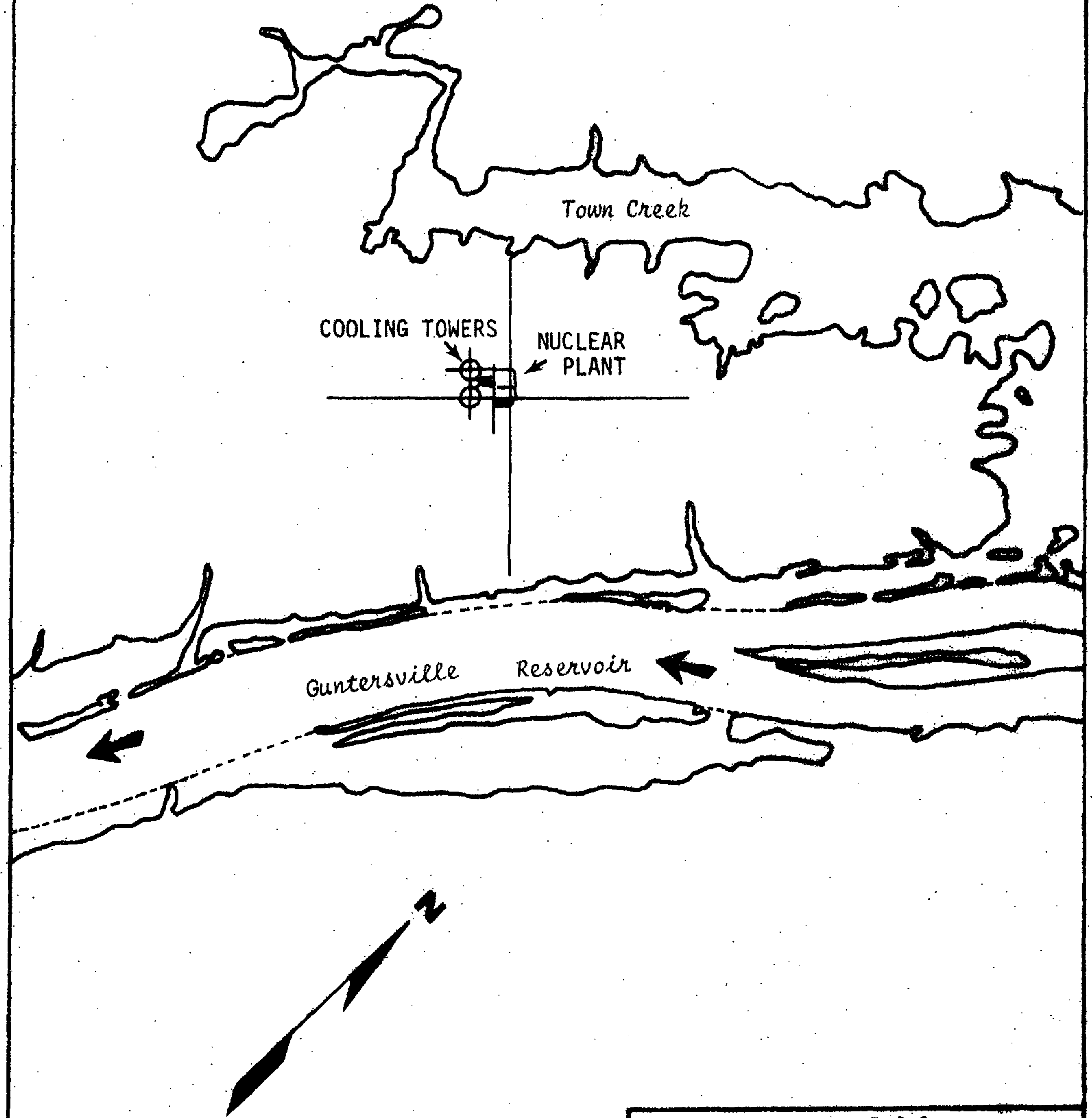


Figure 2.6-1
COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
NATURAL DRAFT TOWERS-CLOSED SYSTEM
SCHEME 7

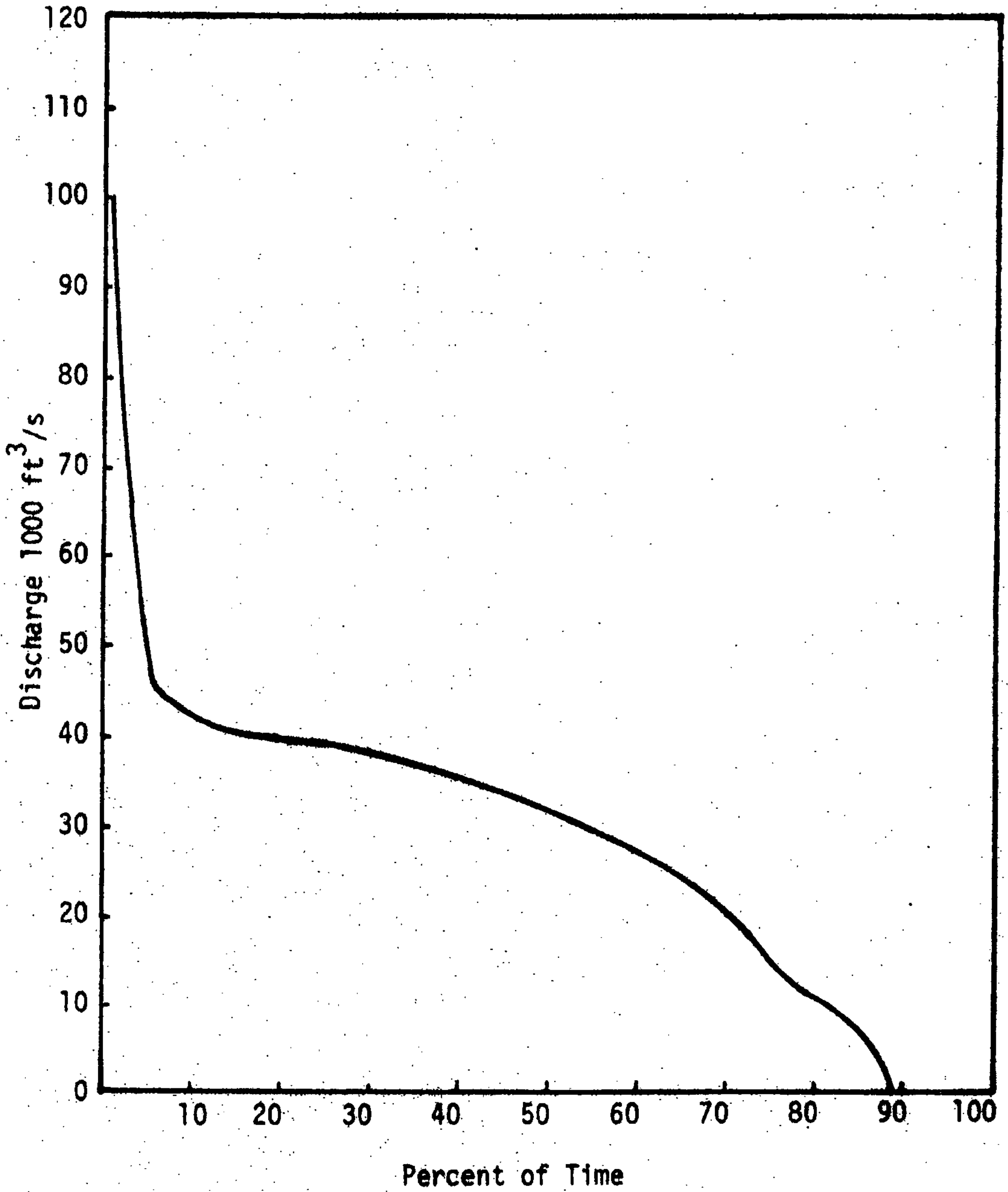


Figure 2.6-2

NICKAJACK DAM
Hourly Flow
May 1968 - October 1971

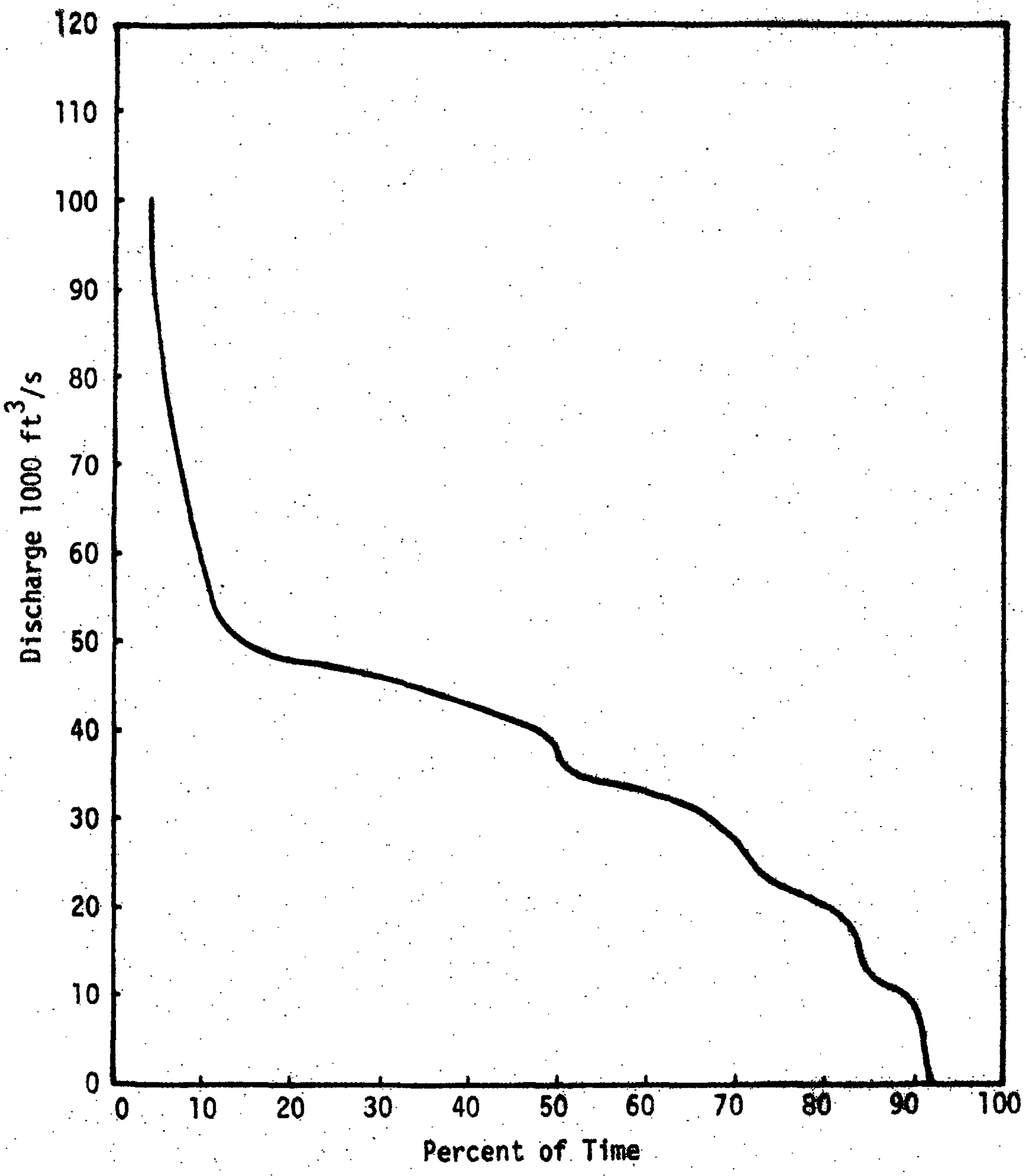
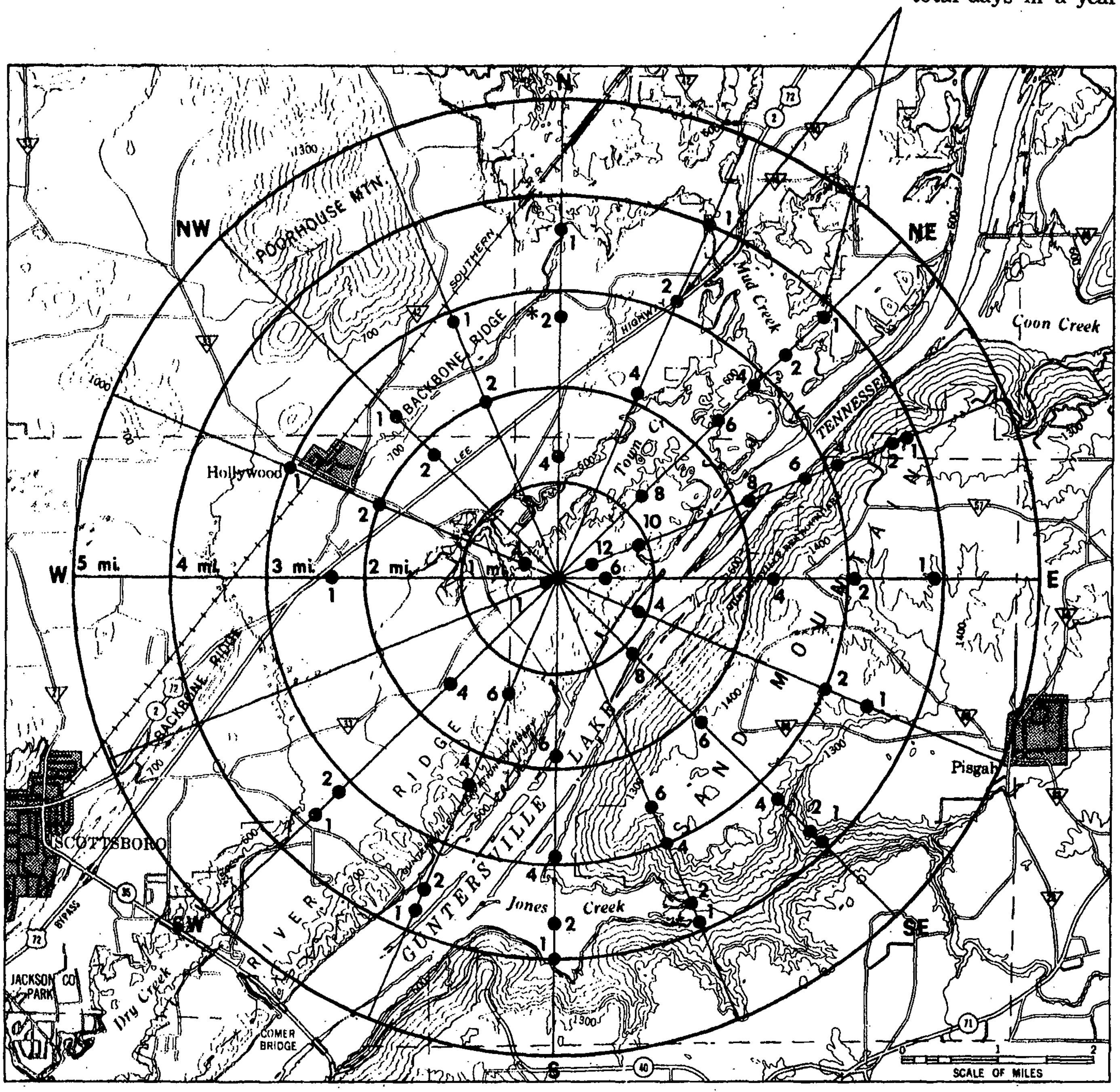


Figure 2.6-3
GUNTERSVILLE DAM HOURLY FLOW
10 YEARS OF RECORD
1959 - 1968

* Example: 2 percent of the time (7 days per year)
plumes with lengths ≥ 2.7 miles
occur in the 22½° sector north of site

Percent of
total days in a year

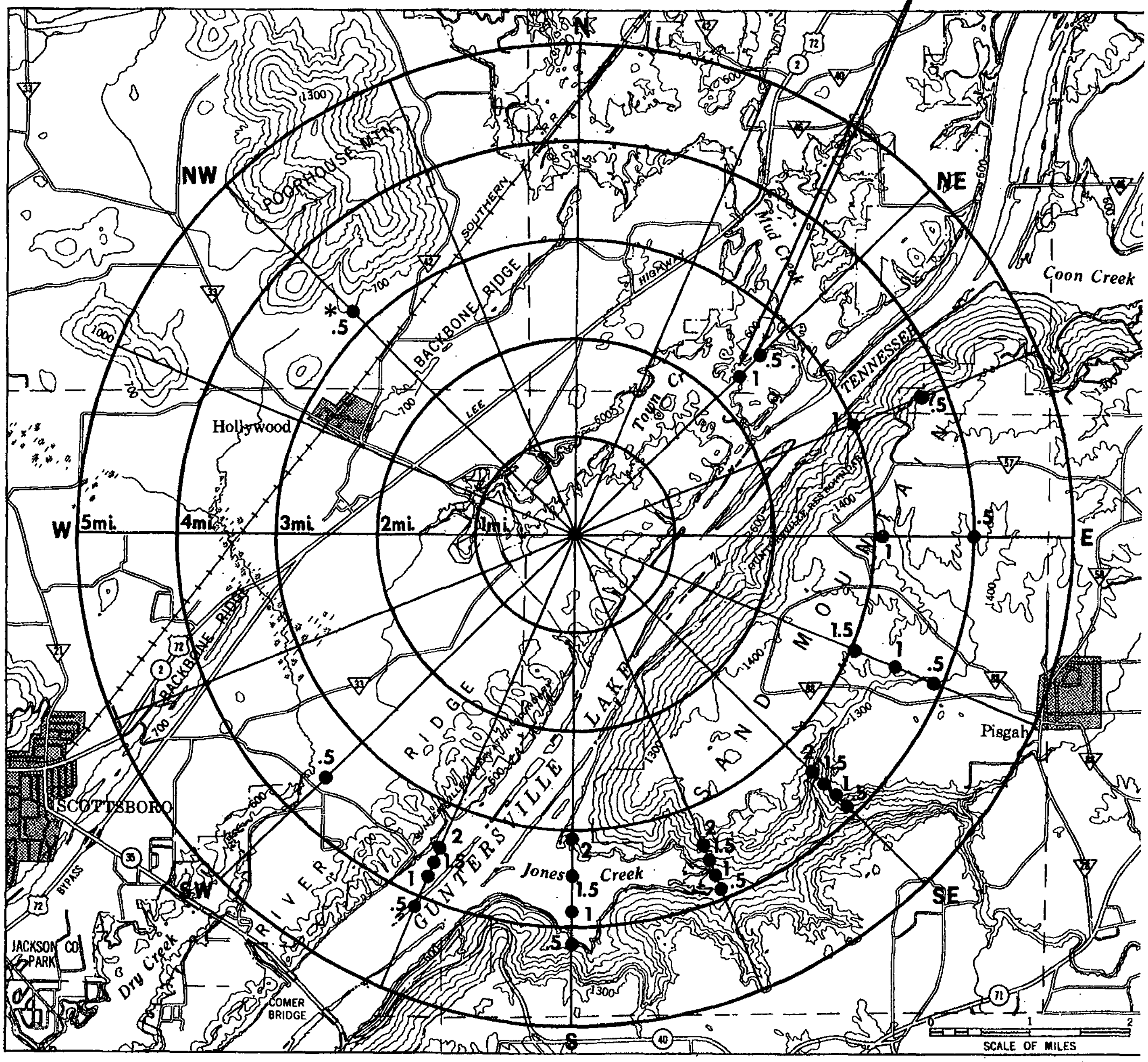


Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 4 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
(ALL TEMPERATURES)
NATURAL DRAFT COOLING TOWERS
BELLEFONTE NUCLEAR PLANT SITE

*Example: .5 percent of the time (2 days per year) plumes with lengths ≥ 3.2 miles occur in the 22½° sector northwest of site

Percent of total days in a yea



Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 5 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS (AMBIENT TEMPERATURE BELOW FREEZING) NATURAL DRAFT COOLING TOWERS BELLEFONTE NUCLEAR PLANT SITE

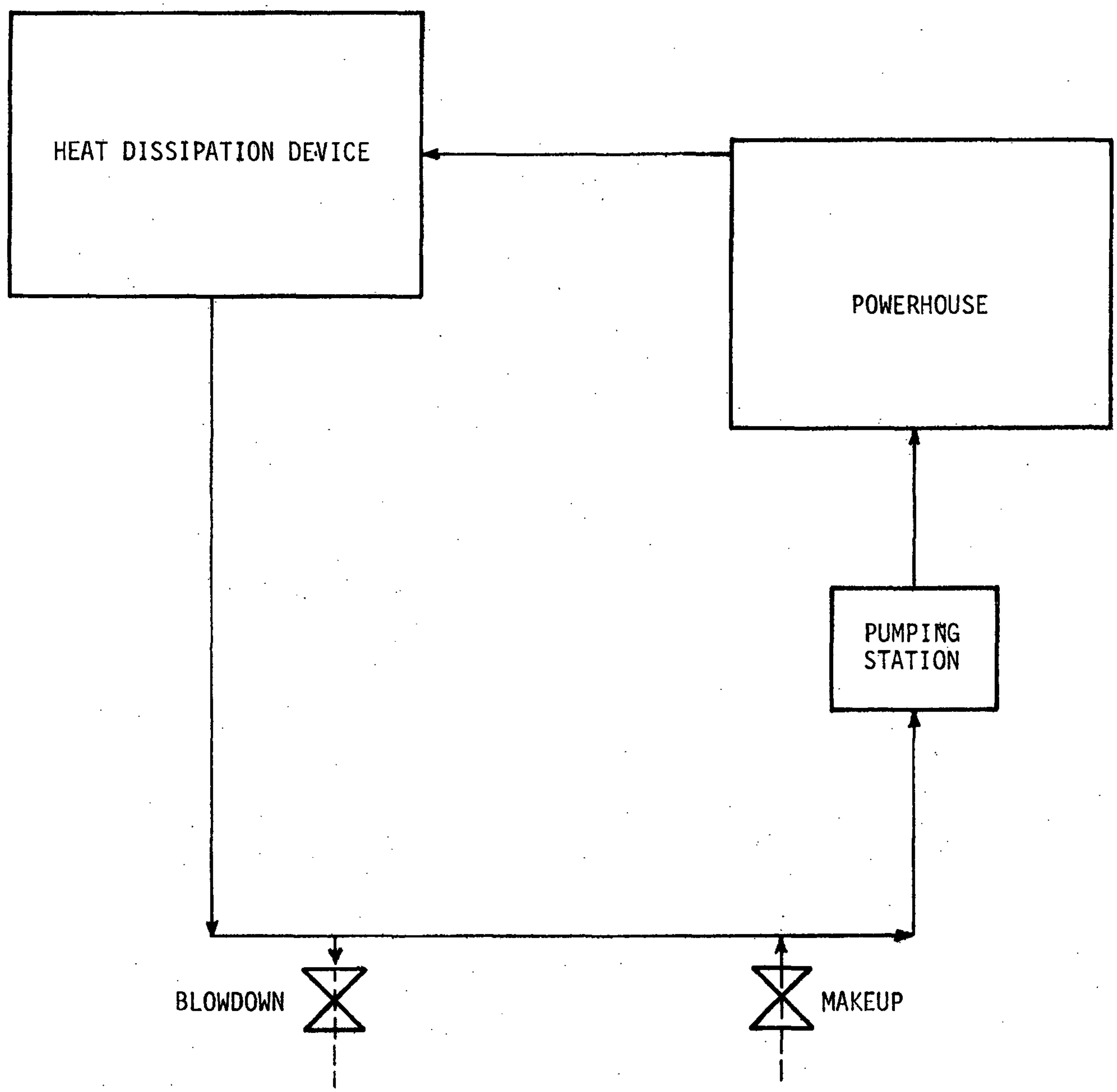
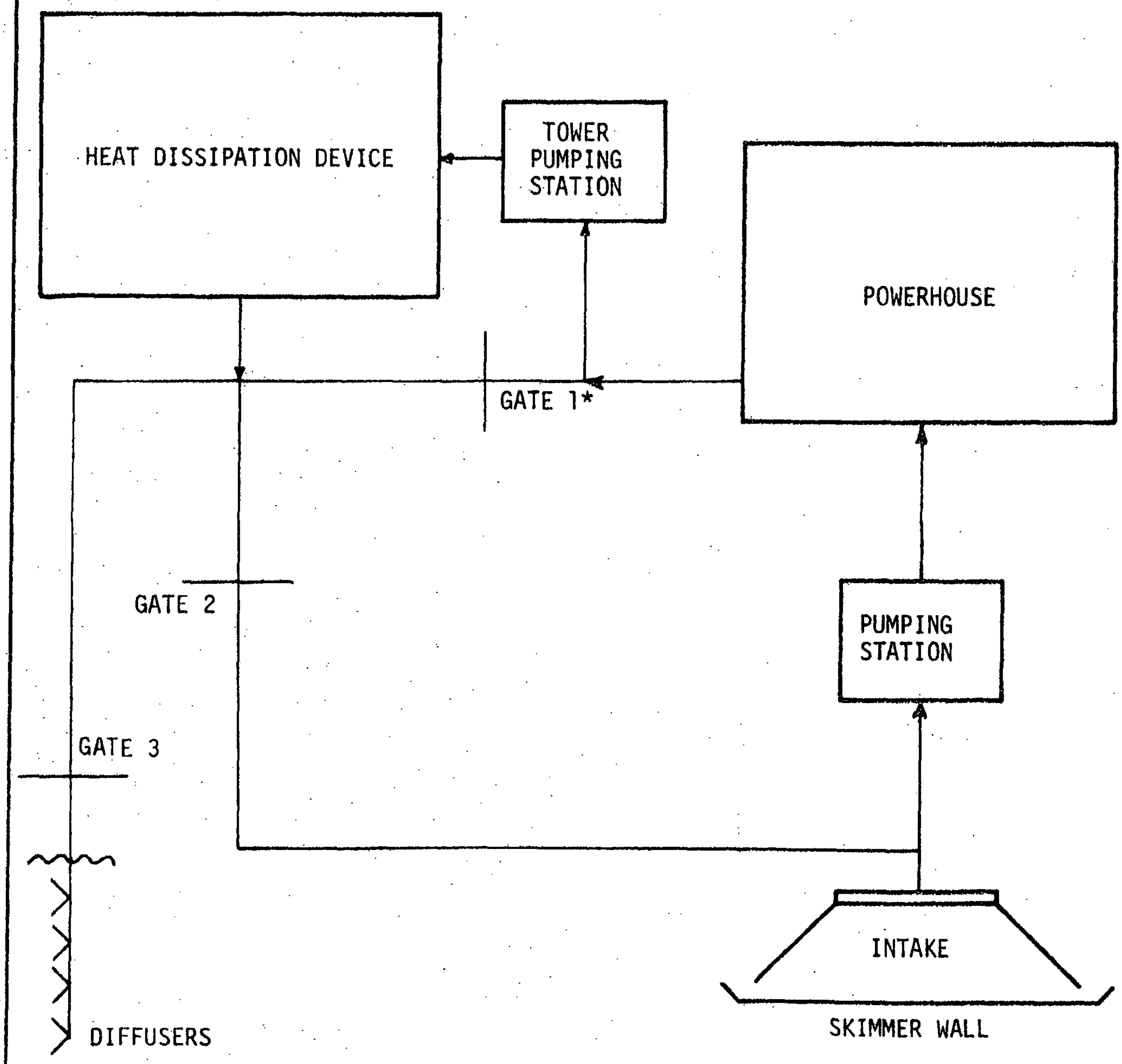


Figure 2.6-6

BELLEFONTE NUCLEAR PLANT
ALTERNATIVE COOLING SYSTEM
CLOSED-CYCLE SYSTEM
SCHEMES 1, 3, 5, 7



GATE NO.	1*	2	3
OPEN MODE	O	C	O
CLOSED MODE	C	O	C
HELPER MODE	C	C	O

*Gate for towers only

Figure 2.6-7

BELLEFONTE NUCLEAR PLANT
ALTERNATIVE COOLING SYSTEM
COMBINED COOLING SYSTEM
SCHEMES 2A, 2B, 4, 6

Figure 2.6 - 8

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
COOLING LAKE
SCHEME 1

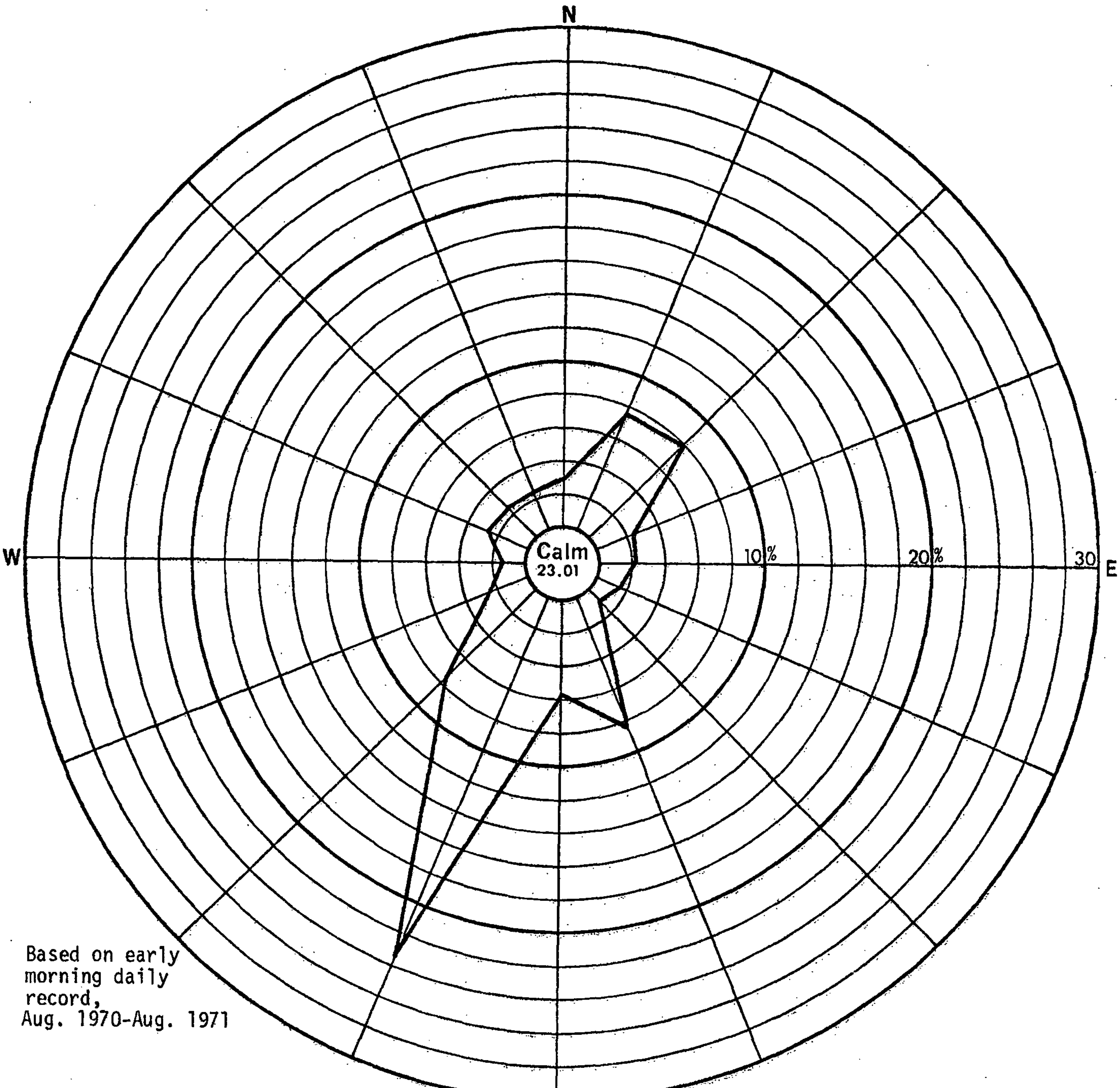
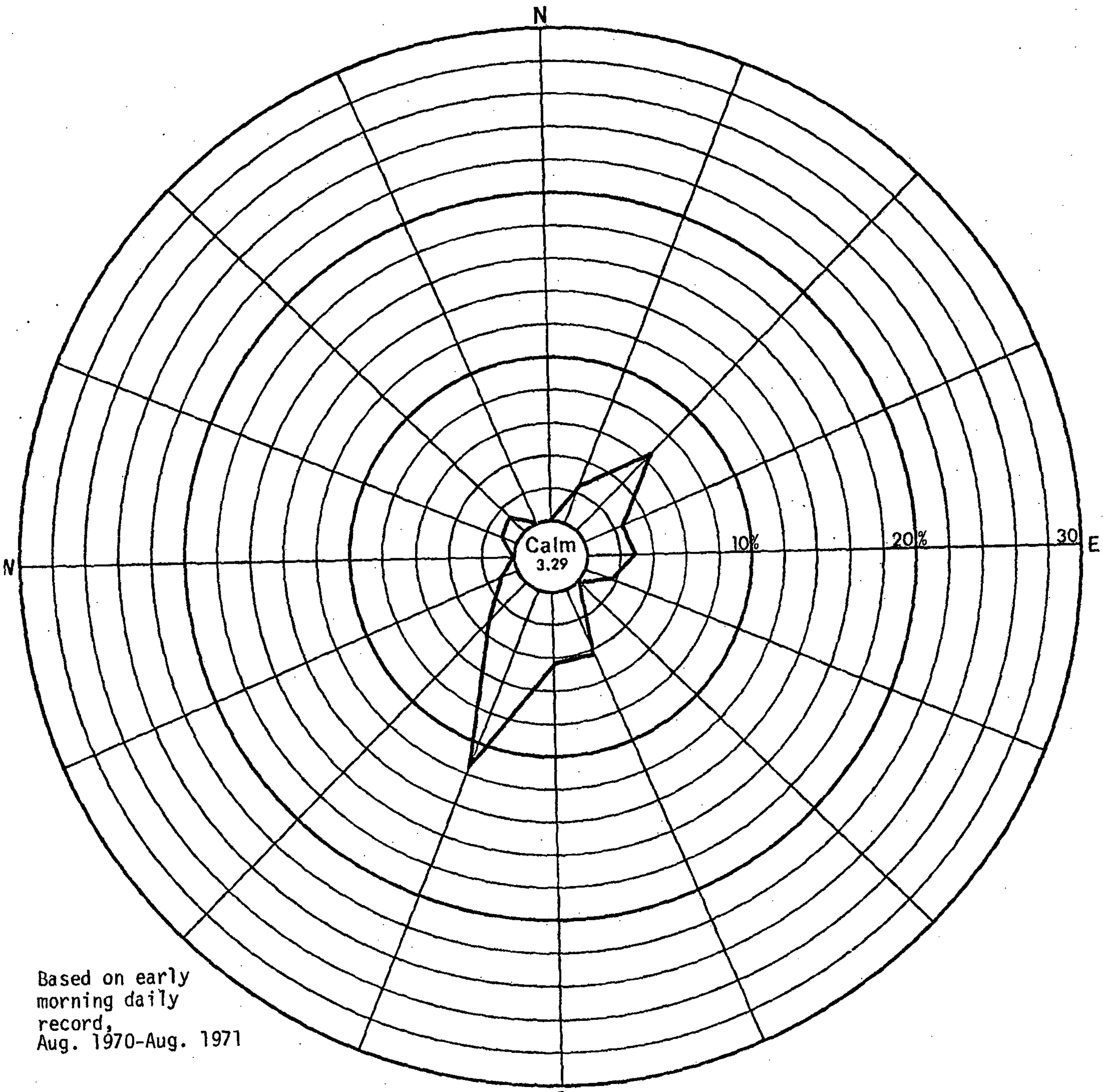


Figure 2.6-9
PERCENT OF OCCURRENCE - EXPECTED PLUME DIRECTION FOR 16 COMPASS-POINT SECTORS (FOR ALL TEMPERATURES)
COOLING LAKE - BELLEFONTE NUCLEAR PLANT SITE



Based on early morning daily record, Aug. 1970-Aug. 1971

Figure 2.6-10
PERCENT OF OCCURRENCE - EXPECTED PLUME DIRECTION FOR 16 COMPASS-POINT SECTORS (AMBIENT TEMPERATURE BELOW FREEZING)
COOLING LAKE - BELLEFONTE NUCLEAR PLANT SITE

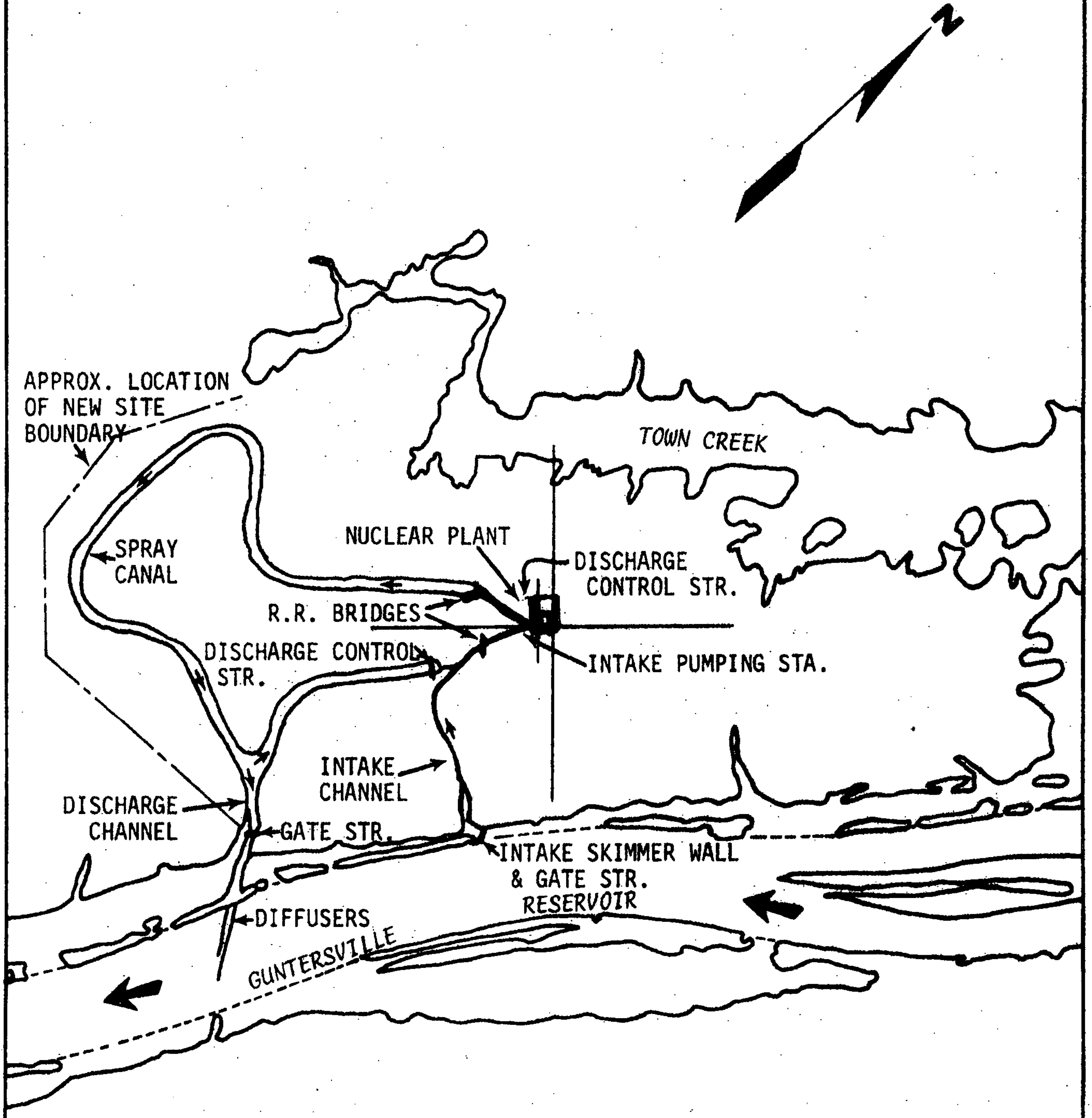


Figure 2.6-11

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
SPRAY CANAL-COMBINED SYSTEM
SCHEME 2A

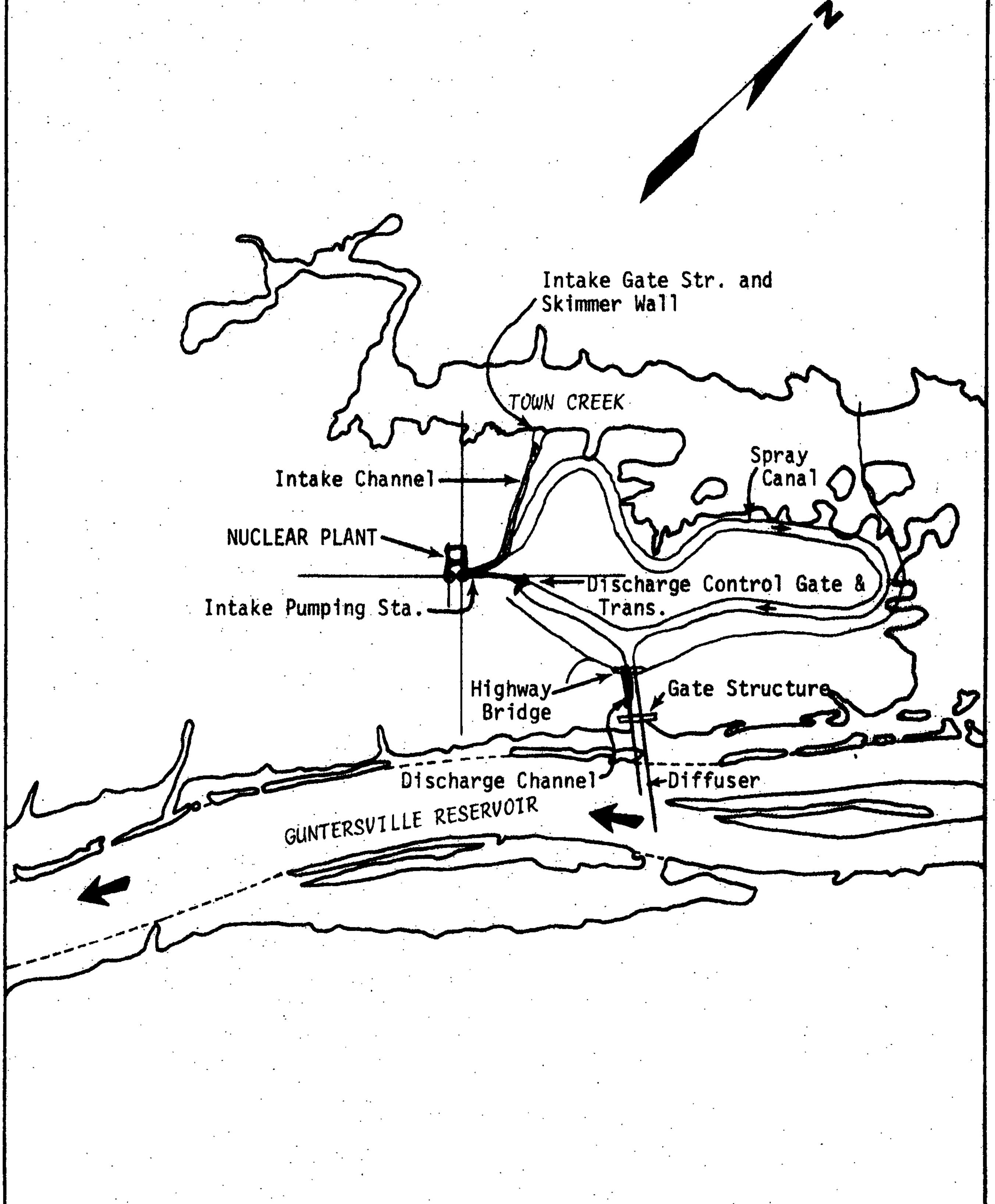


Figure 2.6-12

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
SPRAY CANAL COMBINATION SYSTEM
SCHEME 2B

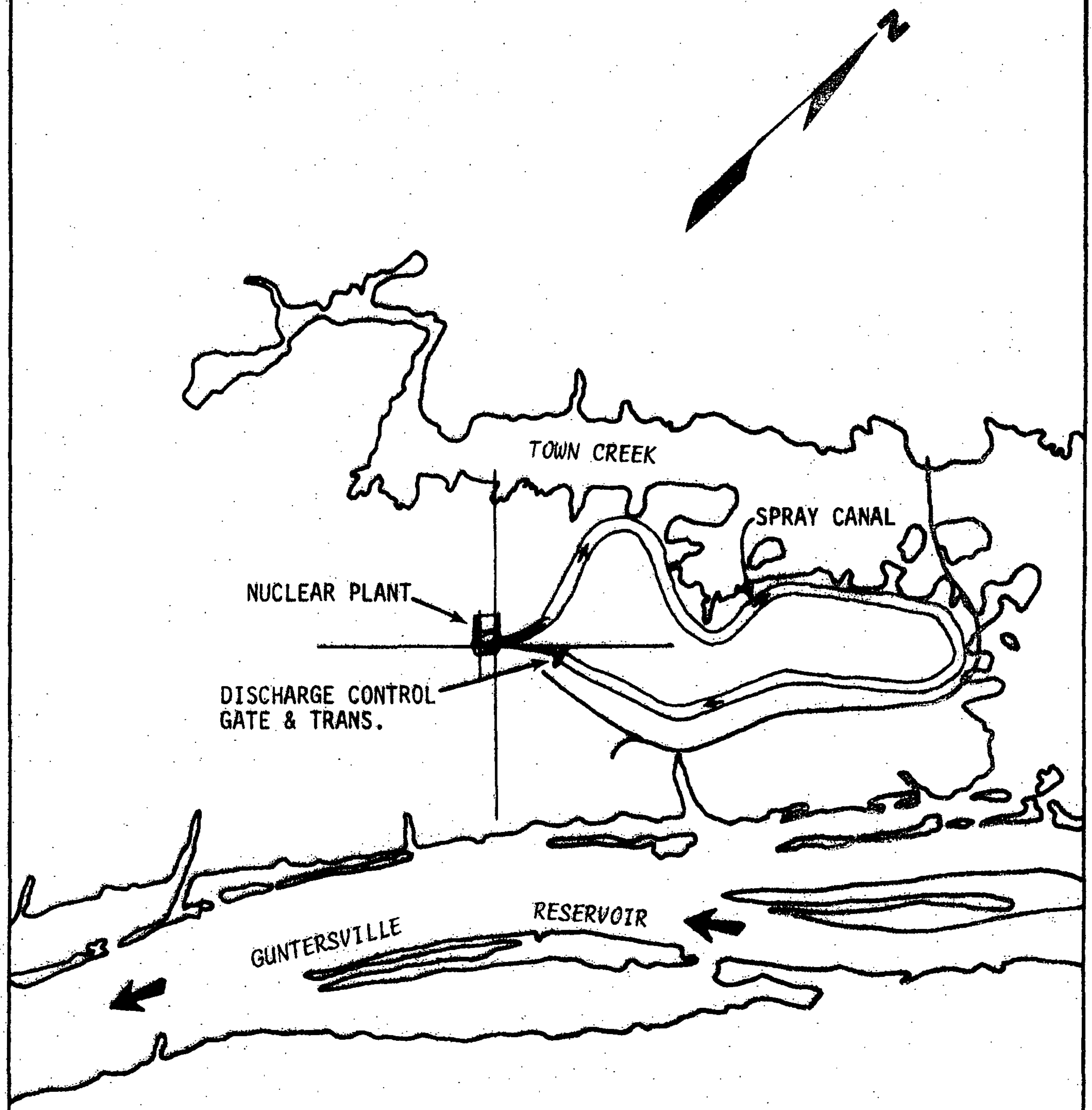
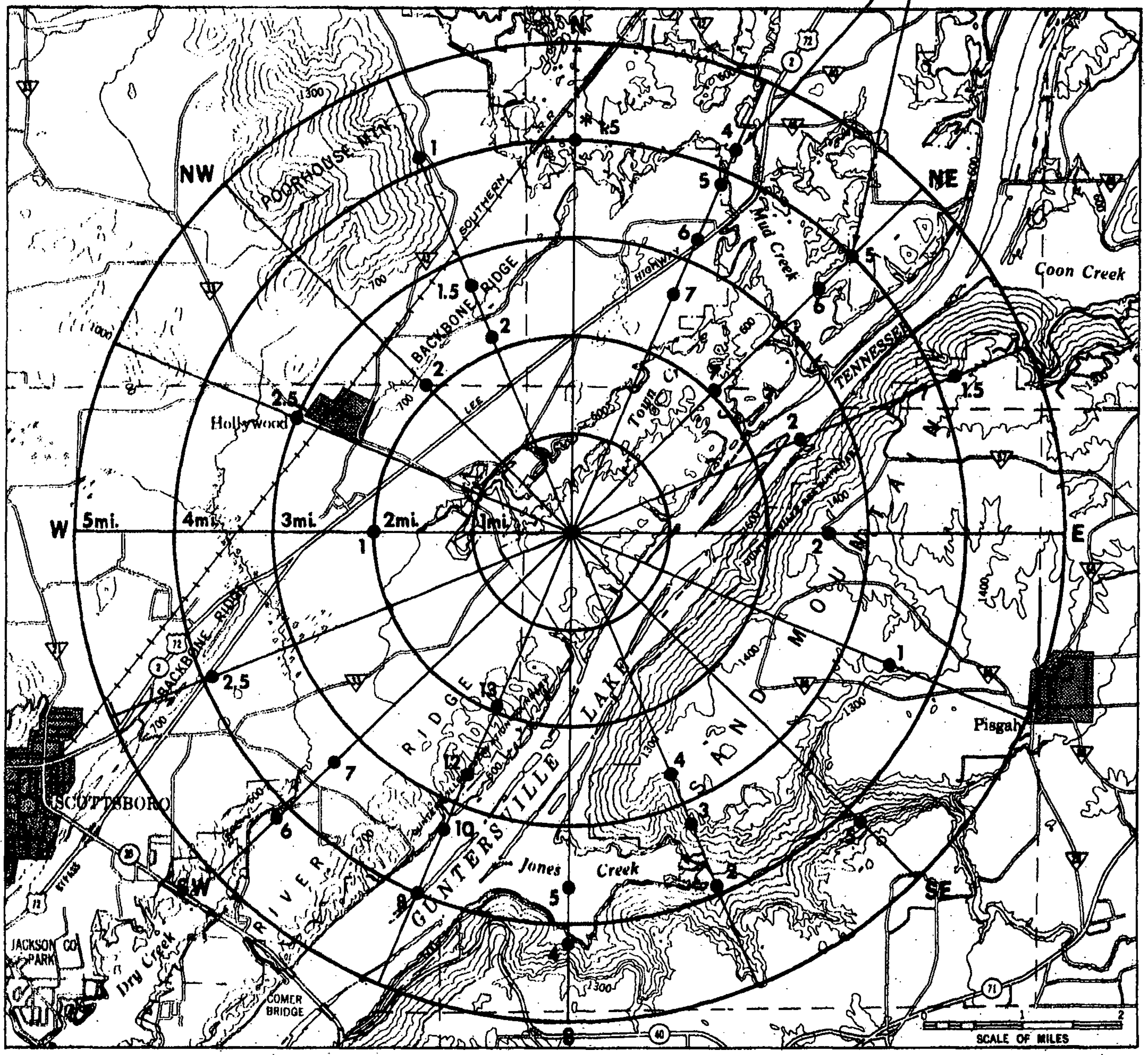


Figure 2.6-13

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
SPRAY CANAL CLOSED SYSTEM
SCHEME 3

* Example: 1.5 percent of the time (5 days per year)
plumes with lengths ≥ 4.0 miles
occur in the 22½° sector north of site

Percent of
total days in a year

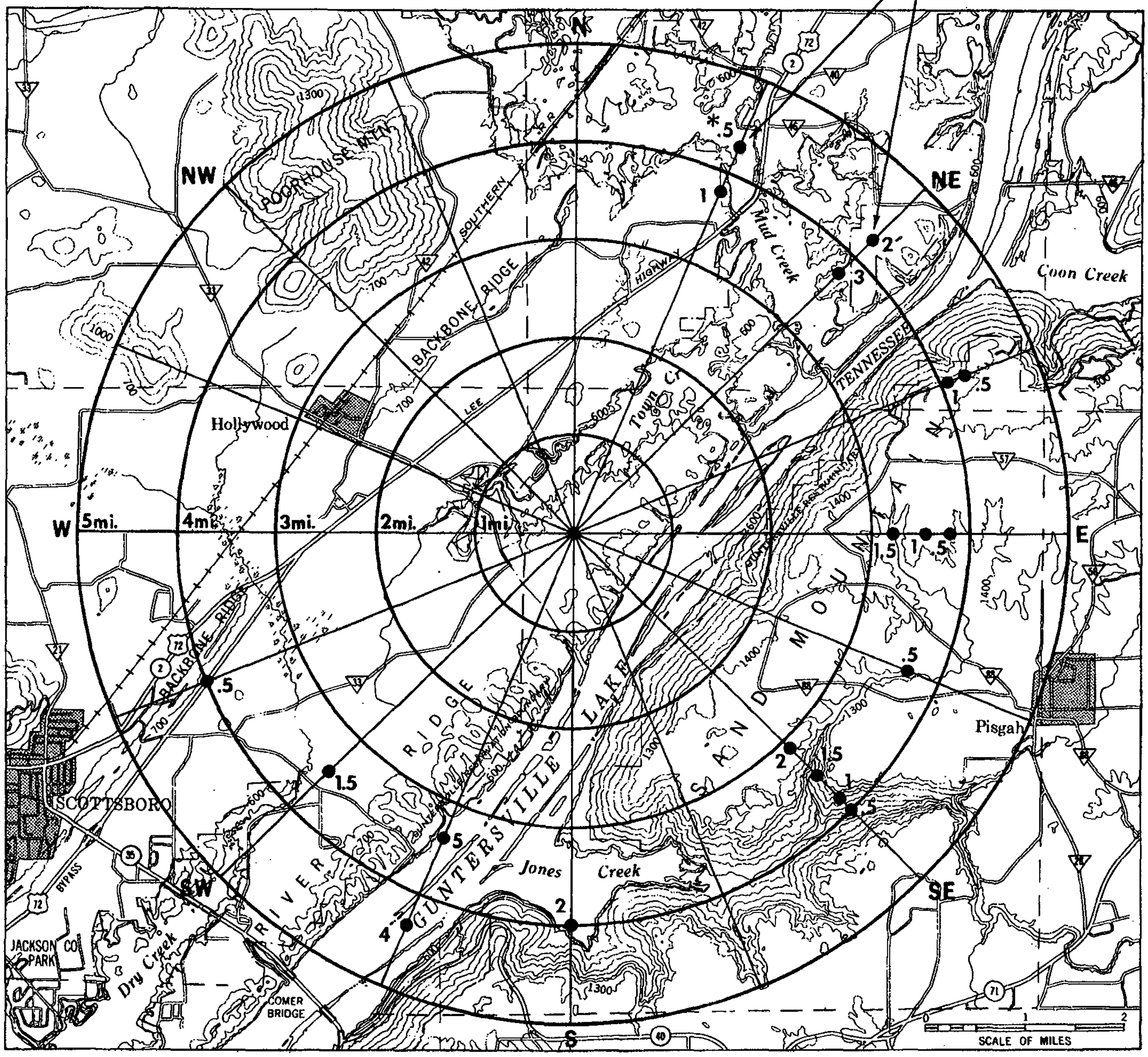


Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 14 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
(ALL TEMPERATURES)
SPRAY CANAL
BELLEFONTE NUCLEAR PLANT SITE

*Example: .5 percent of time (2 days per year)
plumes with lengths ≥ 4.3 miles
occur in the 22½° sector north-northeast of site

Percent of
total days in a year



Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 15 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
(AMBIENT TEMPERATURE BELOW FREEZING)
SPRAY CANAL
BELLEFONTE NUCLEAR PLANT SITE

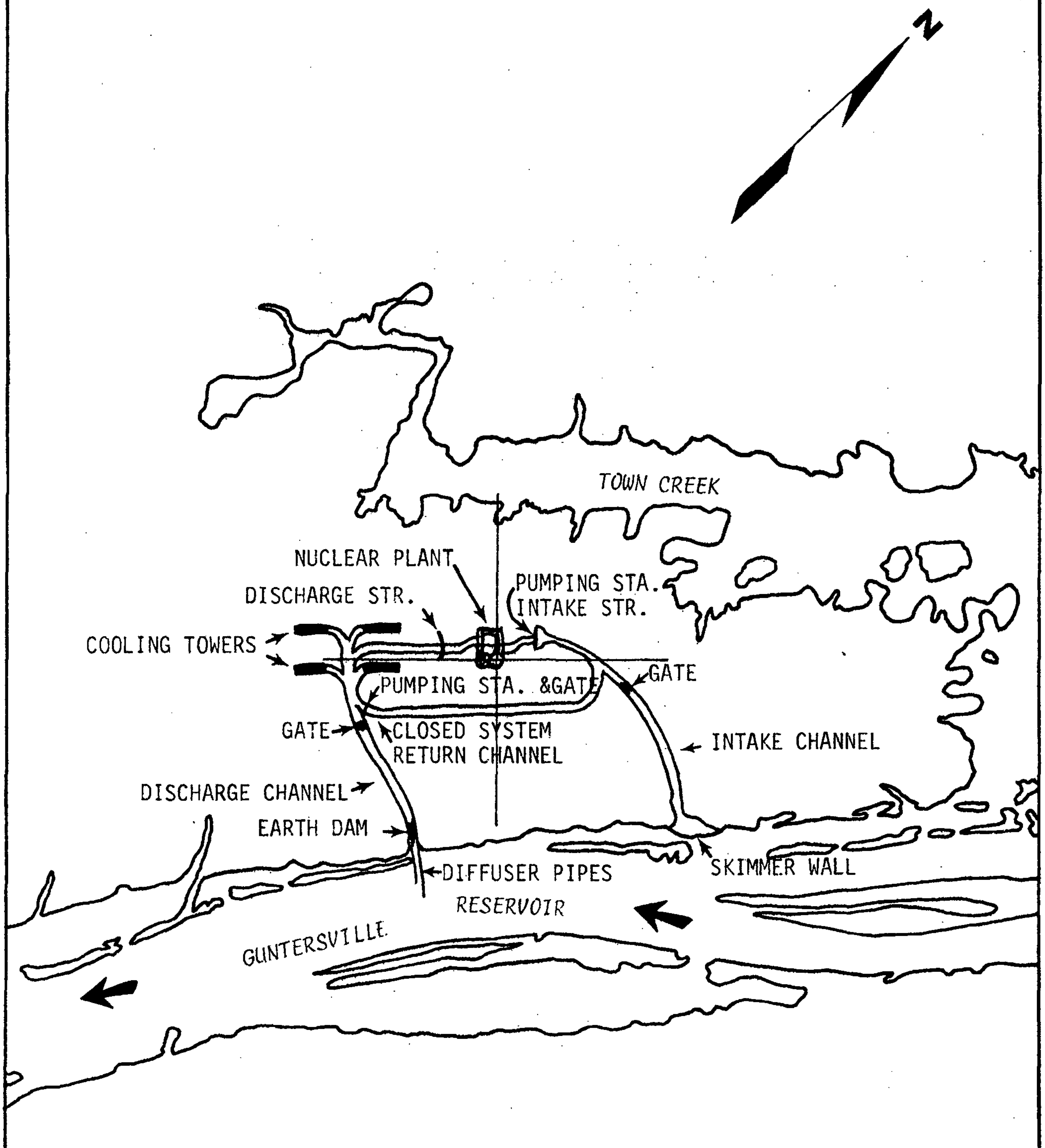


Figure 2.6-16

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
MECHANICAL DRAFT TOWERS-COMBINED
SYSTEM SCHEME 4

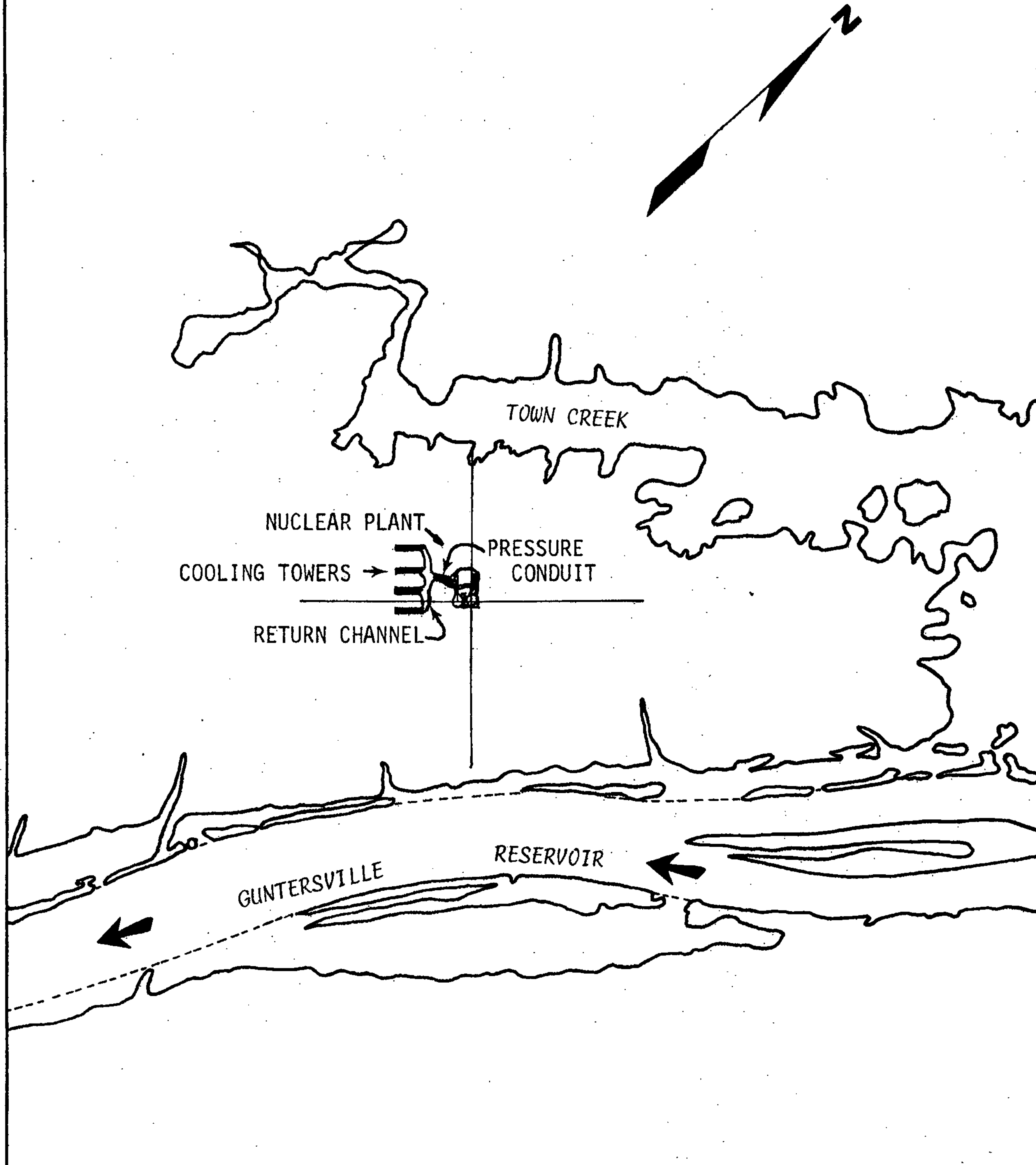
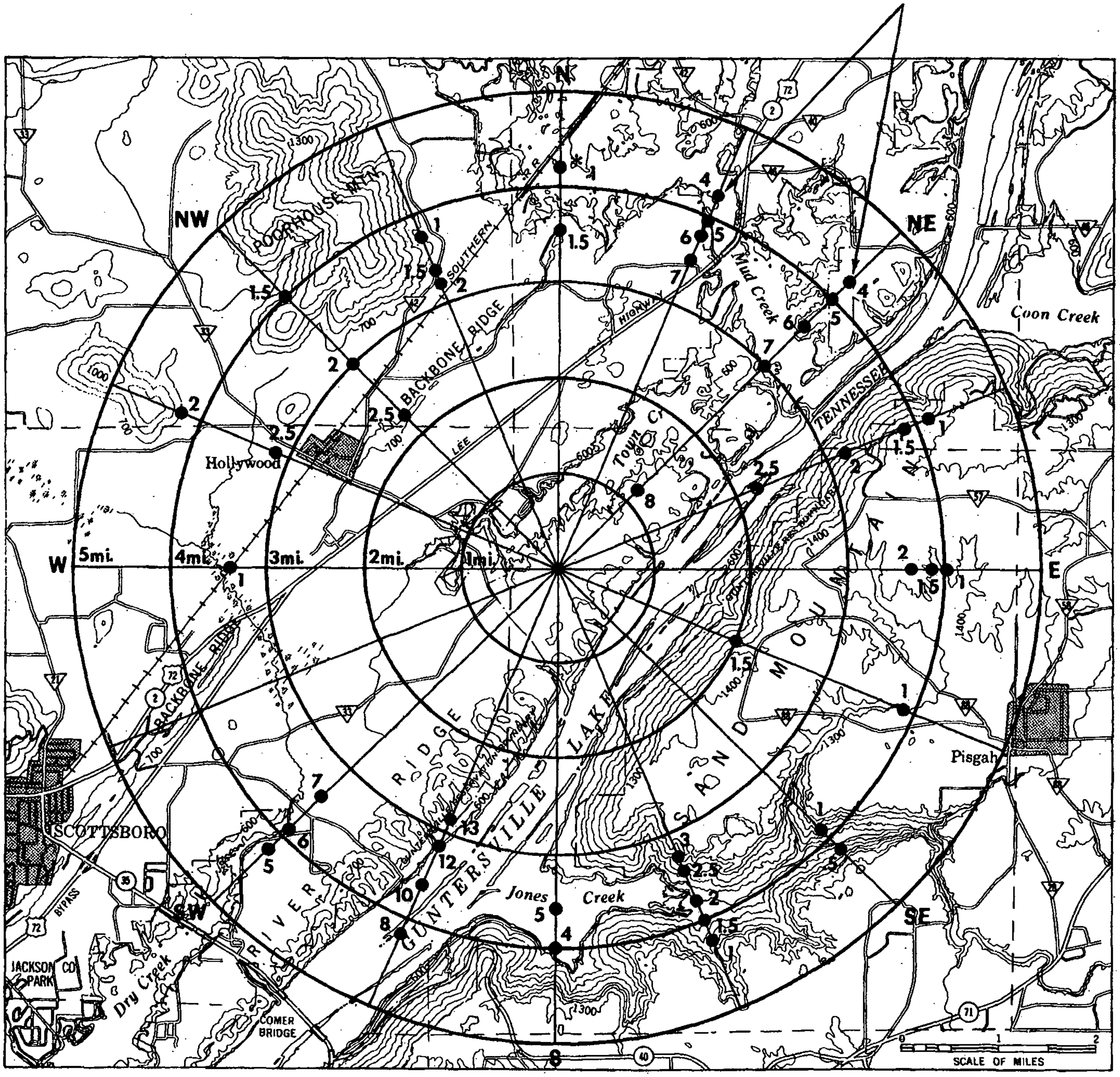


Figure 2.6-17

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
MECHANICAL DRAFT TOWERS
CLOSED SYSTEM SCHEME 5

*Example: 1 percent of the time (3 days per year)
plumes with lengths ≥ 4.2 miles
occur in the 22½° sector north of site

Percent of
total days in a year

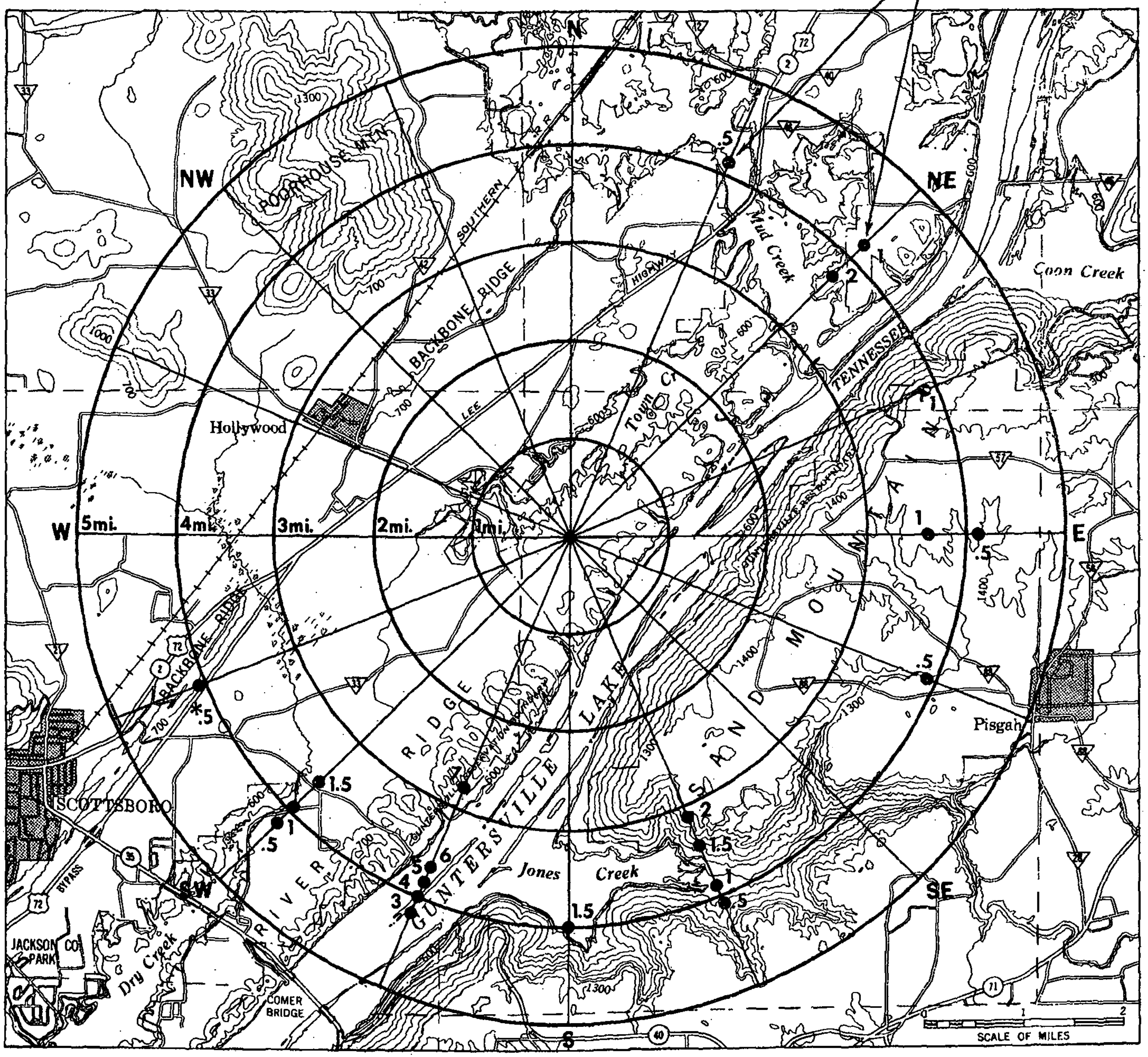


Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 18 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
(ALL TEMPERATURES)
MECHANICAL DRAFT COOLING TOWERS
BELLEFONTE NUCLEAR PLANT SITE

*Example: .5 percent of the time (2 days per year)
plumes with lengths ≥ 4.1 miles
occur in the 22½° sector west-southwest of site

Percent of
total days in a year



Based on daily early morning record
Aug. 1970 – Aug. 1971

Figure 2.6 - 19 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
(AMBIENT TEMPERATURE BELOW FREEZING)
MECHANICAL DRAFT COOLING TOWERS
BELLEFONTE NUCLEAR PLANT SITE

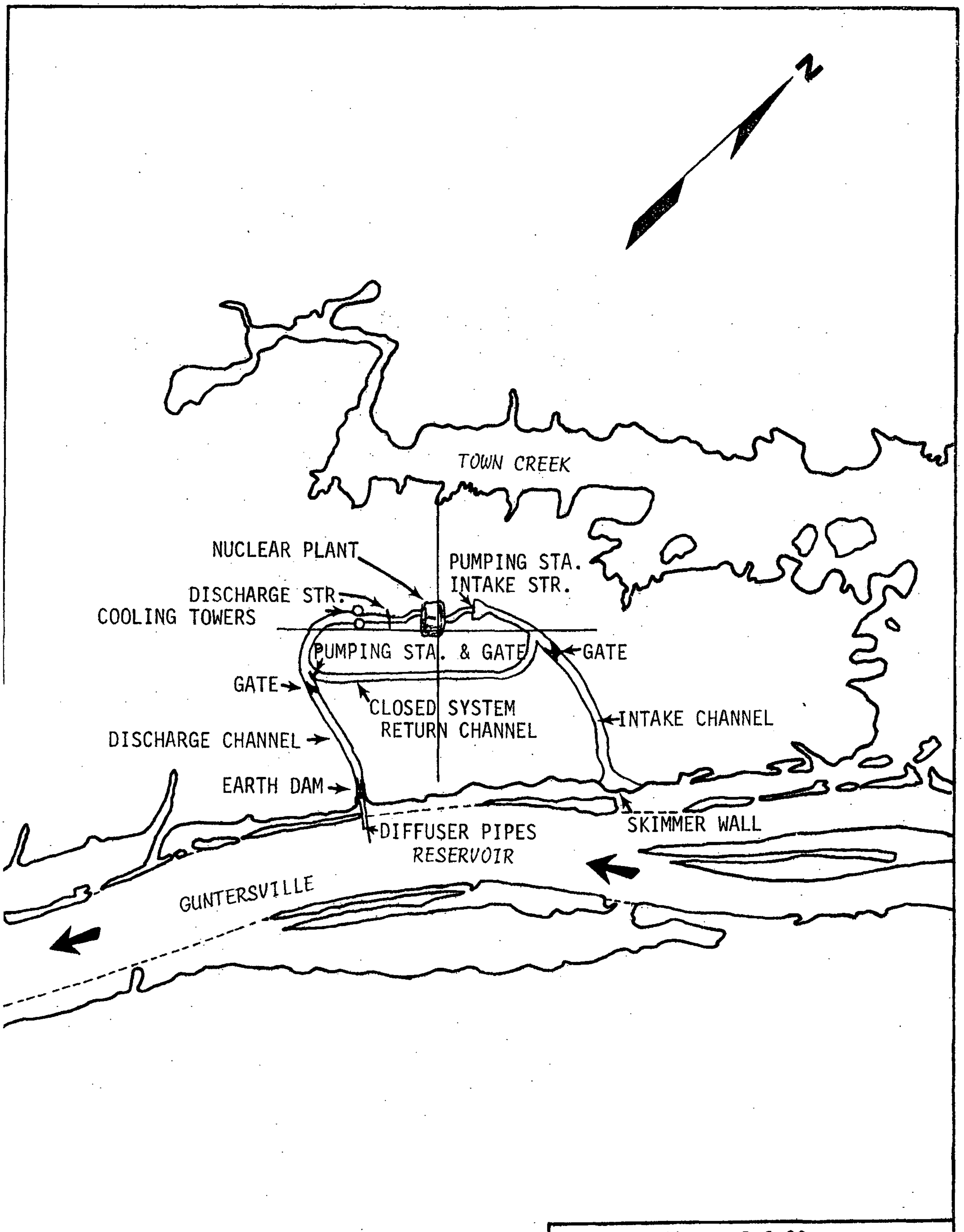


Figure 2.6-20

COOLING WATER SYSTEM ALTERNATIVE
BELLEFONTE NUCLEAR PLANT SITE
NATURAL DRAFT TOWERS
COMBINED SYSTEM SCHEME 6

2.7 Construction Effects -

1. General construction considerations - Initial construction work will include three main categories of construction activities: (1) general grading of the site; (2) construction of the "Construction Plant Facilities" including various shops, warehousing facilities, utility services, concrete mixing plant, administration buildings, roads, railroads, etc.; and (3) excavation of earth and rock in the area of the main powerhouse complex.

The next principal phase of work will be the permanent concreting program for all structures. This is planned to begin about 4 months after the initial construction activities.

Construction activities at the site will be planned to minimize undesirable effects, such as accumulation of scrap materials, burning of cleared brush and trash, and silting of the reservoir during any required dredging operations associated with intake channel excavation. Since there is very little timber and brush to be cleared from the site, air pollution resulting from the burning of this material will be minimal and of short duration.

Temporary construction buildings will be arranged in a neat and orderly manner to minimize land use requirements, to expedite construction operations, and to facilitate routine groundskeeping and houskeeping needs. Warehousing operations will be centralized at the project for surveillance and control purposes.

Because of the general cleared condition of the site it is anticipated that a total area of only 75 to 85 acres will be affected by tree cutting and clearing required for the construction area needs. Merchantable timber, if any, will be sold. No significant impact on forest resources will be caused by construction on the plant site.

Preliminary plans indicate an approximate earth excavation requirement in the main powerhouse complex of 170,000 yd^3. This material will be used for both construction plant and permanent plant fill requirements. The general methods described for protection against soil erosion and resultant siltation are generally those standardized type construction methods that have been used successfully over the years. However, as new techniques are developed which would give a better balance of reduction of environmental impacts and cost, TVA will use these techniques wherever their use is feasible.

Construction effects associated with offsite transmission facilities are discussed in section 2.2.

Following completion of the plant, the complete temporary construction facilities will be dismantled and all material will be disposed of, either through shipments to other TVA projects or by sale. The total construction area will be well landscaped.

(1) General clearing - TVA plans to acquire approximately 1,500 acres of land for the plant site. The land has been generally cleared by previous owners except for some 830 acres of woodland.

The main powerhouse complex is tentatively centered in a large previously cleared area. This complex, including the switchyard, takes in an area of approximately 90 acres with less than 35 percent of this area covered by trees and underbrush. Following is a tabulation of the approximate areas from which trees must be cleared for construction needs:

	Approximate Area Required (acres)	Approximate Area to be Cleared (acres)
Powerhouse complex including switchyard	90	31
Cooling towers	10	4
Railroad and access road	25	11
Construction plant shop and administration	50	2
Visitors' overlook	10	10
Parking lots	11	6
Warehouse and storage area	60	15
	256	79

The construction plant area is being designed to provide the maximum support assistance to the construction of the project. Clearing requirements were coordinated with the TVA Architectural Branch to avoid indiscriminate clearing and to provide screening of the construction area from public roads. Coordination of the construction project with architectural personnel assures that as many tree stands as possible will be left within the construction plant area for their aesthetic value where these will not create costly and dangerous obstacles to construction equipment and personnel movements.

Much of the wooded area will remain undisturbed unless major design changes create additional clearing requirements. Based on present design data available it is assumed that approximately 755 acres of woodland will remain undisturbed for the 2-unit installation. This comprises approximately 91 percent of the existing woodland.

(2) General grading and excavation - Current design information indicates the following grading and excavation quantities will be required in the construction of the Bellefonte Nuclear Plant.

	Grading and Excavation Earth (CY)	Excavation Rock (CY)	Backfill or Embankment (CY)
Main PH complex	170,000	-	385,000
Switchyard	0	-	256,000
General yard	-	-	117,000
Dikes and holding ponds	130,000	-	5,000
Intake channel	100,000	80,000	-
Pumping station	22,000	25,000	50,000
Visitors overlook area	16,000		13,000
Access highway	110,000		175,000
Access railroad	100,000		195,000
Construction plant	*		*

*Construction plant layout is not complete; however, the layout will be made so as to have a balance of cut and fill material.

Following clearing and removal of stumps, grading operations will be sequenced to remove and store topsoil prior to conducting a general grading and excavation program.

The initial grading operation will be to remove the overburden from the main powerhouse complex and cooling tower area down to final plant grade of elevation 628. Existing ground elevations in these areas range up to about elevation 642, requiring about a 14-foot cut at the maximum to reach plant grade. As can be seen from the above tabulation, earth material must be obtained from a borrow source to provide for the total fill material needed. On completion of the borrow operation, the borrow area will be graded to fit into the surrounding area and restored to a natural condition by seeding and mulching.

The next major operation will be the excavation of the powerhouse complex. Earth overburden will be removed by large rubber-tired panscraper units with the excavation outlines conforming to design drawing details. Usable material will be stored for future use and spoil material will be wasted in preselected areas where it will be graded to conform with the surrounding landscape, covered with topsoil, and seeded and mulched to avoid erosion.

On completion of the removal of earth overburden, foundation rock will be excavated by the presplit method with excavation outlines as required for the structure foundations. The rock will be broken up by small blasting charges and removed by use of power shovels and trucks.

Concurrent with the above excavation program will be the building of construction plant shop and service facilities for use in the construction of permanent plant features. Those temporary facilities will include the administration building; field offices; craft shops; concrete mixing plant; warehouse and storage yards; raw and treated water systems for fire protection, equipment cooling, drinking water, concrete mixing, etc.; service air systems; construction barge dock; substation and electrical distribution; sewage collection and treatment systems; roadways; railroads; etc. Timing for this work will be to complete the facilities required for service in starting the first permanent concreting operation about 4 months after starting initial onsite work.

Following the above operation, excavation will be conducted for the intake channel and pumping station for the essential raw water cooling and makeup system. A temporary dike will be constructed at the reservoir end of the channel to allow excavation to be conducted in the dry. Following completion of the channel and pumping station, flooding of the channel will be accomplished by pumping into the diked channel from the reservoir. The dike will be removed by panscrapers, draglines and/or clamshells, and by dredging. Breaching of the temporary dike will not occur until the water levels are equalized across the dike to avoid siltation wash into the channel areas.

To maintain an emergency cooling water supply at minimum reservoir water levels, the essential cooling water channel must be dredged to the main river channel. Dredging will be accomplished by a suction dredge with the spoil material being disposed of in an upland area to avoid excessive siltation of the reservoir. Siltation controls are being studied for consideration of use during the dredging program.

Design details at this stage are insufficient to indicate the extent of use of riprapping to control reservoir bank erosion.

2. Siltation control - General grading for both the construction plant area and the permanent plant area will be accomplished in accordance with grading plans developed by design and construction engineering personnel. Following clearing and grubbing, usable topsoil is removed and stored for future use in final landscape work. The topsoil will be stored in a manner to minimize loss due to

erosion. Grading work is accomplished according to the grading plans, which include the construction roadway system, drainage ditches, catch basins, sloping of areas to drain, and filled areas for construction shops and administrative office buildings. These grading operations are conducted to provide and maintain a controlled surface drainage system to minimize erosion and resultant silting of the reservoir. Certain methods of erosion control used in conjunction with a master grading plan include the use of berms, diversion dikes, check dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, special drains, and other control devices.

Since TVA performs most of its own work with force account labor, it very seldom becomes involved with contractor efforts to control erosion. This provides the means for strict control over construction phases which could result in environmental impacts. However, since the bases and support piling for the cooling towers are to be contract erected, TVA will enforce erosion control considerations as a part of the cooling tower contract requirements.

Also, since TVA performs most of its own grading operations, good control is maintained at all times over the amount of erodible material exposed. Inspectors working for the project management organization will control the extent of erodible material uncovered and direct the implementation of erosion control devices as deemed necessary to protect adjacent streams. These inspectors and/or engineers will insure that erosion control practices are reasonably current with the excavation, borrow, and grading operations.

The total project lies within relatively tight confines that will allow good current control by inspectors and engineers.

Some material which has been excavated will be stored in rolled sloped mounds to avoid saturation and erosion and to permit its later use as fill. Temporary construction sumps will be constructed in the powerhouse area for the diversion and control of runoff inside the excavated area. Water will be pumped to the yard construction drainage system and further treatment, such as settling pond use, will be effected, if required, to avoid excessive siltation of the reservoir.

Gravel will be used in the construction areas to provide cover for parking, storage, and work areas. Heavy rock bases are laid for construction roadways to avoid rutting and erosion from the use of heavy equipment. Side ditches are cleaned out periodically for proper drainage and side slopes are protected where deemed feasible by seeding, matting, or mulching.

Present plans indicate that the excavation of the intake channel to the essential cooling water pumping station is the major area of possible dredge or dragline operation which would have an undesirable effect on the quality of the water in the reservoir. As previously described, excavation of a portion of this channel will be conducted behind a dike which must eventually be removed by dredge or dragline and the remainder of the channel will be dredged to the main river channel. Special efforts will be made to minimize silting in the reservoir. However, a certain amount of turbidity and siltation is an unavoidable consequence of operations such as this, and fine control is very difficult to accomplish.

Appropriate siltation control methods will be utilized during construction of the blowdown diffuser to minimize siltation away from the immediate construction area.

3. Solid waste - Trees which must be removed that have no commercial value and stumps will be cut, piled, and burned. All burning will be performed in compliance with Federal, state, and local air quality regulations. There will be no burning of solid waste containing garbage. Metal, lumber scrap, and other salvable material will be collected for periodic sale and removal from the site. Broken concrete, rock, and residue from burning will be used as landfill material onsite. Other solid waste will be collected and disposed of by a private contractor in a state-approved sanitary landfill. The considerations made for disposing of solid wastes from the plant (section 2.5) will be followed in determining the ultimate disposal of these construction wastes.

4. Sanitary wastes - A temporary sewage treatment plant capable of handling the peak construction force sewage load will be installed and operated to meet applicable standards.

In addition, chemical toilets will be used in isolated or remote areas during the construction period, and the servicing contractor will be required to dispose of raw sewage in a manner which is environmentally acceptable. Generally, these wastes are collected in contractor-owned tank trucks and are hauled to a local community sewage treatment plant for disposal.

5. <u>Chemical cleaning</u> - Chemical cleaning operations prior to unit startup will be conducted to minimize releases to the reservoir and to ensure that any chemicals released have been neutralized and diluted to concentrations which are acceptable for discharge into the reservoir. Procedures for chemical cleaning are not final, but present plans are to clean piping systems and components before erection. Prior to startup or initial operation, systems will be thoroughly flushed: first with a weak solution of trisodium phosphate to remove grease, oil, or similar contaminants and any loose matter, and then given a final flush with filtered or demineralized water. The flush water will be discharged to holding ponds for further dilution and treatment to reduce any objectionable constituents to concentrations which are acceptable for discharge into the reservoir.

Procedures normally include the use of multiple ponds to allow for monitoring various degrees of treatment so that the final effluent to the receiving waters is within applicable water quality standards. Standard design and construction procedures will be utilized in regard to the pond dike system. All unconsolidated fill material will be removed from the dike foundations and the dikes will be constructed with clean impervious soil placed in layers and compacted with earth-hauling equipment. All pond areas will be stripped of vegetation and unconsolidated materials. No problems with either overflow or pond flooding are foreseen.

Flushing oils used during the cleaning process for transformer insulating oil systems and turbogenerator lube oil systems will be reconditioned for reuse or will be disposed of at some offsite location.

6. Miscellaneous - In addition to those considerations already discussed, the following miscellaneous effects have been identified.

A small river docking facility may be constructed to handle barge traffic into and out of the plant. This facility would be constructed with steel pilings to permit use of the facility throughout the lifetime of the plant if considered desirable. Only minor interference with recreational and navigational features is anticipated and this only when barges might be tied up at the dock. After the plant is constructed, the dock is expected to be used only intermittently, and no significant adverse impact on the use of waterways would be expected to occur.

To minimize effects of dust during construction, the use of tank trucks equipped with sprinkler equipment will be employed.

Excavation activities during construction may temporarily affect ground water movement in the immediate vicinity of the excavations, but the ground water movement should return to normal after construction is completed. No public or private use of ground water is expected to be affected due to construction of the plant.

Complete plans have not been developed at this stage for the furnishing of potable water for both the construction plant and the permanent plant needs. The site is located only about 7 miles from Scottsboro, which has a modern and adequate (3,500,000 gal/d) water supply system. It is anticipated that arrangements can be made to purchase potable water from Scottsboro. Construction needs would vary from a normal daily requirement of 30,000 gal/d (assuming use in concreting operations) up to a peak use of 250,000 gal/d during startup periods for the plant where high water usage is required in the plant flushing and cleanup cycles. Use of water from Scottsboro would require that 3 miles of 8-inch pipe main be constructed along U.S. Highway 72 north of Scottsboro to a point where TVA would connect. This would also make treated water available along the route of the pipeline to many people who do not now have treated water service.

Raw water for construction needs in fire protection, equipment cooling, and other services will be pumped from the reservoir using a temporary pumping station located slightly offshore near the plant site.

7. Impact of construction traffic - There will be two access roads to the site during most of the construction program, one via existing roads south of the plant site and a new permanent access road from U.S. 72 north of the site. Initially most all traffic will enter the project area via the existing highway which passes through the old townsite of Bellefonte. By the time the construction force reaches 1,000 employees (est. 450 cars) the new access road should be open to traffic. After this occurs employees living north of the plant site will likely use the new road while those living to the south will continue to use existing roads leading to the south entrance. The Division of Construction plans no new road construction or general upgrading of existing roads in the Bellefonte area; however, some repairs may be required due to abnormal use during the construction program. Responsibility will be determined on an individual basis with local highway officials at the appropriate time. At peak of activity

it is estimated that TVA and contractor employees will drive about 1,200 vehicles to work.

Since most of the heavier items of permanent equipment will arrive by rail or barge shipment, numerous equipment deliveries by motor freight are not expected. Approximately one-half of these will enter the project site through the south entrance assuming interchange with a local carrier with terminal facilities in Scottsboro. Concrete aggregates, cement, etc., will require many shipments, and quite likely these also will be by truck.

2.8 Socioeconomic Impact - Population in the area will continue to grow along with the industrial growth in the region. Construction of the Bellefonte Nuclear Plant will have a twofold impact on the surrounding area. First, there will be the temporary impact of construction employees who move into the area to work on the project. Second, permanent employees to supervise, operate, and maintain the plant will also be moving into the area.

This section includes estimated data of the construction employees' impact and the projected schedule for permanent employment.

1. Construction employment impact - One impact of the construction of the Bellefonte Nuclear Plant will be attracting workers who will move into the area of the plant site, thereby providing a temporary stimulus to the economic growth of the area. The two main concerns are housing and schools, although other public and private facilities will be affected.

Workers moving into the area are estimated to comprise between 25 and 30 percent of the total construction work force. In general, the lower percentage will apply during the initial and final stages of construction. The higher percentage will be approached as the work force includes larger numbers of workers with specialized skills not available in the local work force.

Approximately 45 percent of those workers moving into the area are expected to buy or rent houses. An additional 35 percent are expected to buy or rent mobile homes and the remaining 20 percent probably will rent apartments or sleeping rooms.

Workers who move and bring their families should make up about 70 percent of all workers moving into the area. The remaining 30 percent should be mostly single men or men who will live in the area during the week and return home on weekends. On the average, workers who bring their families will have about one school age child per family.

The Scottsboro-Hollywood area can be expected to absorb approximately 70 percent of the impact from movers. An additional 20 percent will be distributed in Browns Valley as far south as Guntersville and to the north as far as Bridgeport. The remaining 10 percent will be scattered among the small communities on Sand Mountain and the Cumberland Plateau which have good access to the site.

Using the percentages discussed above, impact estimates were prepared for selected employment levels (1,000 and 2,000 men) to provide some typical figures. These estimates are contained in Table 2.8-1. This table does not include estimates for effects on service-related functions such as housing construction, additional stores and businesses, etc. Table 2.8-2 contains the projected construction employment to help estimate the timing of the impact.

The following discussion details the estimated impacts due to an additional employment of 2,000 workers in Jackson County.

(1) Population impact - The 1970 population of Jackson County was 39,202 and the Scottsboro-Hollywood total was 9,625 (Scottsboro 9,324 and Hollywood 301). Thus, the total population influx of 1,400 is 3.6 percent of Jackson County's population and the 980 people locating in Scottsboro-Hollywood is a 10.2 percent

increase. Due to the potential for growth in Jackson County and especially Scottsboro - Hollywood, this population influx should be accommodated with no significant adverse impact.

(2) Impact on schools - According to the Economic Atlas (October 1972) prepared by the Top of Alabama Regional Council of Governments, the 1970-71 enrollment in Jackson County schools was 6,959 and in Scottsboro 3,183 for a total of 10,142. Approximately 250 additional school age children are expected in the Scottsboro - Hollywood area at an employment level of 2,000. Assuming they all went to Scottsboro schools, this would be a 7.9 percent increase in enrollment. The remaining 170 distributed among other Jackson County schools total a 2.4 percent increase.

Normal growth in the area can be expected to create physical facilities sufficient to accommodate the additional students and only the additional expenditure for instruction will be estimated. According to the Economic Atlas, cited above, Scottsboro had a per capita expenditure for instruction of $345.54. Thus, 250 additional students would indicate an increase of about $86,500 in expenditures for instruction. The 1970-71 total for Scottsboro was $1,099,857.66.

(3) Impact on Economy; Personal Income - In 1969, personal income in Jackson County totaled $87,872,000 (BEA - Department of Commerce). An average annual wage of $10,000 earned by the 600 workers moving into the area would be $6,000,000 which is about 6.8 percent of the total. This magnitude of increase of resulting economic activity is expected to be within the capabilities of existing establishments to handle without expansion or significant increase in personnel.

(4) Impact on Economy; Wholesale Trade - TVA's experience at Browns Ferry indicates that about 0.5 percent of the construction cost of a nuclear plant is spent on purchases and special contracts in the "local economy." "Local economy" is a variable term depending upon the item or service to be purchased. At Bellefonte, Scottsboro may provide certain generally available goods and services while Chattanooga or Huntsville might be the nearest source for more specialized needs. However, the basic evaluation is to determine whether or not the additional demand on the economy might create a "boom and bust" situation with its attendant hardships and economic dislocations. Therefore, for purposes of evaluation, the total expenditure is assumed to be made in Jackson County.

Wholesale trade in Jackson County totaled $16,945,000 in 1967 (Economic Atlas). Based on the Browns Ferry study, the average annual expenditure in the local economy due to construction of the Bellefonte Plant is expected to be approximately $500,000, which is about a 3 percent increase in annual wholesale trade. This level of increase would be within the range of existing establishments to accommodate without significant physical or personnel expansion. Thus, the infusion of this additional economic activity as well as that produced by increased personal income is not expected to create conditions which might produce an economic "bust" when construction is completed.

(5) Impact on housing - Tables 2.8-4 and 2.8-5 present various data on vacant housing in the Bellefonte area and larger regions. Numbers are contained in Table 2.8-4 to give an indication of the actual housing available. Percentages are given in Table 2.8-5 to enable some comparison of relative availability with the

201-County Tennessee Valley Region and the 16 Alabama counties in the region. Data are shown for all vacant dwelling units and those vacant dwelling units which have complete plumbing. Plumbing is used as a surrogate for housing quality since the 1970 Census did not include this evaluation.

A substantial number and percent of vacant dwelling units are in the category "Other" which means that they are not in the market for various reasons. Thus, for example, over one-half (94 out of 176) of the vacant dwelling units in Scottsboro are not available to a prospective tenant. For that reason, a better picture of housing availability is obtained by examining only those for rent or for sale.

In general, there are relatively fewer dwellings available for rent or for sale in the Bellefonte area than in other areas of the region. An exception is Stevenson's 3.50 percent rate of vacant-for-rent dwelling units. However, the total number of 28 is very small in terms of supplying the projected need. In general, this "tight" housing situation is expected to continue for some time due to continued economic growth which is expected to attract additional population into the area.

From 1960 to 1970, there was a spectacular growth in mobile homes in Jackson County which reflects, in part, the lack of suitable conventional housing. In 1960, there were 91 mobile homes (0.9 percent of the housing stock) while in 1970 there were 1,004 (8.4 percent of the housing stock). The 8.4 percent is about twice the percentage of mobile homes in the Tennessee Valley region (4.1 percent) and in the 16 county area (4.8 percent). Of the 1,004 mobile homes in Jackson County, 212 are in Scottsboro, 74 in Stevenson, and 67 in Bridgeport.

Housing choice estimates in Table 2.8-1 can be considered the "demand" and housing vacancy information in Table 2.8-4 can be considered an indication of "supply". It is clear that the supply is not close to meeting the demand for dwelling units at the 2,000-employee level. This is based on the available vacant housing with plumbing in Scottsboro, Bridgeport, and Stevenson (85-90 dwellings compared to the demand for houses plus apartments - 390). Given the time lag between the 1970 Census and the projected demand for housing, adjustments in the housing market can be anticipated.

First, the demand pressures can be expected to accelerate construction of housing in the area. Due to the continued growth anticipated in the Bellefonte area, this could have a positive effect on the supply of standard housing after the peak of construction without creating an oversupply which could depress the market. Second, some adjustment in demands might occur to increase the demand for mobile homes and reduce demand for conventional housing. The data on mobile homes between 1960 and 1970 indicate an adequate marketing system and the existence of substantial concentrations in the towns indicate a level of management expertise sufficient to cope with additional demand. On the other hand, if the present proportion of mobile homes is a peak, the demand created during construction could tend to stabilize the mobile home developments.

(6) Impacts on traffic - An estimated 1,200 cars will travel to and from the plant site at the peak of construction. The 1970 average daily traffic on U.S. Highway 72 past

the plant site was about 3,700 (1970 Alabama Traffic Flow Map). Thus, the traffic near peak employment will be significantly increased and some congestion and delay is expected. However U.S. Highway 72 will be four-lane past the site before the start of construction which will provide increased carrying capacity and tend to reduce the effects of the increased traffic load on regular users.

2. Permanent employment impact - Various factors require that permanent operating personnel be onsite during the last half of the construction phase of the plant. The permanent supervisory, operational, and maintenance work force will eventually stabilize at around 170 people. Table 2.8-3 shows that these people will start working there very near the point of peak construction employment and will all be employed about 2 years before the estimated completion of construction. Their impact on the area will be in addition to that of the construction employees. Although this will place an additional demand on the services of the area, it will also provide an economic stimulus. At current salary scales, the combined work force can be expected to have an annual payroll of about $2 million.

There are no previous surveys to provide a basis for estimating permanent employee housing choice, family size, or family composition. However, it should be noted that this group will choose a place to live on a somewhat different basis than construction workers. Whereas construction personnel may be willing to sacrifice urban services and convenience due to the relatively short time they will be living in the area, permanent employees will be more reluctant to do so. In addition to housing, they will be looking for good schools, adequate medical facilities, and convenient shopping.

3. Mitigation of impacts - In addition to those consultations with local and area officials described in section 1.4, future meetings with local leaders are planned to discuss school requirements and increased assistance for education, sewage collection and treatment, solid waste management, improvement of health services, and industrial development. TVA will continue to work with state and local officials and civic groups throughout the construction and operation of Bellefonte Nuclear Plant to mitigate possible adverse socioeconomic impacts caused by the project. When construction begins on the Bellefonte Nuclear Plant, detailed and up-to-date information regarding the availability of housing will be acquired by TVA to assist employees in locating safe and sanitary dwellings. Until then an indication of housing availability in the Bellefonte area can be obtained through data from the 1970 Census of Housing (Table 2.8-4).

Table 2.8-1

ESTIMATED POPULATION EFFECTS

BELLEFONTE NUCLEAR PLANT CONSTRUCTION EMPLOYEES

	Employment Level	
	1,000	2,000
Percent Movers	25	30
Number of Movers	250	600
Demand for:		
Houses	110	270
Mobile Homes	90	210
Apartments and Sleeping Rooms	50	120
Movers with Families	180	420
Movers without Families	70	180
School-Age Children	180	420
Total Population Influx	600	1400

Table 2.8-2

PROJECTED CONSTRUCTION EMPLOYMENT

BELLEFONTE NUCLEAR PLANT

Month		Projected Employment
July	1974	0
October	1974	100
January	1975	450
April	1975	600
July	1975	850
October	1975	1,010
January	1976	1,150
April	1976	1,350
July	1976	1,500
October	1976	1,670
January	1977	1,850
April	1977	2,040
July	1977	2,150
October	1977	2,270
January	1978	2,250
April	1978	2,300
July	1978	2,240
October	1978	2,200
January	1979	2,070
April	1979	1,850
July	1979	1,660
October	1979	1,380
January	1980	1,090
April	1980	830
July	1980	630
October	1980	420
January	1981	300
April	1981	100
July	1981	0

Table 2.8-3

PROJECTED PERMANENT EMPLOYMENT

BELLEFONTE NUCLEAR PLANT

Month		Projected Employment
April	1978	10
July	1978	30
October	1978	50
January	1979	70
April	1979	90
July	1979	155
October	1979	170 (Expected Total Permanent Employees)

Mean annual salary based on present pay scales is about $11,250.

Table 2.8-4

BELLEFONTE NUCLEAR PLANT

HOUSING VACANCY INFORMATION[a]

JACKSON COUNTY AND SELECTED COMMUNITIES

	For Sale	For Rent	Other[b]	Totals
Jackson County				
Number	68	249	589	906
Average Value or Monthly Rent	$13,325[c]	$45	-	-
With all plumbing	47	90	341	478
Bridgeport				
Number	5	18	22	45
Average Value or Monthly Rent	$ 8,150	$48	-	-
With all plumbing	4	14	17	35
Scottsboro				
Number	28	54	94	176
Average Value or Monthly Rent	$19,925	$59	-	-
With all plumbing	25	30	81	136
Stevenson				
Number	4	28	20	52
Average Value or Monthly Rent	e	$34	-	-
With all plumbing	e	12	17[f]	29

a. The source is the 1970 Census of Housing. This data covers vacant dwelling units suitable for year-round occupancy. Vacant seasonal dwelling units are excluded.

b. Includes housing units: (1) sold or rented but awaiting occupancy; (2) held for occasional use; or (3) not on the market for some other reason, e.g., awaiting settlement of an estate, or personal reasons of owner.

c. Average value is based on 56 housing units since value is tabulated only for vacant-for-sale 1-family houses which are on a place of less than 10 acres and have no business or medical office on the property. Value is not tabulated for mobile homes, trailers, cooperatives, and condominiums.

d. Average rent is based on 160 housing units since rent is tabulated for all vacant-for-rent units except 1-family houses on a place of 10 acres or more.

e. Summary count less than 5 - data suppressed.

f. This is the difference between the total and "for rent" vacant units without plumbing. It may include some "for sale" units.

Table 2.8-5

Bellefonte Nuclear Plant

Comparison of Housing Utilization Rates

	Percent of year-round units					
	Vacant for Rent		Vacant for Sale		Other Vacant	
	Total	With all plumb.	Total	With all plumb.	Total	With all plumb.
201-County Tennessee Valley Region	2.45	1.64	0.74	0.63	3.69	1.97
16 Alabama Counties in Region	2.27	1.47	0.83	0.75	3.19	1.90
Jackson County, Alabama	2.00	0.70	0.53	0.36	4.55	2.63
Bridgeport	1.91	1.48	0.53	0.42	2.33	1.80
Scottsboro	1.67	0.93	0.87	0.78	2.92	2.51
Stevenson	3.50	1.50	0.50	n.a.	2.50	n.a.

Source: U.S. Census of Housing, 1970.

2.9 <u>Other Impacts</u> - The following potential environmental impacts have been considered in addition to those discussed elsewhere in this document.

1. <u>Access facilities</u> - Tentative plans provide for the permanent access to the site to be via a blacktop causeway across the Town Creek embayment. An earthfill will be made from a point near the northwest tip of the peninsula to an island from whence the earth-filled, culvert-supported causeway will connect to the west bank of the Town Creek embayment. The culverts will allow a 6-foot clearance for boats at the normal high-water level of 595 feet above mean sea level. The road from the west bank of the Town Creek embayment will connect with U.S. Highway ~~way~~ 72 at a point about 3 miles northwest of Hollywood.

The lower sides of the earthfill affected by water will be riprapped, and the upper slopes will be grassed to prevent siltation and erosion.

TVA considered two alternative routes for the access road. The cost of the resource commitments for the alternatives in terms of land use, historical significance, public convenience and recreation, and the related economics of each were considered as follows:

1. The most direct route would be the construction of a road from the plant to the existing county road which connects Hollywood and Bellefonte. This access route would be the least expensive and removes essentially no land from productive use. However, this route has two disadvantages: (1) It would significantly increase traffic through the old townsite of Bellefonte, and (2) it would preclude the use

of approximately 500 acres of land on the end of the peninsula for recreation unless an evacuation route were provided. In order to utilize this area, an evacuation route must be provided which leads away from the plant in the unlikely event of an accident requiring evacuation. Such a route must leave the plant in a northerly direction crossing the Town Creek embayment.

2. The route across the Town Creek embayment requires the construction of an access road 2.7 miles long which will remove about 10 acres of land from productive use. This route is estimated to cost approximately $400,000 more than the direct route discussed above. The environmental impacts associated with building the causeway across the Town Creek embayment include the turbidity and siltation during construction, the more limited water transfer for fish movement, and loss of some aquatic habitat in Town Creek embayment. The advantages of this route are that it minimizes possible damage or destruction to the historical structures in the Bellefonte townsite and the public convenience and recreation potential of approximately 500 acres of land is enhanced.

After considering these alternatives, TVA selected the indicated route across Town Creek as representing the best balance between cost, environmental impact, and the other considerations discussed.

Construction facilities access will be temporarily provided from the county road connecting Hollywood and Bellefonte.

Tentative plans call for railroad access to the site to be provided by approximately 3 miles of new roadbed extending from the Southern Railway main line at a point about 1 mile west of Hollywood. The right of way for the access railroad will require about 65 acres of land.

TVA considered two alternate routes for the access railroad. Consideration of resource commitments for these alternates is as follows:

1. A route slightly shorter than the one selected, crossing the Town Creek embayment and extending in a generally northwestward direction, was considered. This route was slightly more expensive than the selected route and had these additional disadvantages: (1) several large tracts of land would be split; (2) at-grade crossings of two county roads would be necessary, with one road requiring extensive adjustment; and (3) possibly two or three residences would be affected and might have to be relocated. The environmental impacts associated with building this route would be the dust and noise inherent in construction, the temporary turbidity and siltation of the Town Creek embayment during construction of the crossing, and loss of some aquatic habitat in Town Creek embayment. This route would require about 60 acres of land for right of way north of Town Creek.
2. The selected route extends in a generally westward direction to a point on Southern Railway about 1 mile west of Hollywood. Advantages of this route are that (1) construction cost is

slightly less than the other alternative; (2) it would provide more direct rail access to potential industrial lands between the plant site and the city of Scottsboro; (3) the route is adjacent to property lines for a great portion of the length; and (4) no impact on Town Creek embayment.

2. Aesthetics - The plant will be located on a broad plain of a peninsula. A wooded ridge on the southeastern edge of the peninsula separates the plain from the body of Guntersville Reservoir. The north and northwestern edges of the site are penetrated by natural inlets from Town Creek embayment. The southwestern boundary of the site connects with the mainland. To reduce the visual impact of the large facilities, the structures are grouped in a diminishing progression of scale from the reactor, auxiliary, control, turbine, and service buildings to the office building and gatehouse. The materials vary to reflect the changes in scale--monolithic concrete for the larger solid masses, lighter fenestration for the turbine building, and precast concrete, brick, and glass for the office building and gatehouse.

Particular attention will be given to the site development and landscaping. Natural features of the terrain will be preserved as much as possible, and even utilized to reduce the impact of the installation on man and the environment. The landscaping will provide a harmonious transition between the natural setting and the plant site. The plant design, integrated with the landscape, will create an inviting and pleasant setting for both employees and visitors.

The location of the nuclear plant, amidst the surrounding recreational developments, provides a unique and interesting place to visit for both educational and recreational purposes. A visitors' center and overlook and a recreation area are to be provided for the site.

3. Archaeology - Two sites of potential archaeological significance in the project area are known to exist and have been previously recorded by the Department of Anthropology of the University of Alabama (Appendix C). These two sites are not in the immediate construction area; thus no restrictions on future explorations will occur.

4. Cemetery relocation and protection - Two old family cemeteries are located within the bounds of the property being acquired by the project (Appendix A). Both are inactive with no evidence of upkeep or interments in several decades. The most recent tombstone inscription found in the Shipp Cemetery is 1907. The most recent inscription found in the Finnell Cemetery is 1872. Field estimates place the number of graves in Shipp and Finnell Cemeteries at four and six, respectively

The Shipp Cemetery is surrounded, except for an entranceway, by a rock wall and located within lands that have been pastured. Cattle have gotten into the cemetery. At least one monument is broken and the entire cemetery is overgrown with weeds.

The Finnell Cemetery is located in a pasture with no fence protecting it. It has obviously been used as pastureland. At least two monuments in this cemetery are broken.

Under these conditions a larger number of graves than indicated by the initial count could exist in each cemetery.

However, it is impossible to make an exact determination without disturbing the cemetery area.

The Shipp Cemetery is located within the area of proposed project construction and will require relocation to avoid being destroyed. The Finnell Cemetery is located outside the proposed structure area but is within the general area; and further, its current access route will be severed by project construction. Project security measures could also preclude access to the portion of the peninsula on which the cemetery is located.

In order to facilitate plant construction, TVA would relocate these two cemeteries in accordance with a long-standing and well-accepted cemetery relocation policy. Relocation would be done with the consent of surviving relatives and in accordance with state and county health regulations and under the guidance of the appropriate Federal court. The cemeteries will be placed in comparable or superior locations and conditions when relocated.

5. Water use compatibility - Projection of the impact of the facility on the uses of surface and ground water resources of the region has been undertaken in order to assure that adequate consideration is given to alternate and shared uses of the water and to overall plans for development of the area. The watershed, flowrates, velocities, volumes, and characteristics of the water are given in Section 1.2, Environment in the Area, as baseline environmental data.

Because of the relatively small quantities of both radioactive and nonradioactive liquid discharges released to Guntersville Reservoir and the treatment of wastes as described in sections 2.4 and

2.5, the plant will have only minimal effects on the chemical and physical characteristics of the reservoir. The present usage of this portion of the Tennessee River will not be altered in any way by the construction and operation of the Bellefonte plant.

The Bellefonte plant will use a maximum of about 100 million gallons of process water per day which will not curtail known or projected industrial water uses of the average quantity of 23.5 billion gallons of water flowing by the site each day.

6. Land use compatibility - Use of the Bellefonte site for a nuclear plant would be a significant change in land use, but it is expected that this use would be compatible with both the existing and projected land uses in the surrounding area. Three aspects of compatibility are discussed below and are related to onsite uses, existing land use in the surrounding area, and projected use in the surrounding area.

(1) Onsite use compatibility - Agricultural use of the site will cease, at least during the period of construction and operation of the plant. The abandoned structures on the site will be demolished because their structural condition precludes any economic use.

Although there are no developed recreation facilities in the area and the only land in public ownership is the narrow shoreline strip, the site area now receives some visitation for recreation use. However, the use of this area is an insignificant part of the total visitation to Guntersville Reservoir which amounts to approximately 5.5 million visits per year.

(2) Existing land use compatibility - There are no offsite impacts which would significantly hinder the continuation of existing land uses in the surrounding area (Appendix A, figure A-1). Agricultural and forestry activities may be reduced slightly by the access road, the railroad, and by the transmission lines, but the use of the remaining land can continue. Free access will be maintained to the sand and gravel operation so that it can continue uninterrupted. Town Creek Subdivision can continue development although the view from the homesites will be altered. The effect of this aesthetic alteration on the desirability of the subdivision is unknown.

(3) Future land use compatibility - Development of the Bellefonte site for industrial purposes (in this case a nuclear generating plant) is in accord with the projected land use for the site and the adjoining land to the southwest. This is shown on figure 2.9-1 as well as the projected development of Scottsboro-Hollywood and other communities.

The projected development pattern in figure 2.9-1 is taken from the future land use map contained in the report "Sketch Regional Plan - Year 2000" prepared by the Top of Alabama Regional Council of Governments. This sketch plan is a broad concept of how future growth in the TARCOG region will likely be accommodated based on land suitability, transportation, economic and population trends, and resource potentials. Of particular importance to consideration of the Bellefonte plant is the projected pattern of dense urban and industrial development in the area.

For some time, the waterfront land near Scottsboro has been recognized as having high potential for the location of industry. TVA has long designated the land for eventual industrial use and this has also been the judgment of Alabama industrial development agencies.

One specific attribute of primary industrial land is rail transportation. In light of this and TARCOG's sketch plan, TVA coordinated the location of the necessary rail spur to the Bellefonte site with TARCOG to maximize its enhancement of the industrial potential of the remaining land.

Comparing the present and projected pattern and extent of dense urban development, it is evident that the most significant growth will be taking place in Hollywood. Although Scottsboro is expected to continue to grow in population, the pattern is expected to be generally within the present limits of development.

Hollywood's growth pattern is expected to be somewhat toward the site but mostly to the southwest of the site. This reflects both the road pattern and the economic and social ties to Scottsboro. Since this pattern already reflects the industrial use of the Bellefonte site, no change is anticipated due to the location of a nuclear plant there.

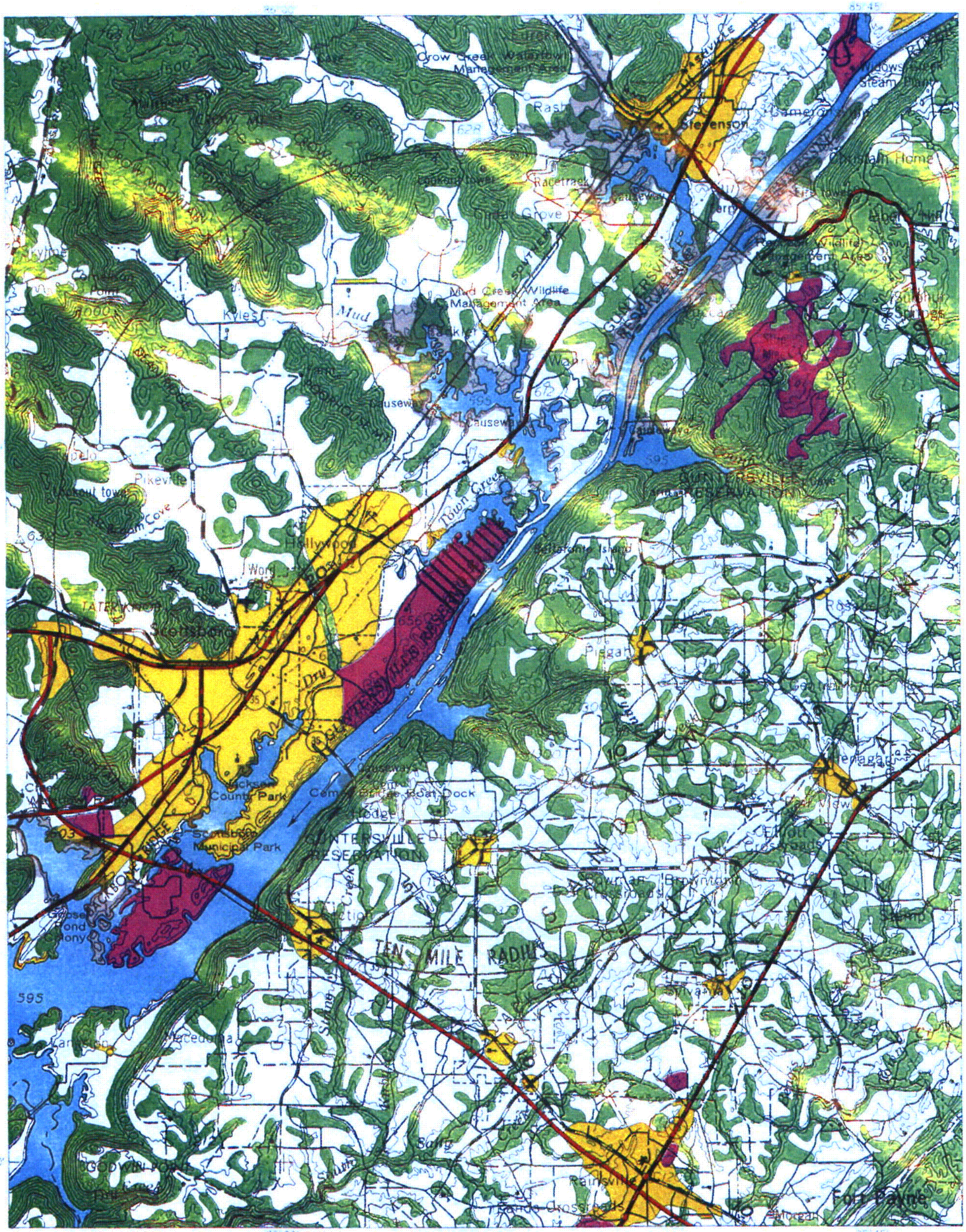


FIGURE 2.9-1

PROJECTED LAND USE WITHIN 10 MILES OF THE BELLEFONTE NUCLEAR PLANT SITE (2000)

LEGEND

- URBANIZED
- INDUSTRIAL
- FOREST
- AGRICULTURE AND OPEN SPACE
- WATER
- BELLEFONTE SITE
- RECREATION AND WILDLIFE AREAS
- CITY LIMITS (1972)
- MAJOR HIGHWAY CORRIDORS

SCALE OF MILES

1 0 1 2 3

JANUARY 1973

N

Contour interval 100 feet

Projections adapted from the map "Sketch Regional Land Use and Highway Plan—Year 2000" from the report "Sketch Regional Plan—Year 2000" published in May 1971 by the Top of Alabama Regional Council of Governments.

FIGURE 2.9-1

PROJECTED LAND USE WITHIN 10 MILES OF THE BELLEFONTE NUCLEAR PLANT SITE (2000)

LEGEND

- URBANIZED
- INDUSTRIAL
- FOREST
- AGRICULTURE AND OPEN SPACE
- WATER
- BELLEFONTE SITE
- RECREATION AND WILDLIFE AREAS
- CITY LIMITS (1972)
- MAJOR HIGHWAY CORRIDORS

SCALE OF MILES

1 0 1 2 3

JANUARY 1973

N

Contour interval 100 feet

Projections adapted from the map "Sketch Regional Land Use and Highway Plan—Year 2000" from the report "Sketch Regional Plan—Year 2000" published in May 1971 by the Top of Alabama Regional Council of Governments.

3.0 ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

The CEQ guidelines require a discussion of any probable adverse environmental effects which cannot be avoided, such as water or air pollution, damage to life systems, urban congestion, threats to health, or other consequences adverse to the environmental goals set out in Section 101(b) of NEPA.

The environmental review of the proposed construction and operation of the Bellefonte plant evaluated the baseline data on appearance, quality, productivity, and usage of the preexisting environment in the area. Probable changes in these factors have been either calculated or estimated as a means of determining the degree of the change to be expected.

The following discussions summarize probable effects which cannot be avoided and the steps taken to minimize adverse environmental impacts.

1. Water pollution - Some unavoidable impacts to Guntersville Reservoir will occur during construction of the plant. These include some siltation as a result of grading, excavating, and dredging; discharge of small amounts of chemicals used in cleaning equipment; and discharge of the sewage treatment plant effluent.

These impacts will be minimized by the following means:

. Dredging of the intake channel will be accomplished by a suction dredge with the spoil material being deposited in an upland fill area to avoid excessive siltation of the reservoir.

. Berms, diversion dikes, check dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, special drains, and other control devices will be used to control surface drainage and erosion during grading operations.

. Soil and rock from excavation work will be used as fill or stored in compacted mounds until needed to prevent wind and rain erosion.

. Spoil material from excavation work will be wasted in preselected areas as fill, graded to conform to surrounding landscape, covered with topsoil, seeded, and mulched to avoid erosion.

. Impacts due to chemical discharges to the reservoir will be minimized by the use of holding ponds, neutralization, and other treatment which may be required to reduce concentrations substantially below harmful levels.

. Extended aeration treatment of sanitary wastes and chlorination of effluent will be provided during construction.

Operation of Bellefonte will result in small amounts of heat, chemical, sanitary, and radioactive liquid wastes being discharged into Guntersville Reservoir. Mitigation of possible related effects will be accomplished as follows:

. Closed-cycle natural draft cooling towers will minimize the quantity of waste heat discharged to the receiving waters.

. A diffuser will rapidly mix the heated cooling tower blowdown with unheated reservoir water.

. A 2-basin lagoon will remove settleable solids from makeup water filter plant sludges.

. Secondary treatment of the sanitary wastes with provision for effluent chlorination will be provided for the permanent plant.

. Radioactive waste liquids will be treated by evaporation and tritiated liquid will be recycled.

As indicated, adequate treatment of liquid effluents is provided prior to being discharged to ensure that all applicable stream standards are met and that the quantities and concentrations released will be small enough to ensure that any adverse environmental effects are minimal and localized. Water, aquatic life, and life systems will be carefully monitored to detect possible adverse environmental effects, although some adverse effects may be undetectable.

2. Air pollution - The construction of Bellefonte will result in a minimal short duration impact to the atmosphere from selected burning of cleared brush and trash.

There will be some radioactive gaseous wastes released to the atmosphere and some negligible additions of nonradioactive gaseous emissions to the atmosphere. Some local accumulation of dissolved solids may take place on surfaces exposed to the drift from the cooling towers. In addition, large quantities of waste heat and moisture from the cooling tower plumes may result in some alteration of the local atmospheric conditions. During adverse weather conditions this increased moisture content may cause local fogging and icing. However, such occurrences resulting from the operation of the cooling towers should be infrequent. To the extent that local fogging and icing does occur, it represents an unavoidable adverse environmental effect.

Mitigation of the probable related effects from these discharges to the atmosphere is accomplished as follows:

. Brush and trash burning will be done in accordance with applicable state regulations and as atmospheric conditions permit.

. Radioactive gaseous waste will be held up 60 days to permit decay of essentially all noble gases except krypton-85 before release.

. Natural draft hyperbolic cooling towers disperse heat and moisture to the atmosphere about 500 feet above the ground.

. Cooling tower design will keep water losses due to drift from the cooling towers to a minimum.

No significant adverse environmental effects should be caused by these releases to the atmosphere.

3. Impact on land use - The construction and operation of the Bellefonte Nuclear Plant will result in a change in land use of approximately 1,500 acres from predominantly farming and pasture to industrial use. In addition, right of way easements will be obtained on approximately 2,910 acres of land, of which about 25 percent is in woodland, 25 percent in farming and pasture, and the remainder in uncultivated open land.

The land use adjustments are not judged to be significant adverse environmental impacts.

4. Damage to life systems - When the auxiliary cooling water and cooling tower makeup water passes through the traveling

screens, fish larvae and plankton will be drawn into the water intake. These will be destroyed in passing through the closed cooling system. To the extent that the plankton and larval fish drawn into the water intakes serve as a food source for aquatic life and the basis for harvestable fish production, their destruction is an adverse effect which cannot be avoided. However, since the quantity of water required for auxiliary cooling and cooling tower makeup represents only 0.4 percent of the average annual flow past the site, these effects should not damage significantly any life system.

5. Threats to health - The facility is being designed and constructed and will be operated in accordance with all applicable regulations in order that the health and safety of the public will be safeguarded.

Significant accidental releases of radioactive products at the plant or during transportation of radioactive materials are very improbable. Should such a release occur, implementation of the radiological emergency plans would mitigate the potential risk to the public.

6. Socioeconomic effects - The construction and operation of the plant will have an economic and social impact. Although the plant will provide an economic stimulus to the region, stress on present institutions, such as schools and housing facilities, will unavoidably result in placing a greater demand on both the public and private sectors to provide the necessary community services. TVA will work with appropriate local and regional authorities to minimize these stresses.

7. <u>Conclusions</u> - While the construction and the operation of Bellefonte will result in some adverse environmental effects which cannot be avoided, these effects should not conflict with the environmental goals set out in Section 101(b) of NEPA. If any significant adverse effects attributable to the construction or the operation of the plant become evident or through the various environmental monitoring programs are shown to be inimicable to Section 101(b) goals, appropriate steps will be taken to correct the situation.

4.0 ALTERNATIVES

This environmental statement considers the ways in which the plant will interact with the environment by reevaluating the environmental consequences considered earlier and minimizing any further adverse environmental consequences that would affect the overall balance of environmental costs and benefits by studying and adopting appropriate alternatives. Analyses of alternative systems are described in sections 2.1 through 2.9. Alternative methods of generation and alternative plant sites are discussed in detail in sections 4.1 and 4.2 respectively.

4.1 <u>Alternative Generation</u> - The purchase of electric power in lieu of constructing additional generating capacity is not a feasible alternative. To supply equivalent amounts of power and energy on a year-round basis to TVA, another large electric utility with extensive transmission interconnections would have to install generating capacity in amounts slightly greater than that of the Bellefonte Nuclear Plant, build several high-capacity transmission lines to the TVA area, and transmit the power to TVA. To construct such facilities on another power system would not avoid an impact on the environment but would only create an environmental impact in another area. Even if the assumption is made that the plant locational factors and costs would be equal, the cost of transmission lines, the transmission line losses, the use of land for transmission line rights of way, and the exposure to transmission line outages would result in waste of natural resources, materials, and funds, and would provide a more costly and less reliable source of power for the TVA region than will the construction of additional TVA generating facilities.

Planning for this capacity addition required that considerations be given to maintaining a practical mix of conventional hydro, pumped-storage hydro, gas turbine, fossil-fired, and nuclear generating units. Since TVA expects to have the 1,530-MW Raccoon Mountain Pumped-Storage Project in operation by 1975 and over 1,000 megawatts of gas turbine peaking capacity on its system by 1978, a substantial amount of TVA's planned generating capacity is designed for peaking service. Studies of the system load characteristics and the characteristics of the existing generating facilities indicate that the installation of additional pumped-storage or other peaking capacity is not an economical alternative in the 1979 period. The system needs, as indicated by TVA planning studies, required that detailed comparisons be made between base-loaded fossil-fired units and nuclear-fueled units.

The use of hydroelectric units was eliminated as an alternative because there are no hydroelectric sites in the TVA service area suitable for base-load hydroelectric generation in the amount required to serve the capacity and energy demands of this time period.

Gas-fired plants were not considered a feasible alternative because the quantity of natural gas required would not be available in the TVA area. The fuel requirements for a gas-fired plant of the approximate size required would consume about 170 billion cubic feet of natural gas each year. During the past 3 years, TVA has contacted all major suppliers of natural gas in the TVA area in order to secure a natural gas supply for the approximately 1,000 MW of gas turbines which TVA has installed or has under construction. Only limited success was achieved in obtaining a natural gas supply for these gas turbines. The natural gas contracted for is only available in the summer, and none could be obtained on a year-round basis. Based on these investigations, it was concluded that a natural gas supply was not available in the quantity required for a gas-fired plant of the capacity of the Bellefonte Nuclear Plant.

By its order No. 467 and rulemaking notices R-467 and R-468, which proposed a system of priority of service among classes of gas consumers based on type of use, the Federal Power Commission has indicated that it no longer considers natural gas an appropriate fuel for the production of electric power in large fuel-burning installations.

Two major disadvantages in planning an oil-fired power plant the size of the Bellefonte plant are the uncertainty of a long-range fuel supply and the high cost of oil. In 1970 TVA began contacting the major oil companies in the United States to develop a dependable supply of fuel for gas turbines and for use in steam-electric generating plants. Letters of inquiry were sent to sixteen major oil companies in May 1970. Of the twelve companies that responded to the letters, eight indicated no interest at that time in supplying oil for power plants. Meetings were held with the remaining four companies which responded, and none was interested in a long-term contract for supplying the quantity of oil needed for a 2,600-MW oil-fired power plant. The suppliers indicated that this quantity of oil (20 to 24 million barrels per year) could not be supplied from domestic sources. Therefore, a long-term contract would be contingent on a supplier obtaining an oil import quota each year since the TVA operating area lies in Petroleum Administration for Defense (PAD) Districts 2 and 3. As a result of these inquiries, TVA concluded that the long-term requirements of an oil-fired steam-electric generating plant could not be assured. Since 1970 TVA has held discussions with three oil companies and these discussions have reaffirmed the conclusion that contracts for this quantity of oil are contingent on a supplier obtaining an oil import quota and that the oil supply could not be assured. TVA believes that an assured fuel supply must be available before a decision is made to construct a generating plant.

Air pollution control regulations have greatly increased the demand for low-sulfur fuel oil, and oil import quotas have placed a greater burden on domestic supplies. Domestic demand for fuel oil has increased at a rate of about 5 percent per year since 1968 while the domestic production has increased at a rate of about 1.5 percent per year. Also, the ratio of domestic reserves to production decreased from 12.8 years in 1960 to about 9 years in 1970 when proven reserves were 29.6 billion barrels and production was 3.32 billion barrels. The increased demand and reduced domestic reserves will force more dependence on the restricted and uncertain foreign supplies. In 1970 foreign sources supplied 23 percent of the domestic oil requirements. The shortage of low-sulfur oil reserves and difficulty in securing a reliable foreign or domestic supply at this time make the selection of oil as fuel for a base-load plant the size of Bellefonte an unacceptable alternative.

Even if an adequate supply of fuel oil for the life of the plant were assured, the cost of oil as fuel would make the selection uneconomical for base-load capacity. On a heat content basis, low-sulfur fuel oil costs more than four times as much as nuclear fuel. The following table shows a comparison of approximate costs of nuclear and oil-fired plants of the 2,500-MW size category.

	Nuclear	Oil-Fired
Plant investment, $/kW	261	175
Levelized fuel cost, ¢/10^6 Btu	15.6	70.0
Net plant heat rate - Btu/kWh	9,943	9,043.0
Annual production expense, mill/kWh:		
Plant investment	3.2	2.2
Operating and maintenance	1.9	6.7
Total	5.1	8.9
Difference	Base	3.8

This difference in annual production expense is estimated to represent an annual cost difference of about $66.5 million.

TVA performed an analysis of the two remaining feasible alternative types of generation - coal-fired units and nuclear-fueled units - to meet the system needs in the TVA area. Estimates of the total installed cost, assessment of the technical aspects of the offerings, and other economic evaluations were made. A summary of the results of this analysis for plants of the 2,500-MW size category is tabulated below:

	Coal-Fired Plant	Nuclear-Fueled Plant
Plant investment - $/kW	249.8	261
Levelized fuel cost - ¢/10^6 Btu	25.0	15.6
Net plant heat rate - Btu/kWh	8,947.0	9,943
Estimated Annual Production Expense[a] - mill/kWh		
Plant investment	3.1	3.2
Operating and maintenance cost	2.7	1.9[b]
Total	5.8	5.1
Difference	0.7	Base

a. Based on a 10-year present worth evaluation at 8 percent interest.
b. Includes estimated cost of nuclear insurance.

Based on the 0.7 mills/kWh difference indicated above, TVA estimates that the selection will result in an annual cost saving of about $11 million when compared to a coal-fired alternative.

In terms of overall environmental impact, nuclear generation offers advantages over coal-fired generation. While modern coal-fired units reject about 20 percent less heat to the environment, they emit large quantities of combustion products to the atmosphere and consume large quantities of raw materials. The small amounts of radioactive materials released to the environment from a nuclear plant do not result in any significant environmental impacts. Although the above cost estimates for a coal-fired plant included TVA's best judgment on the cost of SO_2 removal facilities, such facilities are now in the preliminary developmental stage. TVA has no assurance that such facilities will be available on a proven and reliable basis for use on an alternative coal-fired plant for this time period.

Recently, states in the TVA region have adopted SO_2 emission standards which make the feasibility of a new coal-fired plant questionable. Although TVA is proceeding on a demonstration SO_2 removal program on unit 8 of the Widows Creek Steam Plant, a reliable SO_2 removal technology does not now exist. TVA is investigating the feasibility and economics associated with other means of reducing SO_2 emissions, such as coal washing and the burning of low-sulfur fuels, as a means of complying with adopted SO_2 emissions standards. Preliminary indications are that these measures may result in compliance with standards, but there are severe economic penalties associated with their implementation.

Consequently, economical and feasible solutions to the problems associated with SO_2 emissions are not available.

Additionally, the large quantities of coal required for operation of a coal-fired plant and the resulting ash produced present large-scale materials-handling requirements, both at the plant site and along transportation routes, which are significantly greater than for a nuclear plant.

After considering these factors, TVA decided that the nuclear alternative was more acceptable from both the standpoint of economics and environmental impact.

4.2 Alternative Sites

1. Site studies - Studies are made on a continuing basis to determine the best locations for adding electrical generating plants to the TVA power system. These studies have been made since the early 1950's as an integral part of TVA's planning process.

TVA has made extensive studies to identify and investigate sites meeting the basic requirements for future generating facilities. During the more recent years five general areas have been under investigation. These areas included:

1. The Mississippi River upstream and downstream from Memphis and on the Tennessee River including Pickwick Reservoir and the upstream end of Kentucky Reservoir extending from Pickwick Dam to Savannah, Tennessee
2. On the Tennessee River including Guntersville and Chickamauga Reservoirs
3. On the Tennessee River and tributaries extending upstream from Watts Bar Dam to John Sevier Steam Plant
4. On the Cumberland River upstream and downstream from Nashville
5. On the Tennessee and Cumberland Rivers extending from Johnsonville and Cumberland Steam Plants downstream to the Ohio River

More recently these studies have been further expanded to include the Tennessee River north of TRM 174; the Ohio River from Shawnee Steam Plant to Smithland, Kentucky; the Mississippi River from river mile 780 to Cairo, Illinois; and the upper east Tennessee tributary reservoirs of Cherokee, Norris, and Douglas.

As part of TVA's studies to identify sites which have the exacting requirements of power plant sites, preliminary site studies are conducted which include the following:

1. Map reconnaissance, aerial survey, and field reconnaissance
2. Land use and ownership assessment
3. Site access
4. Navigability of waterway
5. Transmission facility proximity
6. Topography
7. Proximity to population centers
8. Flood control studies
9. Cooling water availability
10. Site proximity relative to unique areas such as recreation areas, wildlife areas, or other areas requiring special consideration which would be impacted by the location of a generating plant on the site

As a result of these preliminary site studies, sites are identified for further study of physical characteristics including:

1. Foundation conditions
2. Archaeological studies
3. Meteorological conditions
4. Hydrological conditions

During the period 1967 to date TVA has identified 207 potential generating plant sites as part of its long-term power plant siting program. Preliminary studies of these sites warranted detailed investigations on 24 of the sites. In carrying out the detailed studies, seismic tests were conducted on 21 of the sites and 18 of the sites were core drilled to determine foundation conditions. This site investigation program has been expanded in the more recent years with annual expenditures for site investigations increasing from $499,000 in fiscal year 1971 to over $1.1 million in fiscal year 1972.

When the contract was awarded for the nuclear steam supply system for the proposed plant, a total of 30 sites had been identified for preliminary site studies. Preliminary investigations had revealed that 8 of these sites had the desirable characteristics to warrant further and more detailed studies. During this period, onsite investigations were being conducted on the Tennessee River; therefore, knowledge of foundation conditions at potential sites was necessarily limited to the sites on the Tennessee River. These eight sites were considered as potential sites for the proposed plant and are listed below:

Site	Reservoir	Location
A	Kentucky	TRM 174L
B	Pickwick	TRM 215
C	Guntersville	TRM 369L
D	Guntersville	TRM 386.5R
E (Bellefonte)	Guntersville	TRM 392R
F	Guntersville	TRM 398.5R
G	Chickamauga	TRM 499L
H	Watts Bar	TRM 559R

The locations of these sites are identified on figure 4.2-1.

In planning to meet future load requirements at any given time several generating plants and several acceptable sites will be under consideration. The selection of the next site from the candidate sites will be a matter of sequence of developments, and candidate sites rejected for the first plant will continue to be considered for siting subsequent generating plants as part of the continuing process to determine the best locations for adding electrical generating plants to the TVA power system.

2. Area requirements - The TVA system, which with 20.6 million kilowatts of presently installed generating capacity is the Nation's largest, is interconnected at 26 points with neighboring systems with which TVA exchanges power. The TVA system is, in effect, part of a huge power network consisting of interconnected power systems.

TVA's system is a winter peaking system with major portions of the system demand concentrated in distinct areas. In addition to these load concentrations, interchange agreements totalling 2,060,000 kW with Mississippi Power & Light, the Southern Company, and the Illinois-Missouri group result in additional power flows to the south and west.

In order to study load growth and power flows in the system and to determine the transmission system changes required to accommodate alternative sites, the TVA power system has been divided into five study areas. These areas are shown on figure 4.2-2. The area divisions were selected to divide the system electrically according to concentration of load and generation centers (Memphis, Nashville, Knoxville, Chattanooga-Huntsville, and Muscle Shoals-Mississippi) in areas 1-5 respectively. While these areas are shown individually, the system is not in fact divided since these areas are strongly interconnected with transmission lines, and deficiencies in one area can readily be supplied by surplus capacities in other areas.

As shown in figures 4.2-2 and 4.2-3, areas 2, 3, and 5 are the areas with capacity deficiencies in the winter of 1980, and areas 1, 2, and 5 have summer deficiencies. However, much of the western portion of the TVA service area (areas 1 and 5) is included in an area in which the seismic conditions are not clearly defined. This area is in close proximity to an area in which major seismic activity has occurred as recently as the early 1800's. This area has been under study by TVA and TVA consultants to define the seismic conditions in the area. A report entitled Relationship of Earthquakes and Geology in the West Tennessee and Adjacent Areas was submitted in June 1972 to AEC's Director of Regulation for consideration in determining the seismic design criteria for this area. Therefore, sites A and B cannot be considered for the proposed plant until a determination is made on seismic design criteria for these sites.

Additionally, investigations in the north central portion of the TVA power system (area 2 in figure 4.2-2) had not progressed far enough at that time to identify a specific site which had the necessary characteristics for the location of this facility. Extensive investigations have continued in this area (including the Cumberland and Duck Rivers) for use in siting subsequent generating plants.

Of the six remaining sites four (sites C, D, E, and F) are located on Guntersville Reservoir in area 4. Figures 4.2-4 and 4.2-5 show the impact on the load and capacity for the winter and summer of 1980 resulting from locating the proposed plant in area 4. Figures 4.2-6 and 4.2-7 show the impact of locating the proposed plant at site G or H, both of which are located in area 3.

Descriptions of the potential sites C, D, E, F, G, and H are given below.

(1) Site C - This site is located on the east shore of Guntersville Reservoir at TRM 369. The site is located 6 miles from the nearest town, Grant, Alabama, which has a population of 382, and 30 miles from the nearest city with a population over 25,000, Huntsville, Alabama, which has a population of 137,802. The site is located 16 miles from the nearest highway, 16.5 miles from the nearest railroad, and 28 miles from the nearest 500-kV transmission line. This 700-acre site would require the acquisition of an additional 375 acres of privately owned property. Most of the land on and around the site is sparsely developed with some second-home development occurring about 1.5 miles upstream. A major industry has located approximately 2.5 miles from the plant. The site has a suitable foundation, and development of the site would be generally compatible with projected land uses.

(2) Site D - This site is located on the west shore of Guntersville Reservoir at TRM 386.5. The site is located 4 miles from the nearest town, Scottsboro, Alabama, which has a population of 9,324, and 36 miles from the nearest city with a population over 25,000, Huntsville, Alabama, which has a population of 137,802. The site is located 1 mile from the nearest highway, 2.5

miles from the nearest railroad, and 13 miles from the nearest 500-kV transmission line. This 900-acre site would require the acquisition of an additional 700 acres of privately owned property. Downstream from the site is part of the town of Scottsboro's permanent residential development. Future development plans anticipate further urbanization of this area. While this site has a suitable foundation and is favorably situated relative to transmission and access facilities, conflicting land use requirements make it incompatible for a nuclear plant site at this time.

(3) <u>Site E</u> - This site is located on the west shore of Guntersville Reservoir at TRM 392. The site is located 3-1/2 miles from the nearest town of Hollywood, Alabama, which has a population of 865, and 7 miles northeast of Scottsboro, Alabama, which has a population of 9,324. The site is 39 miles from the nearest city with a population of 25,000, Huntsville, Alabama, with a population of 137,802. The site is located 2.5 miles from the nearest highway, 3.5 miles from the nearest railroad, and 10 miles from the nearest 500-kV transmission line. This 1,500-acre site would require the acquisition of an additional 1,260 acres of privately owned property. The site contains and is adjacent to farmland with high potential for industrial development, and use as a nuclear plant site would be compatible with present and projected land uses in the vicinity.

(4) <u>Site F</u> - This site is located on the west shore of Guntersville Reservoir at TRM 398.5. The site is located 6 miles from the nearest town, Stevenson, Alabama, which has

a population of 2,390, and 37 miles from the nearest city with a population over 25,000, Chattanooga, Tennessee, with a population of 119,082. The site is located 1 mile from the nearest highway, 2 miles from the nearest railroad, and 6 miles from the nearest 500-kV transmission line. This site would require the acquisition of an additional 900 acres of privately owned property. An important wildlife management area virtually surrounds the site and would probably be encroached on were the site utilized. In addition, suitable rock for a nuclear plant foundation is located at a depth in excess of 100 feet.

(5) Site G - This site is located on the east shore of Chickamauga Reservoir at TRM 499 where the Hiwassee River enters the reservoir. The site is located 6 miles from the nearest town, Dayton, Tennessee, which has a population of 4,361, and 30 miles from the nearest city with a population over 25,000, Chattanooga, Tennessee, with a population of 119,082. The site is located adjacent to a highway, 19 miles from a railroad, and 3.5 miles from the nearest 500-kV transmission line. This 1,100-acre site would require the acquisition of an additional 900 acres of privately owned property. No intensive development is located near this site; however, it is just downstream and adjacent to the Hiwassee Island Game Management and Waterfowl Refuge Area which is of major importance to east Tennessee. The compatibility of the site with the continued existence of the wildlife refuge has not been determined. It is judged, however, that impacts of constructing a plant on this site would affect the refuge only during the construction period and no permanent damage to the refuge would result.

(6) Site H - This site is located on the west shore of Watts Bar Reservoir at TRM 559. The site is located 5 miles from the nearest town of Rockwood, Tennessee, which has a population of 5,259, and 25 miles from the nearest city with a population over 25,000, Oak Ridge, Tennessee, with a population of 28,319. The site is located 6 miles from the nearest highway, 8 miles from the nearest railroad, and 6 miles from the nearest 500-kV transmission line. This 1,000-acre site would require the acquisition of an additional 950 acres of privately owned property. The present and projected land use on and around this site is agriculture and openland. Use of the site for a nuclear plant would be compatible with these uses. While TVA analysis of the geology of this area indicates a suitable foundation is likely, permits to conduct onsite drilling have been denied, and to date it has not been verified whether the rock underlying the plant would provide a foundation suitable for the construction of a nuclear plant.

A review of the above site descriptions indicates that conflicts or questions existing at three of the sites (sites D, F, and H) make them less desirable at this time than the other three proposed sites. These include the conflict with the urbanizing growth of a nearby town at site D; the encroachment on an important wildlife sanctuary and the depth of the rock at site F; and the lack of information indicating the suitability of the rock for a nuclear plant foundation at site H. Since sites D, F, and H were either less suitable or their suitability was not fully determined, a detailed site evaluation was limited to sites C, E, and G.

These sites were investigated considering the economic and environmental cost of locating the proposed plant at each of the alternative sites.

3. Physical environment -

(1) Chickamauga site (site G) - For the site on the Chickamauga Reservoir, the following information of the physical environment of the area was known.

(a) Hydrology - At the normal pool elevation of 682.5, the Chickamauga Reservoir is 58.9 miles long and has an area of 35,400 acres with a volume of 628,000 acre-feet. The reservoir has an average width of nearly 1 mile, and navigation is provided by maintaining a minimum channel depth of 11 feet. The average annual flow at the Chickamauga Dam is 32,800 ft^3/s.

The reservoir is located in a region which derives ground water from precipitation which over the 1931-55 time period had averaged about 48-55 inches per year. Some of the precipitation evaporates, runs off into streams, seeps into the soil to be absorbed or used by vegetation, or seeps downward to become ground water. The movement of ground water at the site would be dependent on the underlying geologic formations.

The site has ready access to the Tennessee River for an adequate supply of water for necessary heat dissipation, auxiliary cooling, and other plant needs.

(b) Seismology - The site lies within the Southern Appalachian Seismotectonic Province. The maximum historic earthquake recorded in this province was in Giles County, Virginia, in 1897. This earthquake had an intensity of MM VIII.

(c) Meteorology - The site is located in the eastern Tennessee portion of the Southern Appalachian Region which is dominated much of the year by Azores-Bermuda anticyclonic circulation. This circulation is most pronounced in the fall and is accompanied by extended periods of fair weather and widespread atmospheric stagnation. In winter the normal circulation pattern becomes diffuse over southeastern states as the eastward moving migratory high and low pressure systems, associated with midlatitude westerly current, bring alternating cold and warm air masses into the area with resultant changes in regional and local wind direction, wind speed, atmospheric stability, precipitation, and other meteorological elements. In summer the migratory systems are less frequent and less intense and the area is under the dominance of the western edge of the Azores-Bermuda anticyclone with a warm moist air influx from the Atlantic Ocean.

The meteorology of this area provides a rather limited range of atmospheric conditions for transport and dispersion of plant emissions. Conditions are generally most favorable in winter through spring months when migratory pressure systems move alternately through the area, accompanied by moderate to occasionally high wind. Atmospheric dispersion is least favorable in the fall months when extended periods of atmospheric stagnation reach highest frequency.

(d) Population - The site is located 6 miles from the nearest town of Dayton, Tennessee, which has a population of 4,361, and 30 miles from the nearest city with a population over 25,000, Chattanooga, which has a population of 119,082. As shown in figure 4.2-8, the populations within 5, 10, and 50 miles of the site are 3,691, 16,768, and 683,226, respectively.

(e) Land requirements - The total land required for a nuclear plant on this site is about 1,100 acres. The property not presently in TVA ownership and required to provide the plant needs is approximately 900 acres. A proposed layout of the plant is shown on figure 4.2-11.

(f) Conclusion - From consideration of the above factors, TVA concluded that the Chickamauga Reservoir site would be physically suitable for the location of a nuclear plant.

(2) Guntersville Reservoir sites (sites C and E) - For the two sites located on the Guntersville Reservoir similar information was available for consideration of the above factors defining the physical environment.

(a) Hydrology - At the normal pool elevation of 595.0, the Guntersville Reservoir is 75.7 miles long and has an area of 67,900 acres with a volume of 1,081,000 acre-feet. The average annual flow at the Nickajack Dam at TRM 424.7 is 38,000 ft^3/s and the average annual flow at the Guntersville Dam at TRM 349.0 is 41,000 ft^3/s.

The Guntersville area derives ground water from precipitation which over the 1931-55 time period has averaged about 53 inches per year. The direction of ground water movement at each of the sites would be dependent on the underlying geologic formation.

Each of the sites has ready access to the Tennessee River for an adequate supply of water for heat dissipation, auxiliary cooling, and other plant needs.

(b) Seismology - The Guntersville sites lie within the Southern Appalachian Seismotectonic Province.

(c) Meteorology - The meteorological and climatological data sources for this area are the Widows Creek Steam Plant air monitoring network, the National Weather Service Cooperative Observer Station in Scottsboro, and limited data from the Browns Ferry Nuclear Plant meteorological station.

The Guntersville sites are located in a region which is dominated much of the year by the Azores-Bermuda anticyclonic circulation. This circulation is most pronounced in the fall and is accompanied by extended periods of fair weather, widespread atmospheric stagnation, and smog. In the winter the normal circulation pattern becomes diffuse over the southeastern United States as the eastward moving migratory high and low pressure systems, identified with the midlatitude westerly upper circulation, bring alternately cold and warm air masses into the area with resultant changes in wind, atmospheric stability, precipitation, and other meteorological elements. In summer the migratory systems are less frequent and less intense as the area is under the influence of the western extension of the Azores-Bermuda anticyclonic circulation with frequent incursions of warm moist air from the Atlantic Ocean and Gulf of Mexico. Severe windstorms are comparatively infrequent and generally reach their peak intensity in winter and early spring when maximum air mass discontinuity occurs. Windstorms of short duration occur in summer with thunderstorms. The probability of tornado occurrence in the site area is extremely low. Maximum precipitation occurs in the winter and early spring with the frequent passage of migratory low pressure systems. Maximum short-period precipitation usually occurs with summertime thunderstorms.

Because of the prominent valley-ridge physiographical features of these sites, the local wind pattern is distinctively bimodal (northeasterly downvalley and southwesterly upvalley) within the lower 600-800 feet of the valley floor; above these levels the pattern becomes regional in character with more uniform directional distribution with slightly predominant southeasterly, southwesterly, and northerly winds.

The meteorology of the area indicates a wide range of atmospheric conditions for the transport and dispersion of radioactive waste emissions. Dispersion conditions are most favorable in winter through spring when migratory pressure systems move alternately through the area, accompanied by occasionally moderate to high winds. The least favorable conditions are in the fall when extended periods of anticyclonic circulation, or atmospheric stagnation, are most likely to occur.

(d) Population - Site C is located 6 miles from the nearest town, Grant, Alabama, which has a population of 382, and 30 miles from the nearest city with a population over 25,000, Huntsville, Alabama, which has a population of 137,802. As shown by quadrants in figure 4.2-9, the populations within 5, 10, and 50 miles of the site are 3,378, 13,112, and 653,925, respectively.

Site E is located 3.5 miles from the nearest town, Hollywood, Alabama, which has a population of 865, and 7 miles from Scottsboro, Alabama, which has a population of 9,324. It is located 39 miles from the nearest city with a population over 25,000, Huntsville, Alabama, which has a population of 137,802. As shown by quadrants in figure 4.2-10, the populations within 5, 10, and 50 miles of the site are 2,755, 18,405, and 837,658, respectively.

(e) Land requirements - Site C would require the acquisition of 375 acres of privately owned property to develop this 700-acre site. Site E would require the acquisition of 1,260 acres for developing this 1,500-acre site. The additional acreage required at site E is because the site lies on a peninsula and the entire peninsula would have to be acquired. Proposed layouts of sites C and E are shown in figures 4.2-12 and 4.2-13.

(f) Conclusion - From consideration of the above factors, TVA concluded that the Guntersville sites would be physically suitable for the location of a nuclear plant.

4. Environmental considerations -

(1) Aesthetics - None of the sites considered is in a heavily populated location, and none is at a location frequented by large numbers of visitors.

All sites have been examined for potential visual impacts considering such factors as plant elevations relative to reservoirs and surrounding terrain, distances from well-travelled highways, and distances from waterways. None of the sites is highly elevated with respect to the reservoirs or surrounding terrain. Plant grade elevations vary from about 25 feet above the normal reservoir elevation at site C to about 35 feet for sites E and G. The distance from the reservoir to the powerhouse would vary from about 1,300 feet at site G to about 4,000 feet at site E, with site C at about 3,000 feet. Due to the hilly nature of the terrain at these sites, considerable natural screening is provided for installation at lower elevations. At any of the sites considered the plant would be visible from a state or U.S. highway.

Plant construction plans are coordinated with architectural personnel who route access roads, recommend leaving trees standing in strategic areas as visual screens, and otherwise reduce visual impacts. These practices would be followed at any site and visual impacts would not be expected to be significant except if natural draft cooling towers were utilized. The towers would be visible in the near vicinity of the plant site and their plumes could be visible for as much as 10 miles. The plumes, therefore, could be seen on some occasions from some small towns regardless of the site chosen. The towers themselves are considered to be visually acceptable.

Examination of the alternative sites to determine the visual impacts resulting from transmission line connections indicates that some differences exist. Where the lines leave the plant overland, they can be screened by strategic routing, but where reservoir crossings are required the lines cause greater visual impacts. Therefore, the number of reservoir crossings required is considered as an indicator of the degree of impact. Of the three sites considered, site C would probably require four reservoir crossings, site E would require five reservoir crossings, and site G would require six reservoir crossings. Impacts of crossings can be minimized by use of double-circuit towers and strategic location of crossings. As discussed in section 2.2, a double-circuit crossing will be utilized at the Bellefonte crossing.

Regardless of the location selected, the design of the plant would have as an objective the creation of harmony between the plant and its setting. The architectural design and site development should provide an aesthetically pleasing appearance and mitigate the transition in land use.

It is concluded that through careful planning and coordination of plant design, the plant's visual impacts would be made acceptable at any of the sites considered.

(2) Recreation - The alternative sites were considered for the impacts on recreation potential which might occur due to the construction and operation of a nuclear plant.

Guntersville and Chickamauga Lakes are very similar in terms of suitability for recreation. Each has good sport fishing, clean clear waters, water contact sports, and the beautiful backdrop provided by the wooded Appalachian foothills. These two reservoirs combined attract almost 9,000,000 visits annually--5,358,000 at

Guntersville and 3,636,000 at Chickamauga. These visits occur at boat docks and resorts, state and local parks, wildlife areas, public access areas, and private residences located along the shoreline.

The sites considered on Guntersville Reservoir at TRM 369L (site C) and TRM 392R (site E) are in areas which have high capability for development for family boating activities and recreational lodging. Selection of one of these sites would result in a limited reduction in these potential recreation uses.

The site investigated on Chickamauga Reservoir at TRM 499L (site G) is less suited for recreation but could be used for limited development of facilities for boating and water contact sports. Selection of this site would have no appreciable effect on recreation uses in this area.

(3) <u>Land use compatibility</u> - Assessments of land use compatibility involved in constructing and operating a nuclear plant on each of the sites considered have been made. Present and projected uses of the areas surrounding the sites have been determined to identify potential conflicts. The following tabulation briefly describes some of the features considered in the assessments of sites C, E, and G.

(a) <u>Site C</u> - Most of the land on and around the site is very sparsely developed. Upstream, about 1.5 miles, some second-home development is occurring on the shoreline, and downstream about 2.5 miles, a major industry has located a plant. Development of the site for generating purposes would be generally compatible with projected land uses.

(b) Site E - This site contains and is adjacent to farmland with high potential for industrial development. Thus, use of this site for a nuclear plant would be compatible with present and projected land uses in the vicinity.

(c) Site G - No development is located near this site. However, it is just downstream and adjacent to the Hiwassee Island Game Management and Waterfowl Refuge Area which is of major importance to east Tennessee. The compatibility of the site with the continued existence of the wildlife refuge has not been determined. It is judged, however, that impacts of constructing a plant on this site would affect the refuge only during the construction period and no permanent damage to the refuge would result.

While some incompatibility has been identified, construction of a nuclear plant at any of the sites would not result in any significant impacts on long-term productivity of land of the areas involved. The largest amount of land involved are the transmission line rights of way. Where the transmission lines cross open fields or farmland, only minor restrictions are imposed. Where wooded areas are crossed, some benefits are realized by providing wildlife food and cover although some short-term forest products production may be adversely affected.

All sites are examined for archaeological and historical significance prior to any significant alteration of the site. This procedure may result in exploration of sites with archaeological and historical significance to an area and add to the knowledge of the history of the area.

(4) Impacts on fisheries and wildlife - Studies of fish and other aquatic life inhabiting Guntersville and Chickamauga Reservoirs indicate that neither of these reservoirs is unique with regard to species populations.

A 1970 Chickamauga Reservoir fish population survey indicated on the basis of numbers 12 percent game fish, 55 percent rough fish, and 33 percent forage fish. Bluegill and other sunfish, largemouth bass, spotted bass, white crappie, and white bass dominated the game fish. Gizzard and threadfin shad were the dominant forage fish. Two species of buffalo and freshwater drum dominated the rough fish.

Results of recent surveys of fish populations in Guntersville Reservoir are presented in section 1.2 and appendix B. Results of the 1971 survey reveal considerable variation in the species composition of standing stocks, the variation being greater for young than for adult fish. Sites near, and especially immediately downstream from embayments (e.g., site E) can be expected to show large numbers of larval and young fish.

It is assumed that observance of EPA-approved water quality standards will adequately protect aquatic biota of these reservoirs. Consequently, releases from a nuclear plant at any site considered would not be expected to significantly affect aquatic resources of the area regardless of species population or distribution.

All of the sites considered are in the vicinity of wildlife management area or waterfowl refuge, the most significant one being site G which adjoins the Hiwassee Island Game

Management and Waterfowl Refuge. This refuge supports the largest concentration of geese in the valley region east of Wheeler Wildlife Refuge and is responsible for an annual hunter harvest of an estimated 2,000 to 5,000 geese per year. Some disturbance of wildlife inhabiting the nearby refuges or waterfowl using the areas seasonally would result during the plant construction period. The degree of this disruption cannot be predicted. However, after the major construction activities have ceased, the uses of the areas are expected to return to normal and the operation of a nuclear plant is not expected to significantly affect the wildlife of the areas.

5. Economic considerations - Cost estimates were prepared to establish cost differentials for constructing the proposed nuclear plant at sites C, E, and G. It was assumed that supplemental cooling facilities would be common to each of the sites; therefore, no cost differential was considered for supplemental cooling facilities. The analysis included the cost of access facilities, transmission connections, and site development. The transmission lines for each of the sites would be constructed in two steps which are coincident with the initial operation of units 1 and 2. Site-related costs are summarized in Table 4.2-2.

(1) Site C -

(a) Access facilities - U.S. Highway 431 is about 16 miles from the site. An access road about 1,000 feet long would have to be constructed to connect the site with an improved light-duty road. About 3.8 miles of this road would have to be reconstructed. The remaining 12 miles of medium-duty road would have to be improved, completing the connection of the plant site with U.S. 431.

An access railroad about 16.5 miles long and requiring two bridges would have to be constructed to connect the site with the existing L&N Railroad.

The cost of constructing access facilities to this site was estimated to be $6.6 million.

(b) Transmission connections - Step 1 would require unit 1 be connected to the 161-kV system. Under step 2, two 500-kV lines would be constructed which include a 32-mile line from the proposed plant site to Madison and a 40-mile line from the proposed plant site to TVA's existing Widows Creek Steam Plant. The total cost of these connections is estimated to be $14.66 million.

(c) Site development - With a plant grade elevation of 616 feet, the excavation required would total 1.2 million cubic yards and the fill 1.0 million cubic yards. Rock is located approximately 30 feet below plant grade. The estimated cost of site development is $3.5 million more than at site G which was estimated as a base.

(2) Site E -

(a) Access facilities - U.S. Highway 72 is about 2.5 miles from the site. An access road about 4,000 feet long would have to be constructed to connect the site with an improved light-duty road. About 1.5 miles of this road would have to be reconstructed.

An access railroad 3.5 miles long would have to be constructed to connect the site with the existing Southern Railroad. The access railroad would have to cross U.S. Highway 72 which would most likely require a grade separation at that point.

The estimated cost of constructing access facilities to this site was estimated to be $1.1 million.

(b) Transmission connections - Step 1 would require that the existing Madison-Widows Creek 500-kV line and the Widows Creek-Scottsboro 161-kV line be looped into the plant site. Each 500-kV line would be 11 miles long for a total of 22 line-miles and the 161-kV loop totaling 3 miles. Under step 2, three 500-kV lines would be constructed. These 500-kV connections include a 22-mile line from the plant site to Widows Creek Steam Plant, a 27-mile line from the plant site to Murphy Hill, and a 36-mile line from Murphy Hill to Madison. The total cost of these connections is estimated to be $16.95 million.

(c) Site development - With a plant grade elevation of 627 feet, the excavation required would total 0.8 million cubic yards and fill 0.4 million cubic yards. Rock is located about 20 feet below plant grade. The estimated cost of site development is $1.0 million more than site G which was established as a base.

(3) Site G -

(a) Access facilities - Highway 60 passes near the plant site. Approximately 8 miles of the existing highway would require some maintenance for access to the site.

The nearest existing railroad is the Southern Railway 1 mile west of Charleston, Tennessee. Approximately 19 miles of railroad would be required for rail access to the plant site. Six bridges would be required--five over creeks and one over Interstate Highway 75. The cost of constructing access facilities to the site was estimated to be $5.3 million.

(b) Transmission connections - Step 1 would require the proposed Sequoyah-Watts Bar No. 1 500-kV line be looped into the plant site. The line passes 2 miles from the plant site, thus requiring 4 miles of line.

Step 2 would require the constructing of four 500-kV lines and two short 161-kV lines. The 500-kV connections include looping the Sequoyah-Franklin 500-kV line into the plant site a distance of 20 miles each, constructing a 49-mile line from the plant site to Raccoon Mountain, and constructing a 72-mile line from Widows Creek-Murphy Hill-Madison. The Sequoyah-Watts Bar 161-kV line would be looped into the plant site a distance of 6 miles each. The total cost of these connections is estimated to be $25.575 million.

(c) Site development - The excavation required would total about 0.3 million cubic yards and the fill about 0.5 million cubic yards. Rock is located 22 to 37 feet below plant grade. This site was estimated as a base for developing site development costs.

6. Conclusion - It was concluded that each of the three sites C, E, and G were suitable for a nuclear plant; however,

economic and environmental cost differences exist which make site E the preferred site for the proposed nuclear plant. As shown in Table 4.2-2, sites C and E have substantial economic advantage when compared to site G. In addition, as shown in Table 4.2-1, site G has greater potential for land use conflicts because of its close proximity to the Hiwassee Island Game Management and Waterfowl Refuge Area and requires the most extensive transmission and access facilities of any of the alternative sites. As a result of these considerations, site G was eliminated from consideration for locating the proposed plant.

Sites C and E are both on Guntersville Reservoir approximately 23 miles apart; therefore, many impacts would be very similar at each site. As shown in Table 4.2-2, site E has an economic advantage of approximately $5.0 million. Site C requires the most extensive access facilities, and site E the most extensive transmission facilities. Early in the site review, site E also required some 40 to 60 miles of 500-kV line less than site C. Recent changes in the proposed transmission additions have reversed this advantage. Both sites are relatively isolated with site E having a significantly smaller population within a 30-mile radius but a greater population within a 50-mile radius.

While land use plans indicate both sites (C and E) are compatible for use as a nuclear plant site, site E is in an area with no developed public recreation areas in the immediate vicinity of the site, and site C is located within 1.5 miles of some second-home development and within 3 to 5 miles of boat docks, private clubs, and a group camp.

When considering the economic advantage of site E along with the less extensive access facilities, lower populations within 30 miles of the site, and the greater land use compatibility, TVA selected site E, Bellefonte, as the preferred site for the proposed plant.

Table 4.2-1

SUMMARY OF SITE EVALUATION FACTORS

Site	C	E	G
1. Land Use (Acres)			
Total Site	700	1,500	1,100
Amount to be Purchased	375	1,260	900
2. Proximity to Populated Areas			
Nearest Town	Grant, Ala.	Hollywood, Ala.	Dayton, Tenn.
Distance - Miles	6	3	6
Population	382	865	4,361
Nearest City	Huntsville, Ala.	Huntsville, Ala.	Chattanooga, Tenn.
Distance - Miles	30	39	30
Population	137,802	137,802	119,082
Population			
5 miles	3,378	2,755	3,691
10 miles	13,112	18,405	16,768
20 miles	88,359	50,530	100,220
30 miles	223,524	106,860	287,274
40 miles	459,347	398,665	467,050
50 miles	653,925	837,658	683,226
3. Transmission Line Construction Required - Miles			
500 kV	72	107	165
161 kV	-	3	12
Number of River Crossings	4	5	6
4. Access Facilities			
Highway	Construct 1,000 ft Access Road Reconstruct 3.8 Miles of Road Improve 12 Miles of Road	Construct 4,000 ft Access Road Reconstruct 1.5 Miles of Road	Maintain 8 Miles of Highway

Table 4.2-1
(continued)

SUMMARY OF SITE EVALUATION FACTORS

	C	E	G
Railroad			
Miles of Construction	16.5	3.5	19
Bridges	2	-	6
5. Site Grading - 10^6 yd^3			
Excavation	1.2	0.8	0.3
Fill	1.0	0.4	0.5
6. Land Use Compatibility	Second-home development 1.5 miles upstream. Major industry 2.5 miles downstream. Boat docks, private clubs, and group camps in vicinity of the site. Generally Compatible.	Site contains and is adjacent to farmland. No developed public recreation areas near the site. Compatible.	No intensive development near the site. Adjacent to a game management and waterfowl refuge. Generally Compatible Except for Possible Effect on Refuge During Construction.
7. Recreation	Limited Reduction in Recreational Activities.	Limited Reduction in Recreational Activities.	Limited Reduction in Recreational Activities.
8. Aesthetics	No Conflict.	No Conflict.	No Conflict.
9. Impacts on Fisheries and Wildlife			
Reservoir	Guntersville No Unique Species Population. No Significant Impact.	Guntersville No Unique Species Population. No Significant Impact.	Chickamauga No Unique Species Population. No Significant Impact.

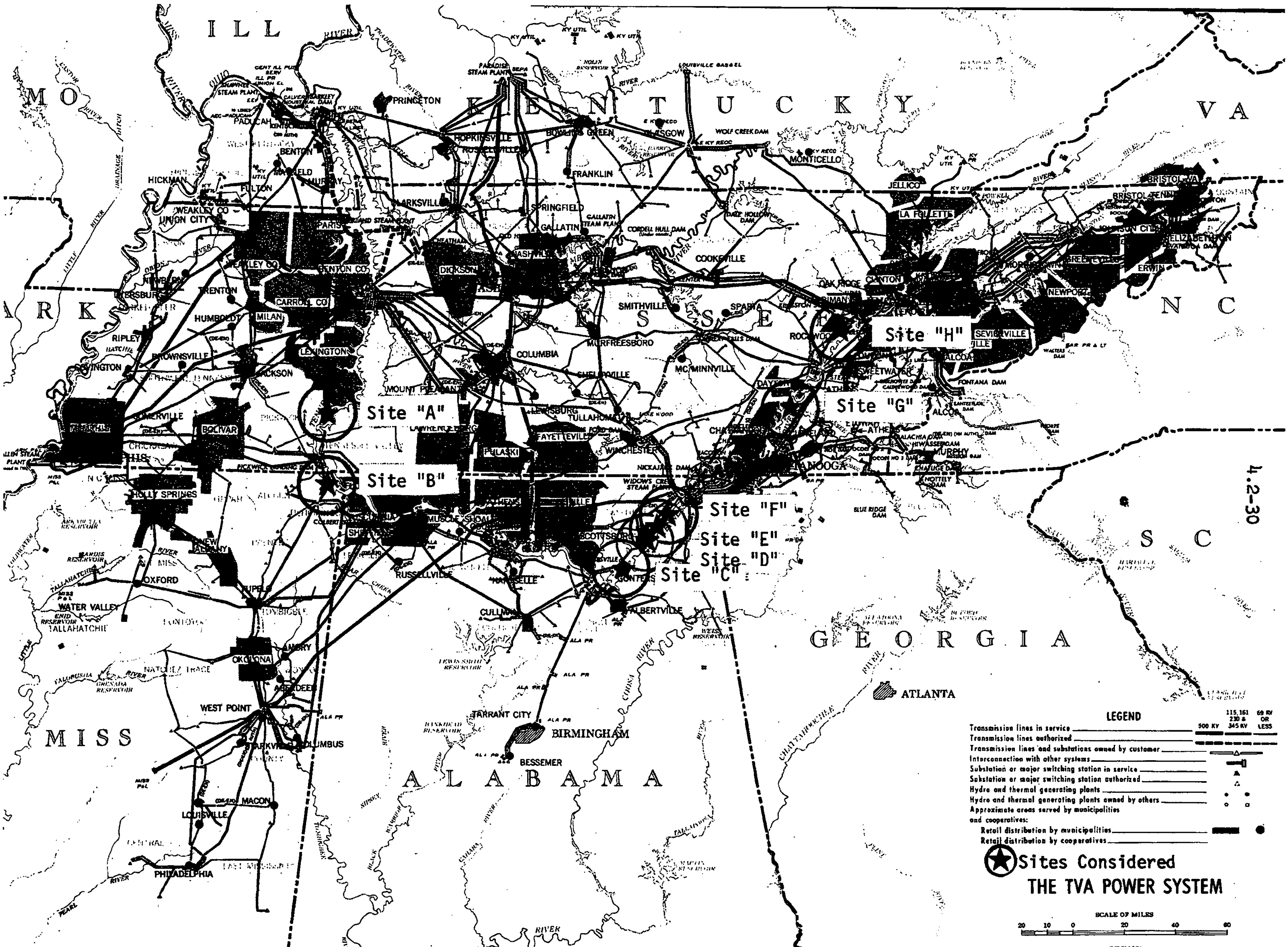
Table 4.2-2

SUMMARY OF SITE-RELATED COSTS*

(Thousands of 1972 Dollars)

Item	C	E	G
Access Facilities**			
Highway	1,600	250	100
Rail	5,000	850	5,200
Site Development	3,500	1,000	Base
Transmission System Connections	14,660	16,950	25,575
Land	432	1,109	570
Total Site-Related Cost	25,192	20,159	31,445
Difference	5,033	Base	11,286

*Cooling facilities costs were judged to be comparable for same heat dissipation.
**Barge facilities costs were judged to be about the same at each site.



ILL
MO
KENTUCKY
VA
ARK
TENNESSEE
NC
MISS
ALABAMA
GEORGIA
SC
Site "A"
Site "B"
Site "C"
Site "D"
Site "E"
Site "F"
Site "G"
Site "H"
PADUCAH
HICKMAN
FULTON
UNION CITY
PARIS
CLARKSVILLE
HOPKINSVILLE
BOWLING GREEN
GLASGOW
FRANKLIN
SPRINGFIELD
GALLATIN
COOKEVILLE
SMITHVILLE
MURFREESBORO
COLUMBIA
SHELBYVILLE
MC MINNVILLE
TULLAHOMA
WINCHESTER
FAYETTEVILLE
PULASKI
JACKSON
LEXINGTON
HUMBOLDT
TRENTON
BROWNSVILLE
COVINGTON
SOMERVILLE
BOLIVAR
HOLLY SPRINGS
NEW ALBANY
OXFORD
TUPELO
WATER VALLEY
OKOLONA
AMORY
ABERDEEN
WEST POINT
STARKVILLE
COLUMBUS
LOUISVILLE
MACON
PHILADELPHIA
RUSSELLVILLE
MUSCLE SHOALS
HARTSELLE
CULLMAN
ALBERTVILLE
GUNTERSVILLE
SCOTTSBORO
CHATTANOOGA
DAYTON
ATHENS
SWEETWATER
ROCKWOOD
OAK RIDGE
CLINTON
JELLICO
LA FOLLETTE
MORRISTOWN
GREENEVILLE
NEWPORT
SEVIERVILLE
ALCOA
ELIZABETHTON
ERWIN
BRISTOL VA
BRISTOL TENN
MONTICELLO
PRINCETON
TARRANT CITY
BIRMINGHAM
BESSEMER
ATLANTA
PARADISE STEAM PLANT
WOLF CREEK DAM
CORDELL HULL DAM
FONTANA DAM
WIDOWS CREEK STEAM PLANT
NICKAJACK DAM
LEGEND
Transmission lines in service
Transmission lines authorized
Transmission lines and substations owned by customer
Interconnection with other systems
Substation or major switching station in service
Substation or major switching station authorized
Hydro and thermal generating plants
Hydro and thermal generating plants owned by others
Approximate areas served by municipalities and cooperatives:
Retail distribution by municipalities
Retail distribution by cooperatives
500 KV
115, 161 230 & 345 KV
69 KV OR LESS
Sites Considered
THE TVA POWER SYSTEM
SCALE OF MILES
20 10 0 20 40 60
JULY 1971

Figure 4.2-1

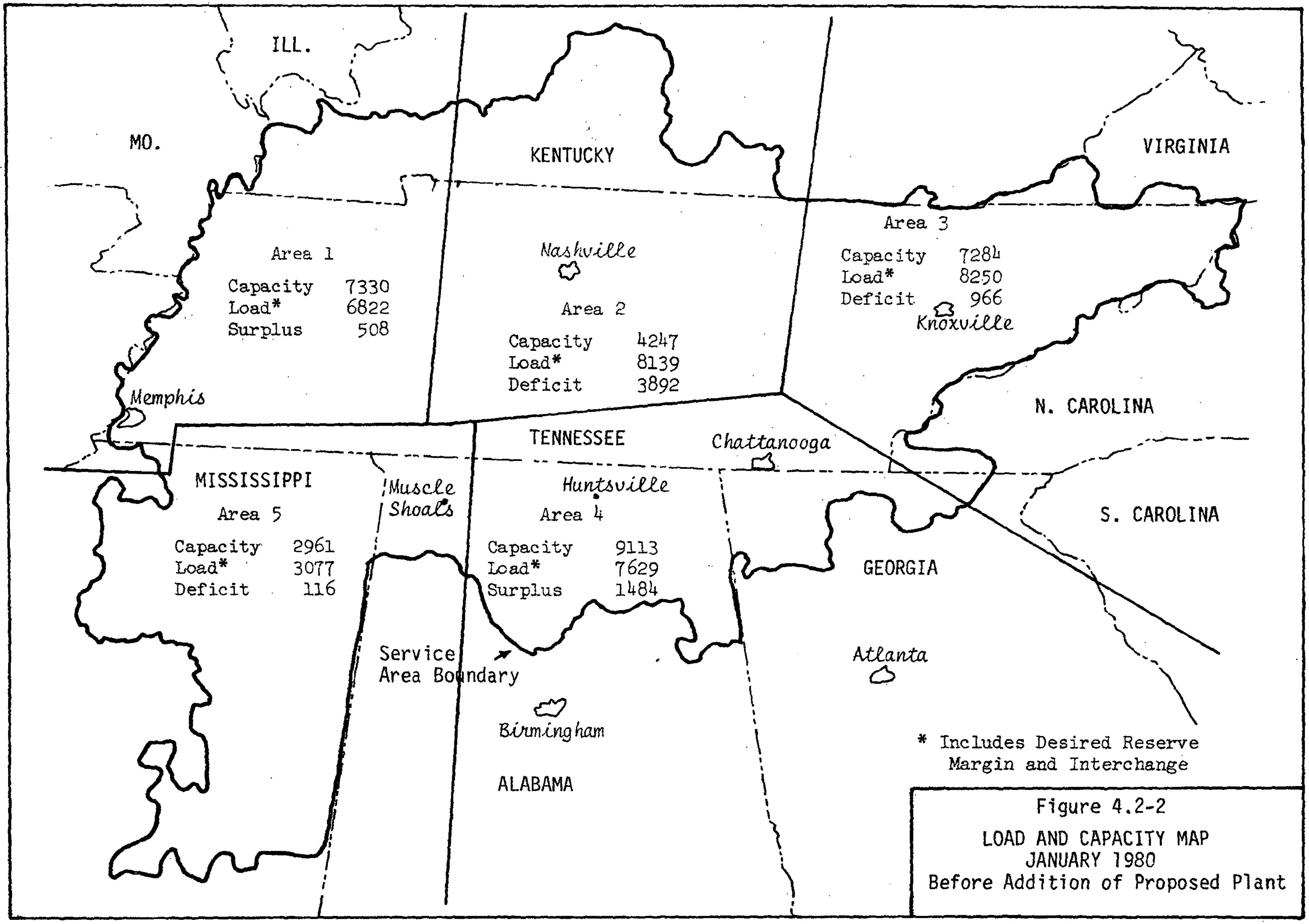


Figure 4.2-2

LOAD AND CAPACITY MAP
JANUARY 1980
Before Addition of Proposed Plant

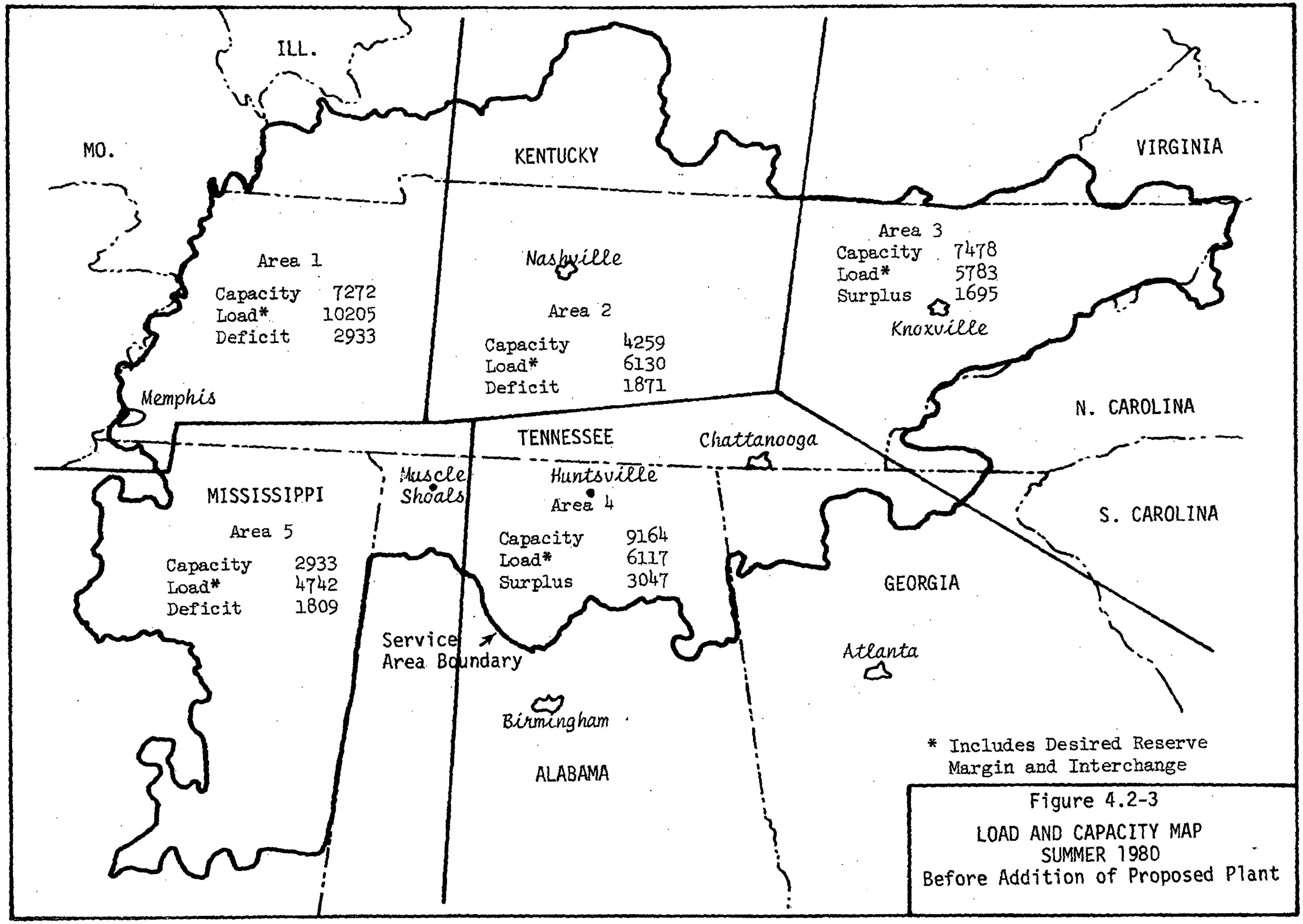


Figure 4.2-3
LOAD AND CAPACITY MAP
SUMMER 1980
Before Addition of Proposed Plant

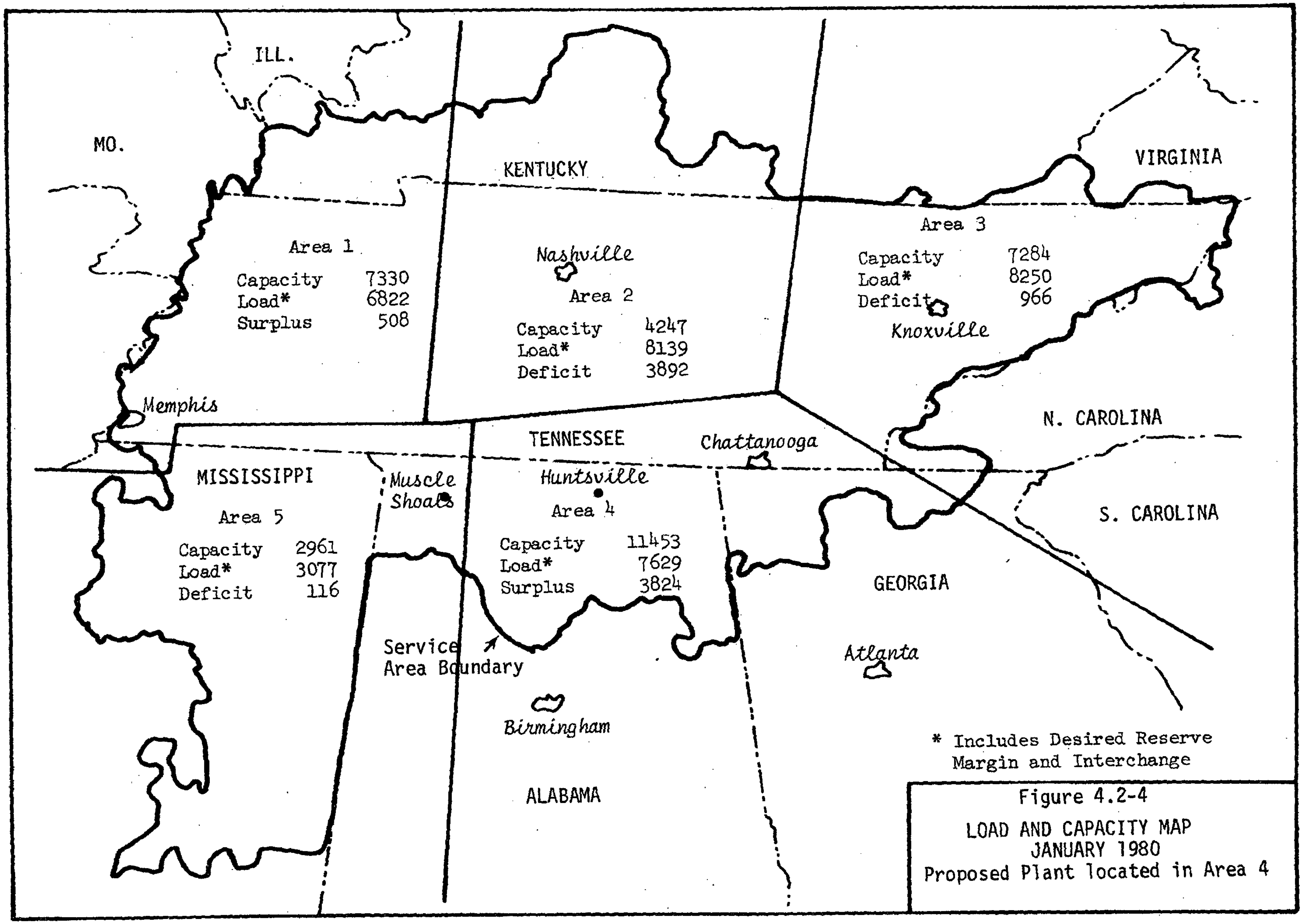


Figure 4.2-4
LOAD AND CAPACITY MAP
JANUARY 1980
Proposed Plant located in Area 4

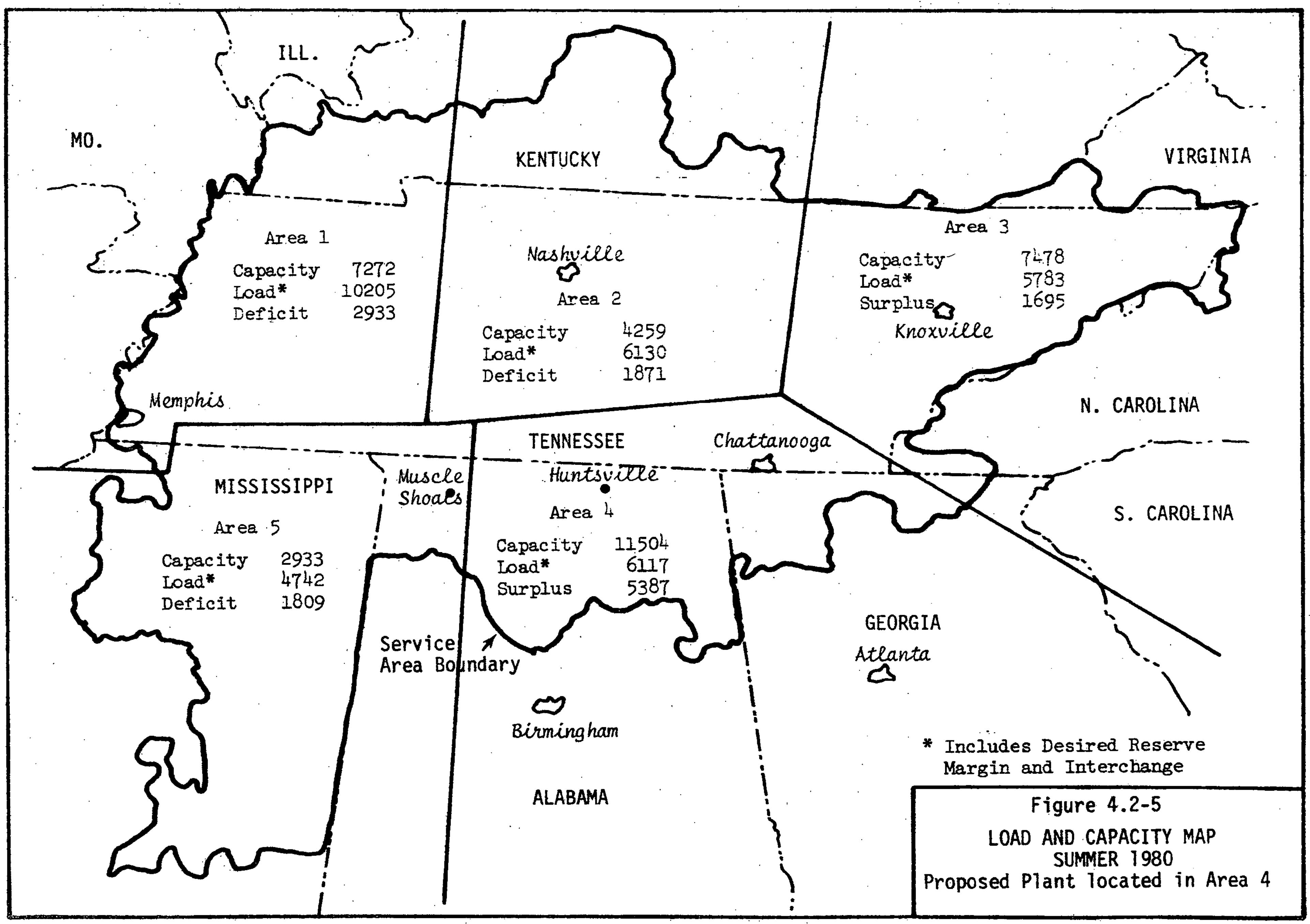


Figure 4.2-5
LOAD AND CAPACITY MAP
SUMMER 1980
Proposed Plant located in Area 4

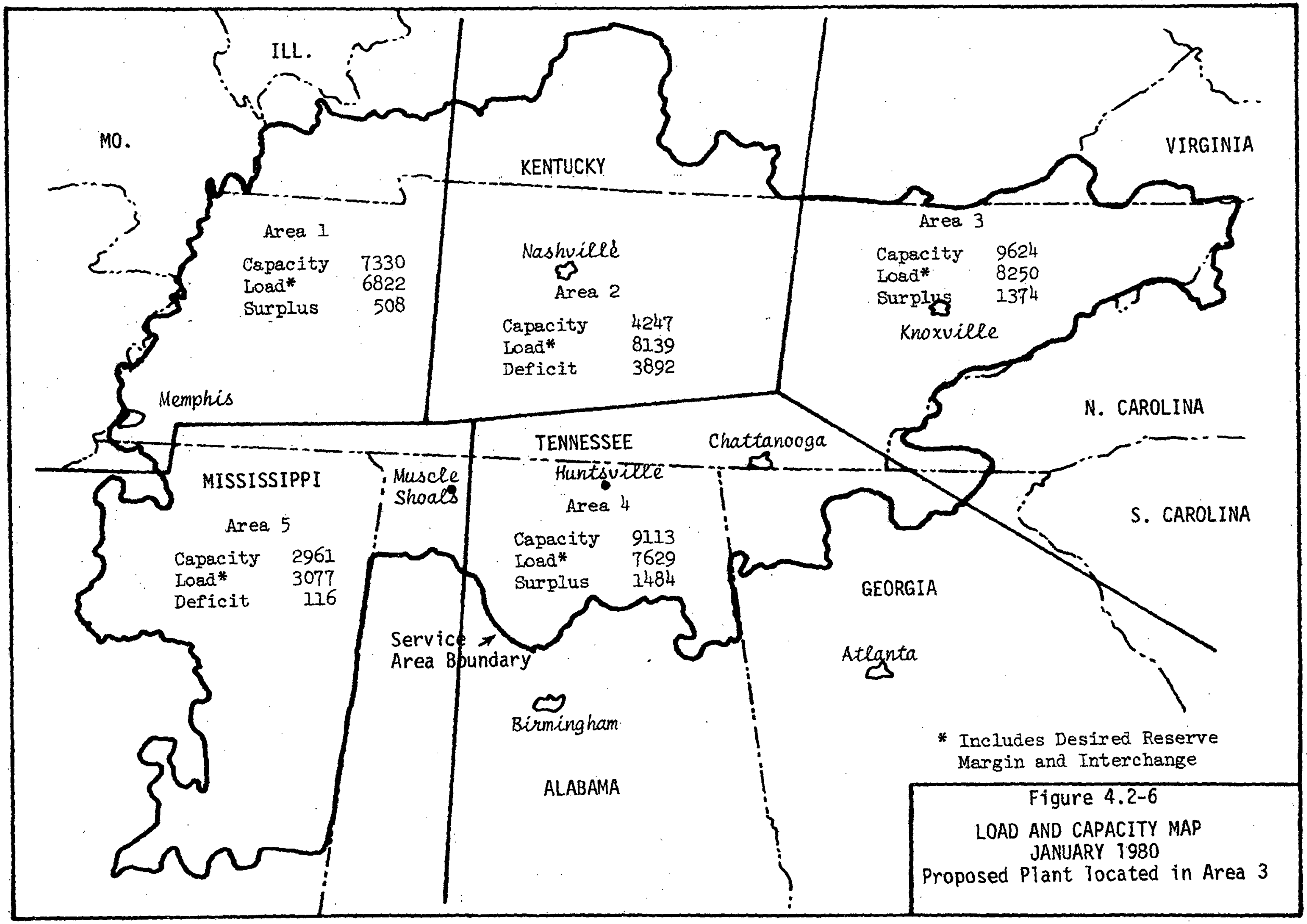


Figure 4.2-6

LOAD AND CAPACITY MAP
JANUARY 1980
Proposed Plant located in Area 3

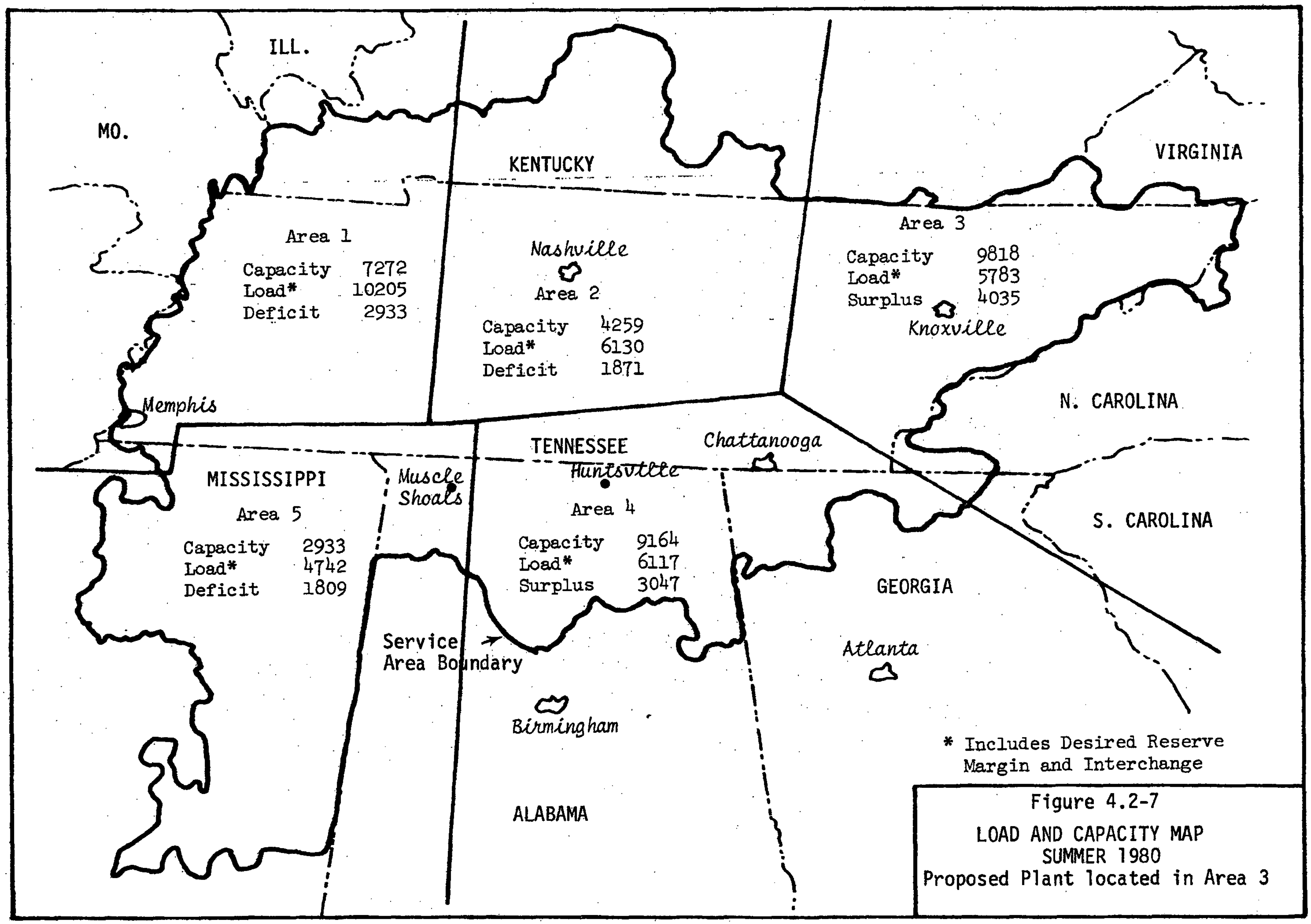


Figure 4.2-7

LOAD AND CAPACITY MAP
SUMMER 1980
Proposed Plant located in Area 3

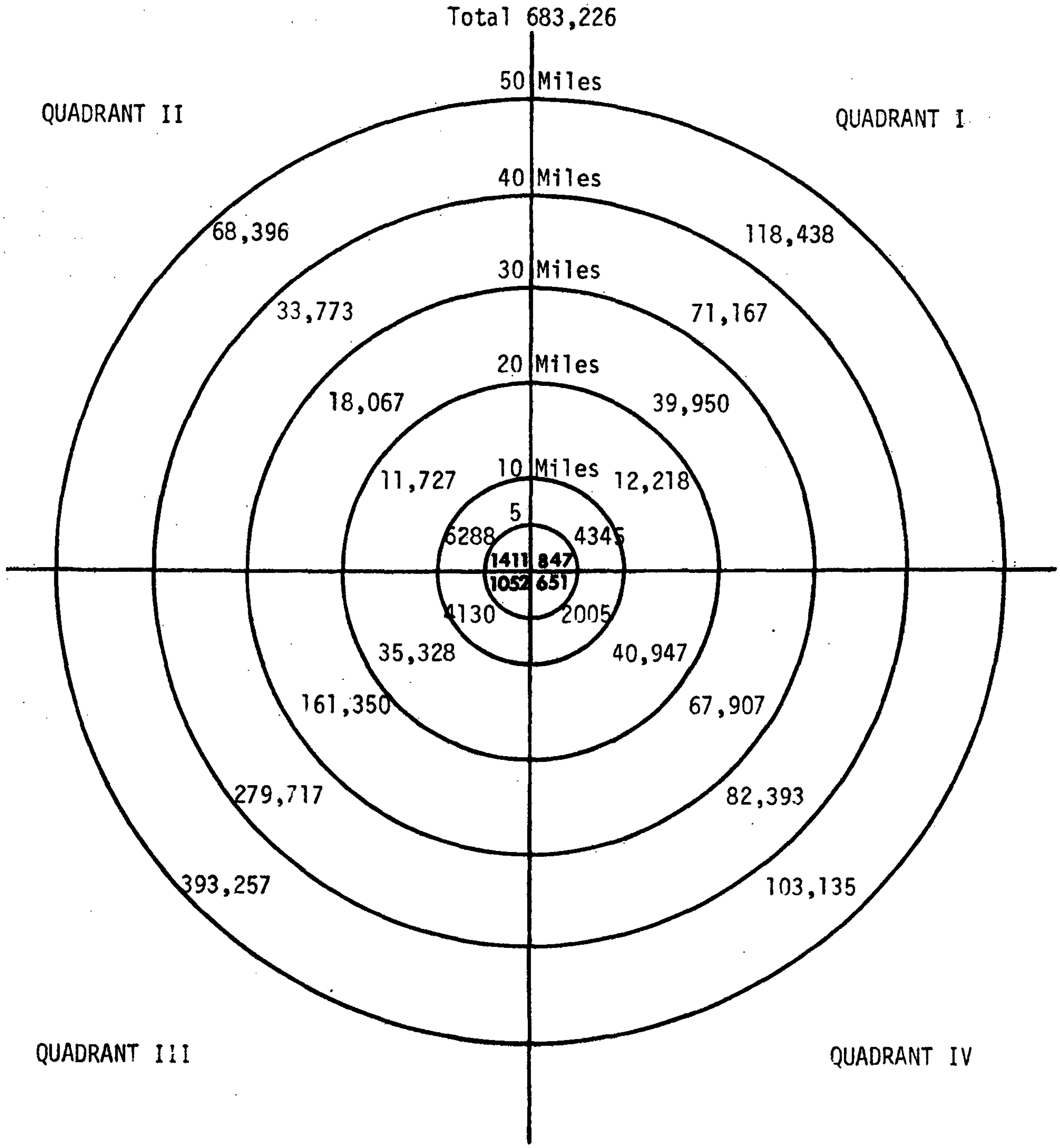


Figure 4.2-8

SITE G
CUMULATIVE POPULATION STUDY

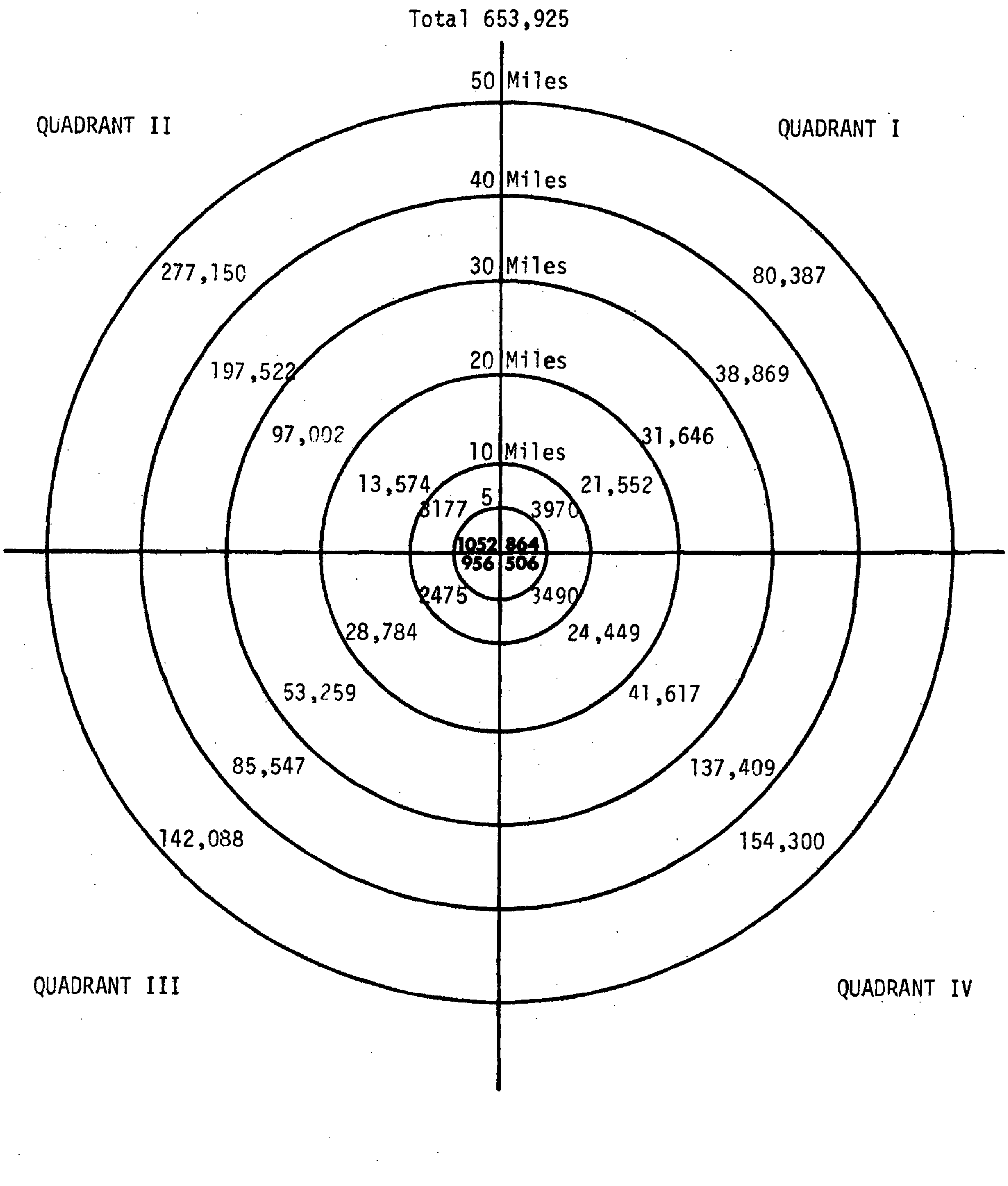


Figure 4.2-9

SITE C
CUMULATIVE POPULATION STUDY

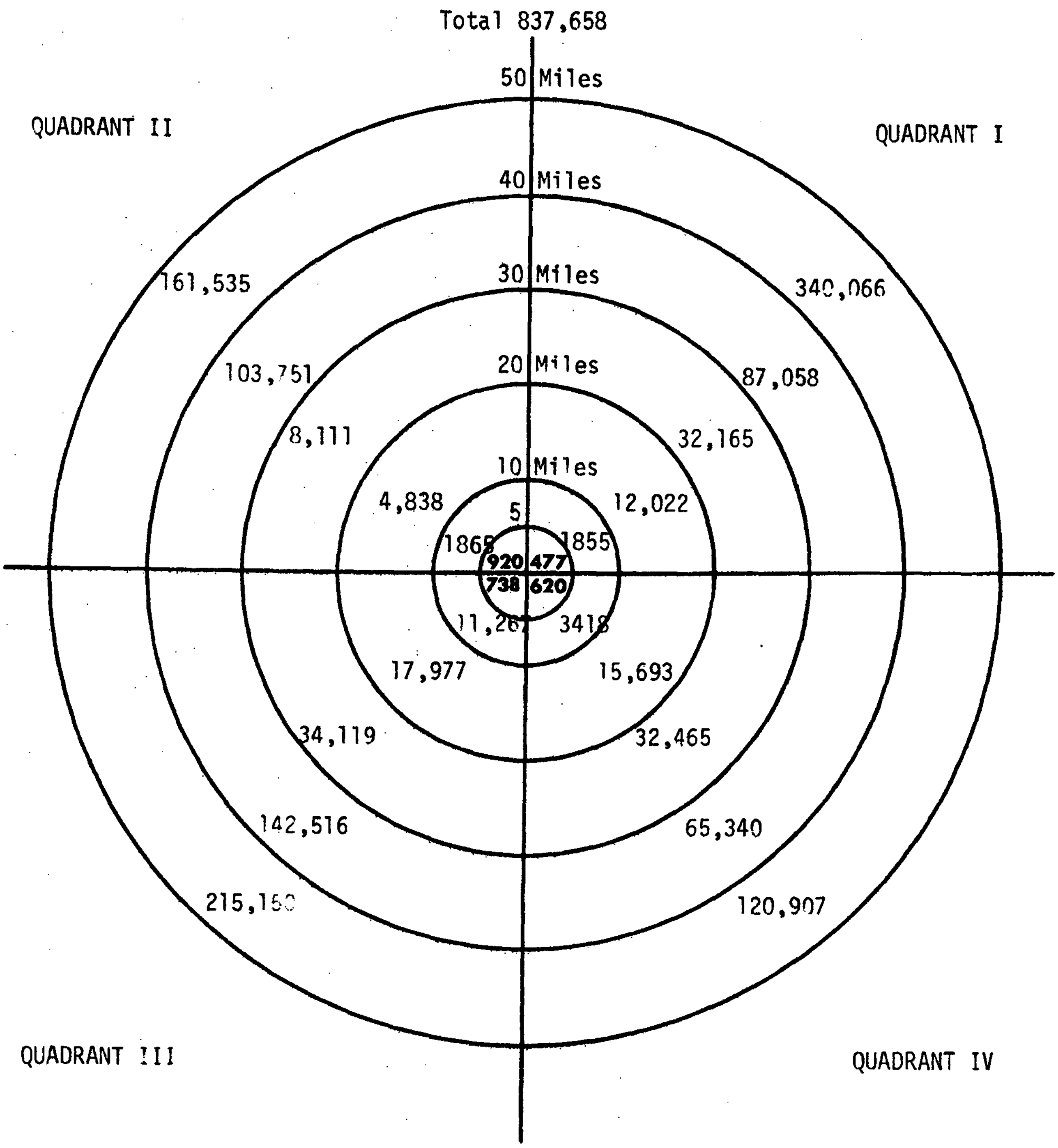


Figure 4.2-10

SITE E
CUMULATIVE POPULATION STUDY

Figure 4.2-11

Plant Site G
Tennessee River Mile 499L
800' 0 800'
APPROX. SCALE

N

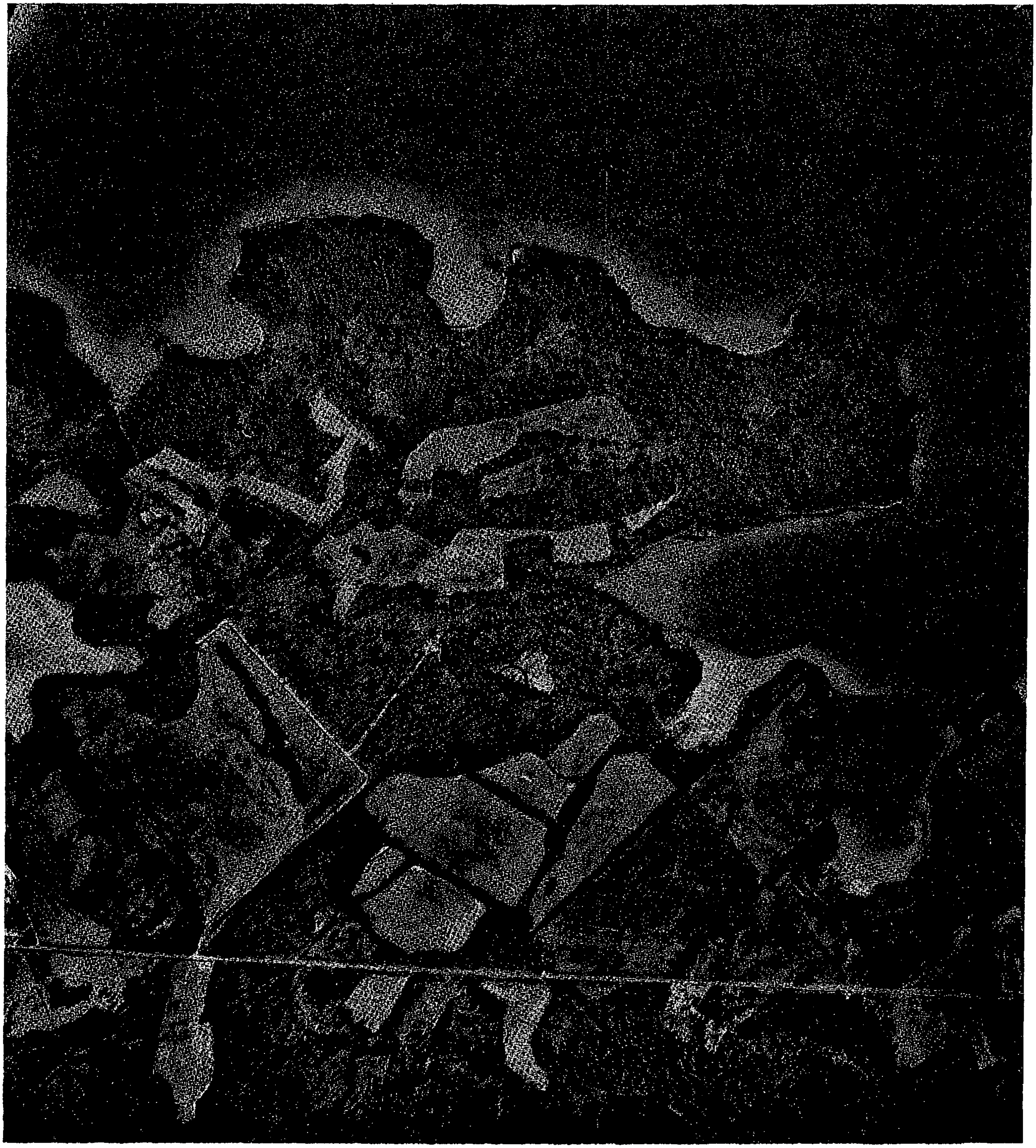
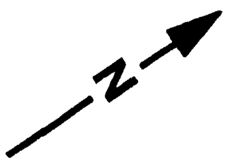


Figure 4.2-12



Plant Site C
Tennessee River Mile 369L
800' 0 800'
APPROX. SCALE

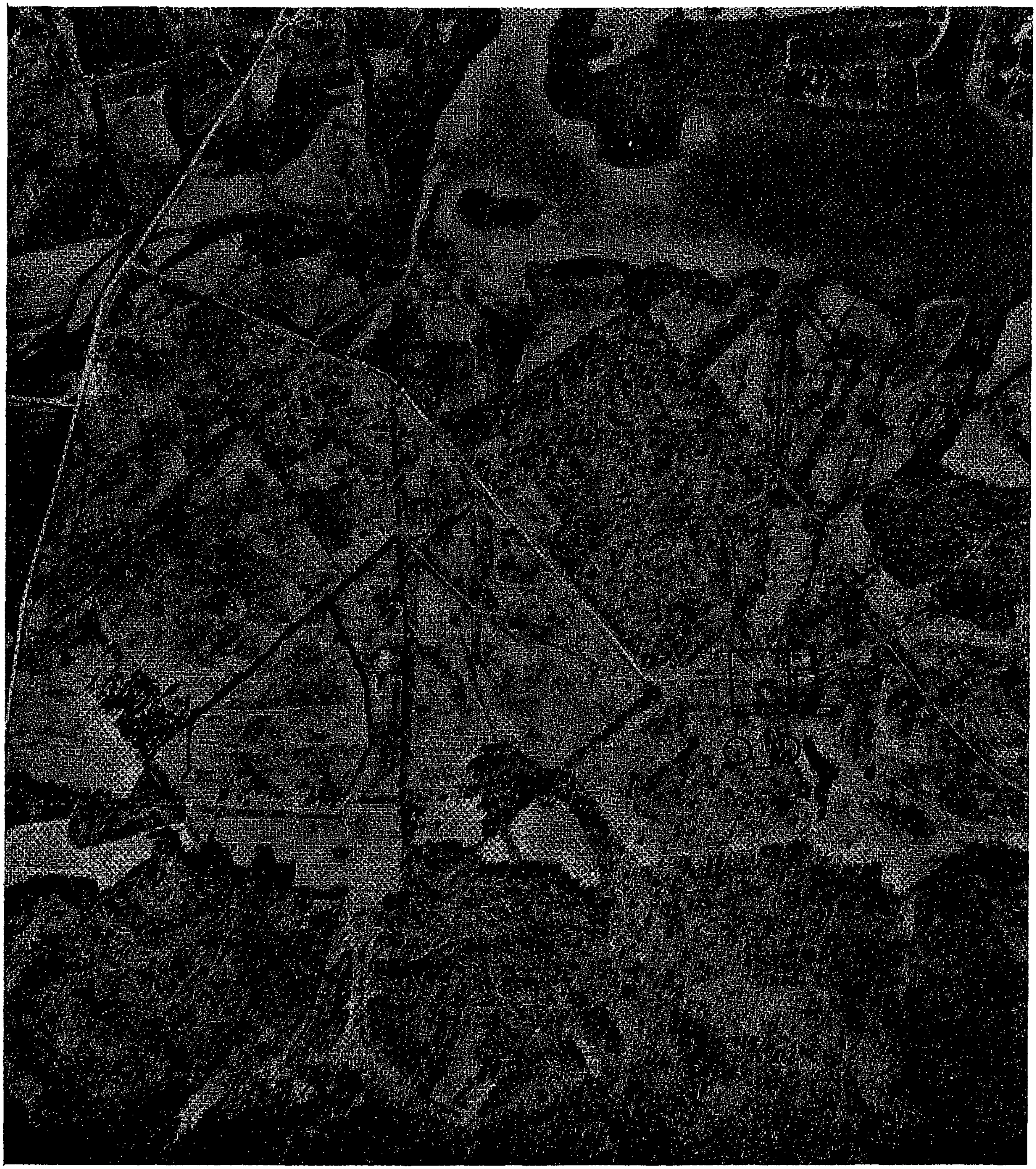
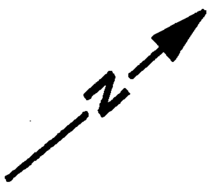


Figure 4.2-13

Plant Site E
Tennessee River Mile 392R

800' 0 800'

APPROX. SCALE



5.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

CEQ guidelines call for a discussion of the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. This requires an assessment of the construction and operation of the plant for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations.

In view of the foregoing environmental considerations, the immediate benefits to be derived from the initiation of this project should not noticeably curtail the long-range beneficial uses of the natural resources of the area. The cumulative effect of the plant will be the further localized shift of land usage to meet the demand for power.

There will be local short-term effects on the environment because of the construction of the facility. However, these effects will be minimized and will have no long-term effects on the environment. During operation there may be local short-term effects associated with radioactive, chemical, and thermal discharges. Releases of radioactive materials to unrestricted areas will be small fractions of the limits established in 10 CFR Part 20. Thermal and chemical discharges to the reservoir will be negligible.

Environmental monitoring programs will include the sampling and analysis of the air, water, aquatic life, and food web near the facility. This will provide a baseline inventory for detecting and evaluating any radiological impact which might lead to long-term effects in order that timely corrective action can be taken if required. Thus, in the sense that each generation is trustee of the environment for succeeding generations, the plant will be constructed and operated in a manner to protect the environment so that succeeding generations will be enabled to attain full use of the environment.

6.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The CEQ guidelines call for a discussion of any irreversible and irretrievable commitments of resources which would be involved in the construction and operation of the facility. This requires identifying the extent to which operation of the facility curtails the range of beneficial uses of the environment.

The construction and operation of the plant will involve the use of a certain amount of air, water, and land. Except for the site itself, the range of beneficial uses of the environment will not be curtailed and these are not irreversible. However, the site will continue to be dedicated to power production for the foreseeable future.

The annual requirement for natural uranium for each reactor is approximately 200 tons of U_3O_8. About 700 kilograms per year of U^{235} and about an equal amount of U^{238} will be consumed by each unit. Some of the uranium can ultimately be recycled for other uses. About 4,800,000 gallons of fuel oil will be required for the auxiliary boilers and diesel generators during tests. To the extent that this fuel is consumed and not subject to being recycled to other uses, it will be an irreversible and irretrievable commitment of resources. In addition to these resources, some byproducts which result from the operation of the plant must also be considered irreversible and irretrievable commitments of resources. These include damaged components which are radioactive, solid radwaste materials, and various chemicals which are used in the plant processes. Chemicals thus used will be widely dispersed to the environment and in most cases will have changed forms. Reclamation of these chemicals after discharge from the plant is impractical.

Since the ultimate disposition of the plant buildings and equipment has not been determined, it must be assumed that both land and construction materials will be irreversibly committed. It is unlikely, however, that more than the equipment and land directly in and beneath the reactor building will be ultimately irreversibly and irretrievably committed.

7.0 AGENCY REVIEW COMMENTS

As indicated earlier in this draft environmental statement, various state and Federal agencies will be provided with copies of this statement and their comments requested thereon. These comments will be listed at this point in the final environmental statement.

8.0 BENEFIT-COST ANALYSIS

This section provides an overall assessment of the economic, technical, and other benefits of the Bellefonte Nuclear Plant weighed against the environmental costs, with the alternatives considered which would affect the balance of values.

TVA from its very inception has been deeply committed to the tasks of environmental improvement. The President in transmitting to Congress in 1933 the bill that became the TVA Act said that TVA ". . . should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the Nation." It is on the basis of these principles that TVA plans and conducts all its activities, be they planning, constructing, and operating a nuclear power plant; planning, building, and operating a water control project; providing research to develop a new fertilizer; setting aside areas for fish and wildlife; developing improved hardwood tree strains; or seeking ways to utilize the rugged scenic qualities of some of the region's natural streams. In all of these and many other varied resource development programs, TVA is deeply conscious of its responsibilities to the people in the TVA region and in the Nation. This posture invariably calls for a balancing of a variety of interests and, finally, decision and action in which differences are reconciled insofar as possible to best serve the needs of the greatest number over the longest possible time. Inherent in this is the requirement of finding a balance between the needs of man, including his need for useful employment, and the safeguarding of his physical environment.

In TVA electric power is regarded as a tool for economic development. Its use has been encouraged as a means for improving the quality of life in the region. Fitted into a comprehensive, unified development program, it has helped ease the burdens of drudgery; provide more jobs and more productive employment; bring the amenities of life to an ever-increasing number of people; and generally improve the health, education, and living conditions of the people.

An ample supply of low-cost electric energy, integrated with a total resource development program, has been a major factor in the progress achieved by the TVA region since 1933. Employment, income, and productivity have all increased with a shift from a primarily agricultural to an industrial economy.

The uses of electricity are many. To the residential user it provides lighting, refrigeration, cooking, washing and drying of clothes, heating, air conditioning, and education and entertainment via radio and television, to name but a few. Most stores, banks, and other commercial ventures are dependent on electricity for conducting business. In industry it is an essential element by which productivity has been increased with an attendant improvement in living standards. While in most industrial activities the cost of electric power is a small fraction of the total cost of production, without electricity modern industry could not provide the Nation with the goods and services it demands. In the aluminum, electrochemical, and metallurgical industries, electricity is a significant component required in the manufacture of these essential products.

The addition of the Bellefonte Nuclear Plant to the TVA system will enable TVA to continue to carry out its responsibility to provide an ample supply of electricity for the TVA region. The benefits of the plant include the value of the electrical power to be generated, the potential for reduction of releases of combustion products to the atmosphere which would be associated with a fossil-fired station of equal capacity, the recreational and educational value to visitors to the plant, increased payments to local governments in lieu of tax payments, and a stimulant to the economic growth of the region by helping to assure an abundant supply of electrical power and increased employment potentials.

The costs of the plant include the commitment of about 1,500 acres of land for the lifetime of the plant; the rejection of about 1.56×10^{10} Btu/h to the air directly and via Guntersville Reservoir from cooling tower blowdown; the consumptive use by evaporation of about 74 ft^3/s of water; minor releases of radioactivity to the air and to Guntersville Reservoir; erosion of soil during construction; a very low probability of releasing radioactivity due to an accident in the plant or an accident during the transport of radioactive materials; and the monetary costs to construct, operate, and maintain the plant.

TVA has attempted, insofar as practicable, to detail those items covered in the Atomic Energy Commissions' proposed guide (issued for comment in August 1972) for benefit-cost analyses for new nuclear facilities in sections 8.1 and 8.2. The weighing and balancing of benefits and costs of alternative sites and subsystems is presented in section 8.3.

While various benefits and environmental costs have been quantified, some are necessarily expressed in qualitative terms. For example, the effect of natural draft cooling towers on aesthetics is treated qualitatively. Moreover, of those factors subject to quantification, all cannot reasonably be expressed in monetary values. Although the number of Btu's added to the cooling water blowdown can be numerically quantified, translation of that number to a monetary value is not reasonable in view of the wide range of variables influencing the significance of the impact. Environmental impacts, therefore, are quantified in commonly used terms such as numbers of fish, gallons of water, and tons of earth.

In addition to analyzing the need for base-load electrical capacity additions, the Bellefonte Nuclear Plant environmental review included an analysis of the alternatives for limiting environmental impacts during the construction of the project and the environmental impacts which will result from operation of the plant. During this environmental review, the design concepts for the plant have been chosen so as to provide a plant which approaches a minimum impact plant. Specific system design concepts were decided as follows:

Gaseous Radwaste - The gaseous radwaste system is being designed to provide a radioactive decay period of 60 days for radioactive gases.

Liquid Radwaste - The liquid radwaste system is being designed to permit recycling of tritiated water to the maximum extent practicable and to permit treating spent condensate demineralizer regenerants during periods when radioactively contaminated as a result of primary system to secondary system leakage.

Heat Dissipation - Heat dissipation will be by means of closed-cycle natural draft cooling towers.

With normal operation from the plant the maximum radiation dose to the hypothetical individual will be about 1 percent of that received from natural background radiation and the population dose within 50 miles of the plant in the year 2020 is projected at about 0.005 percent of the dose from natural background radiation. Therefore, radiation resulting from operation of the Bellefonte Nuclear Plant will result in no undue risk to the health and safety of the public.

With closed-cycle natural draft cooling towers the plant will operate so as to meet applicable water temperature standards.

Conclusion - This environmental review has evaluated the expected environmental impacts of the proposed project and has considered alternatives which would lessen environmental impacts. After weighing the environmental and monetary costs and the technical, economic, environmental, and other benefits of the project and adopting certain alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs.

8.1 Benefits - The benefits of the Bellefonte plant are detailed below and are summarized in Table 8.1-1.

1. Electric power produced and sold - Bellefonte Nuclear Plant includes two units with a dependable capacity of 1,170 MW electrical each, or a total plant capacity of 2,340 MW electrical. The units are scheduled for commercial operation as follows: unit 1, September 1979, and unit 2, June 1980. Since capacity is planned for on a system basis, it is not possible to identify the specific loads which the Bellefonte nuclear units will serve. For the purpose of the benefit analysis, it has been assumed that the plant serves loads based on the incremental increase in loads for each class of customers estimated between F.Y. 1972 and F.Y. 1980. The estimated peak load and sales for these years are identified in the following table:

	F.Y. 1972		F.Y. 1980		Increase	
	Load	Percent of Total	Load	Percent of Total	Load	Percent of Total
Estimated Peak Demand (MW)	16,664		30,300		13,636	
Estimated Sales (million kWh):						
Residential	28,072	30.8	45,833	28.2	17,761	24.8
Commercial	11,901	13.1	22,667	13.9	10,766	15.0
Industrial	32,908	36.2	55,907	34.4	22,999	32.1
Government	13,815	15.2	30,873	19.0	17,058	23.8
Other Sales	4,249	4.7	7,320	4.5	3,071	4.3
TOTAL SALES	90,945	(100)	162,600	(100)	71,655	(100)

The value of a unit of electric energy to the user varies widely depending on the availability and cost of alternative energy sources. No attempt was made to identify such values in this analysis. However, the price customers pay for electric energy presumably establishes a minimum value to the user. Based on the present rate structures of TVA and the distributors of TVA power, the following average prices to the ultimate consumer are estimated:

Residential	1.451 ¢/kWh
Commercial	1.374 ¢/kWh
Industrial	0.761 ¢/kWh
Government	0.656 ¢/kWh
Other	1.058 ¢/kWh

For the purpose of estimating the present value of the revenue received from the sale of this energy it has been assumed that the Bellefonte plant will operate as shown in the following table during its 35-year life:

Years	Capacity Factor	Annual Net Generation (million kWh)	Total Transmission and Distribution Losses (million kWh)	Annual Energy Available For Sale (million kWh)
1-15	80%	16,399	1,123	15,276
16-25	55%	11,274	772	10,502
26-35	40%	8,199	562	7,637

Using the energy available for sale and the current prices paid for electricity shown above, a discount rate of 8 percent, and the assumption that both units operate for the same time period, a value of the sales from the plant was estimated and is presented in the benefit description form. The results are summarized below:

ELECTRIC POWER PRODUCED AND SOLD - BELLEFONTE NUCLEAR PLANT

Levelized Annual Energy Generation (kWh)	$14,779 \times 10^6$
Levelized Total Annual Losses (kWh)	$1,012 \times 10^6$
Levelized Annual Energy Available for Sale (kWh)	$13,767 \times 10^6$

	Average Annual Energy Available For Sale - kWh	Value of Sales During Plant Life 1972 Dollars	Average Annual Value - Dollars
Energy Sold:			
Residential	$3,414 \times 10^6$	577,000,000	49,500,000
Commercial	$2,065 \times 10^6$	331,000,000	28,400,000
Industrial	$4,419 \times 10^6$	392,000,000	33,600,000
Government	$3,277 \times 10^6$	251,000,000	21,500,000
Other	592×10^6	73,000,000	6,300,000
Total Sold	$13,767 \times 10^6$	1,624,000,000	139,300,000

Historically, electricity rates have declined until the mid-1960's. Events of the more recent years have caused this trend to reverse. Higher prices for fuels, higher interest rates, increases in construction costs, and costs of pollution control equipment have been significant factors causing the increases in rates for electric utilities. It was necessary for TVA to increase its rate schedules in 1967, 1969, 1970, and 1973. The effect of these rate increases has resulted in the average cost of electricity to the consumer increasing by 62.4 percent. Thus, the use of current rates could significantly understate the future sale price.

2. Payments in lieu of taxes - Estimates of payments in lieu of taxes include estimates of payments to state and local governments by TVA and by distributors of TVA electricity. Estimates are based on current rates of payment related to the energy which will be generated by the plant.

3. Regional gross product - Benefits of the Bellefonte plant to regional gross product cannot be exactly quantified monetarily. However, a correlation has been made of the average annual dollar flow of gross product with the use of the Bellefonte electrical power in the TVA power service region. This correlation is based on using the average power generation and relationships between gross product and kilowatt-hours equivalent of all energy consumed. The industrial gross product factor was obtained as a product of the relationship between value added and kWh equivalent (Census of Manufacturers, 1967) and the relationship between gross product from manufacturing and value added by manufacturing (Census of Manufacturers, 1967 and Survey of Current Business). The numerical value of the industrial gross product factor was found by this method to be $0.0649 per kWh. The commercial gross product factor was obtained by comparing gross product from commercial activities and an assumed electrical energy output of 25 percent of total energy input to the commercial sector (Energy in the American Economy, 1850-1975, Shurr and Netschert). Numerical values of this factor were $0.187 per kWh for 1967 and $0.184 per kWh for 1969. Giving slightly more weight to the recent figure, $0.185 per kWh was selected as the commercial gross product factor. Industrial power consumed was assumed to include government use of electrical energy. The resulting average annual dollar flow of gross product is estimated at about $880 million.

As noted above, no additional quantification to arrive at a monetary benefit is considered possible. This is because the comparison of dollar value of products produced and energy consumed does not consider other variables in the production of products, such as wages of workers and efficiencies of individual production processes. It should be noted that a plentiful energy source has long been considered essential in the economic and industrial expansion of any region. As required by the TVA Act, as amended, TVA maintains an ample supply of electrical energy in the area in which it conducts its operations. A comparison of statistics in the TVA region with national statistics implies there are some beneficial effects of this plentiful energy source. In 1960 gross regional product was 2.26 percent of national; in 1970 this had increased to 2.69 percent. In 1960 personal income in the region was 64 percent of the national value; in 1970 this had increased to 75 percent. TVA considers that the ample availability of electricity as an energy source has helped realize these growth rates.

4. Recreation - The recreational benefits of the Bellefonte plant are estimated at 4,000 visits per year. This estimate of recreational visits is exclusive of the estimate of educational visits to the plant, which is given below. At a value of $0.75 per visit, the annual value of these visits is estimated to be $3,000.

5. Air quality - Since the Bellefonte plant is a base-load plant, approximately 5.2 billion kWh will be available during the base-load period to replace coal-fired generation which would otherwise have consumed about 2.3 million tons of coal per year. This will result in annual reductions in particulate emissions of about 2,300 tons, SO_2 emissions of about 119,000 tons, and NO_x emissions of about 16,900 tons when based on replacing coal-fired generation which uses coal of the quality now being burned and current technology.

6. Employment - Benefits to employment have been listed as the average annual number of workers whose jobs could be related to the consumption of electrical power produced by the Bellefonte plant. An industrial employment factor, relating kWh equivalent consumed in manufacturing to employment in manufacturing, was determined from national data from the Census of Manufacturers, 1967. A value of 5.4588 workers per million kilowatthours was obtained. A commercial employment factor was obtained by analysis of data from Energy in the American Economy, 1850-1975, by Schurr and Netschert. For 1967 this relationship was 14.83 workers per million kWh; for 1969, 13.39 workers per million kWh. The intermediate value of 14 was chosen for estimating the commercial portion of the employment value listed. Based on the portion of the Bellefonte Nuclear Plant generation allocated to commercial and industrial use, the potential exists for expanding the number of new jobs by about 70,920.

7. Education - The educational benefits of the Bellefonte plant are estimated to be 60,000 visits per year after the plant is operational. The annual value of these visits, at $0.75 per visit, is $45,000. Educational visits by persons to the plant during its construction are estimated to be about the same number as after the plant is operational.

Table 8.1-1

BELLEFONTE NUCLEAR PLANT - BENEFITS

Direct Benefits	
Expected Levelized Annual Generation in Kilowatthours	14,779,000,000
Dependable Capacity in Kilowatts	2,340,000
Proportional Distribution of Electrical Energy - Expected Levelized Annual Delivery in Kilowatthours:	
Residential	3,414,000,000
Commercial	2,065,000,000
Industrial	4,419,000,000
Government	3,277,000,000
Other	592,000,000
Annual Revenues from Electrical Energy Generated in Dollars	
Residential	49,500,000
Commercial	28,400,000
Industrial	33,600,000
Government	21,500,000
Other	6,300,000
Annual Indirect Benefits	
In Lieu of Tax Payments (Local, State) in Dollars	5,900,000
Regional Product	See Text
Environmental Enhancement	
Recreational - Dollars	3,000
Air Quality (Potential to Reduce Pollutants in Tons)	
SO_2	119,000
NO_x	16,900
Particulates	2,300
Employment - Potential Jobs Provided	70,920
Education - Dollars	45,000

8.2 Monetary and Environmental Costs - The monetary (generating) and environmental costs of the Bellefonte plant for the minimum impact and plant design combinations of subsystems are detailed below and are summarized in Table 8.2-1. In addition, incremental generating costs and differences in environmental costs for alternatives for the gaseous radwaste system and the heat dissipation system are summarized in Tables 8.2-2 and 8.2-3 respectively.

Generating costs - The generating costs for the alternative combinations of subsystems have been computed using the following assumptions: current plant capital cost estimates of $580 million (1973 dollars); a power generating cost of 2.2 mill/kWh ($0.0022 /kWh); a declining plant capacity factor as discussed in section 8.1-1; incremental generating costs for alternative subsystems as listed on Tables 8.2-2 and 8.2-3; an 8 percent discount rate; and an assumed plant lifetime of 35 years. The results are summarized in Table 8.2-1.

1. Effects on natural surface water body -

(1) Cooling water intake structure - Mortalities of fingerling and adult fish are not expected as a result of the design of the cooling intake structure to provide a maximum intake channel velocity of less than 0.2 ft/s. Larval fish mortalities are expected as a result of the passage of water through the cooling water system as discussed in paragraph 2 below. Traveling screens at other TVA power plants have caused no appreciable fish kills, and none are expected here.

(2) Passage through the condensers and retention in closed-cycle cooling systems -

(a) Primary producers and consumers - Phytoplankton and zooplankton passing through the cooling water system should not survive. Estimates of total daily quantities (by weight) were made based on concentrations taken during limited sampling in 1971 and 1972, estimates of the withdrawal volumes, and the assumptions of uniform draw by the intake and uniformity of sample distributions in horizontal and vertical cross sections. Additionally, estimates of maximum phytoplankton standing crop were made by coverting the number of cells to equivalent biomass.

Maximum plankton entrainment estimates for the summer season are 896 pounds/day (dry weight) of phytoplankton and 8,960 pounds/day (dry weight) of zooplankton.

The inherent weakness in the estimates of plankton amounts are as follows:

1. The samples are "grab" samples that are not replicated throughout a day.
2. Phytoplankton cell numbers may double in as short an interval as one day.
3. Zooplankton standing crop is estimated with limited numbers of samples.
4. Zooplankton standing crop may change drastically within as short an interval as one week.
5. Communitites of phytoplankton genera are measured and

described - not species populations and/or size and age groups within species populations.

6. Only indirect biomass estimates have been made to date.
7. Season trends develop within phytoplankton stocks as the result of changing solar energy values. The future monitoring program would underestimate these trends during the winter and spring quarters and overestimate in the fall quarter since samples are taken during the first or second week of the quarter. However, present sample schedules fit existing flow or discharge cycles in the river.

(b) Fish - Larval fish which pass through the plant in the cooling waterflow will be killed in this passage due to the temperature rise in the condensers, the duration of exposure to high temperatures, and to mechanical shock. An accurate assessment of the effects on larval fish populations cannot be made at this time. Relatively high concentrations of larval fish are expected in the area since extensive littoral area and productive embayments exist immediately upstream of the plant site. Even though no estimates of actual fish mortalities are possible since insufficient sampling data are available, no significant adverse effect is expected on the reservoir fish population due to the limited withdrawal requirements of the closed-cycle cooling towers.

(3) Discharge area and thermal plume -

(a) Physical water quality - The total plant heat rejection to Guntersville Reservoir will be 3.5 x 10^8 Btu/h from cooling tower blowdown. The volume of water in the mixing zone for cooling water discharges is expected to be very small.

(b) Dissolved oxygen - Observations of the dissolved oxygen levels in the water in the natural draft cooling tower circuit at TVA's Paradise Steam Plant indicate that the aeration provided by the tower fill maintains dissolved oxygen levels in the water near saturation levels. Since the maximum expected temperature in the cooling tower blowdown is 93°F and the saturation dissolved oxygen level at this temperature is about 6.8 mg/l, no discharge of blowdown water with dissolved oxygen content less than 5 mg/l is anticipated.

(c) Aquatic biota - It is TVA's judgment that there is no basis for assuming irretrievable loss of aquatic biota owing to thermal discharges of the plant. Due to the mixing provided by the blowdown diffuser, the applicable temperature rise criteria will be met at all times.

(d) Wildlife - No effects on any area wildlife forms are anticipated from the limited thermal discharges to Guntersville Reservoir.

(e) Migratory fish - It has been judged that a barrier, in the strict sense of preventing or significantly decreasing or retarding fish migration, will not result from the cooling tower blowdown discharge due to the limited amount of heat discharged.

(4) Chemical effluents - As discussed earlier in section 2.5, the concentrations of chemicals to be discharged

from the plant will be within water quality standards prior to discharge. No significant environmental costs are expected from the chemical discharges.

(5) Radionuclides discharged to water body - Doses are calculated according to the methods described in Appendix H. Tritium doses are included for an annual release of 300 Ci. Maximum annual dose rates or dose commitments for each annual intake are reported. Population doses are estimated for the entire Tennessee Valley region.

(a) Aquatic organisms - Dose rates (rads/yr) are for internal and external exposure to benthic invertebrates living in the vicinity of the Bellefonte Nuclear Plant.

(b) People - external - Calculations of the external dose rate to people involved in above-water activities (skiing, fishing, boating), in-water activities (swimming), and shoreline activities are described in Appendix H. The external dose to people involved in shoreline activities is expected to be very small. The simplifying assumption is made that all persons participating in shoreline activities receive the same dose rate as a person boating or skiing. The estimated individual dose rate of 2.6×10^{-8} rem/yr from shoreline activities exceeds the more realistic estimates for above-water activities and in-water activities.

(c) People - ingestion - Maximum dose commitments to the thyroid for the water and fish pathways are shown for both the individual and the population.

(6) Consumption of water - Although estimated evaporation and drift loss rates total about 74 ft^3/s (147 acre-feet per day), no significant effects on either downstream water supplies or irrigation supplies occur due to the insignificant size of these loss rates relative to average streamflow (35,300 ft^3/s). Yearly evaporative losses would be a maximum of about 54,000 acre-feet.

(7) Plant construction -

(a) Physical water quality - During the construction period there will be some dredging of material in Guntersville Reservoir. The use of closed-cycle cooling towers with relatively small makeup water and blowdown water requirements will result in smaller cooling water intake and discharge facilities than for once-through cooling. This will result in correspondingly smaller dredging requirements. All construction activity will be conducted so as to meet all applicable water quality standards. Thus, no dilution volume is required.

(b) Chemical water quality - Chemicals used during construction, including but not limited to chemical cleansing agents, water treatment chemicals, and chemicals used in sewage treatment, will only be released to Guntersville Reservoir in solutions with concentrations which meet chemical water quality standards. Thus, no reservoir dilution volume is required.

(8) Other impacts - No other significant environmental effects have been identified for Guntersville Reservoir. The water surface in Town Creek embayment will be forced to a small channel by the access road causeway and water velocity will be increased

at the causeway opening. Boat traffic to Town Creek will be restricted to small craft by the size of the culvert passageway.

(9) Combined or interactive effects - There is no evidence to indicate that the combined effects of a number of impacts on any population or resource is not adequately indicated by the measures of the separate impacts listed above.

(10) Net effect on Guntersville Reservoir - The construction and operation of the Bellefonte Nuclear Plant, considering the alternatives utilized to minimize environmental effects, is not expected to have any noticeable effect on Guntersville Reservoir. Neither is it expected to prohibit any of the normal uses of the reservoir.

2. Effects on ground water -

(1) Raising or lowering of ground water levels - Water withdrawals for the Bellefonte plant should have no effect on local ground water levels since relatively small quantities of water are withdrawn and since Guntersville Reservoir water levels are maintained according to TVA's reservoir operating guides. Normal fluctuations in water levels in the reservoir are from elevation 593 in winter to elevation 595 in late spring. Minor local ground water disturbances may occur as a result of plant construction, but no permanent ground water level changes are anticipated.

(2) Chemical contamination of ground water - Chemicals discharged from the plant are at such concentrations when discharged that water quality standards are met. Within the plant tanks, drains, pipelines, and transfer and storage lines are isolated

from the ground by concrete and other barriers. Thus, no chemical contamination of ground water is expected.

(3) Radionuclide contamination of ground water -

(a) People - Dose commitments for the annual intake of ground water are based on the calculations described in Appendix H. Conservative assumptions are made for these calculations because accurate data are unavailable. Therefore, the population dose commitments from contaminated ground water are overestimated.

(b) Plants and animals - Calculations of doses to aquatic plants and animals living in the Tennessee River near the Bellefonte Nuclear Plant are described in Appendix H. Doses to organisms exposed to ground water are expected to be less than the estimates of the doses from Tennessee River water, Table H-6 of Appendix H, because of the dilution afforded by uncontaminated water.

(4) Other impacts on ground water - No other significant impacts on ground water have been identified.

3. Effects on air -

(1) Fogging and icing caused by evaporation and drift -

(a) Effects on local ground transportation - The analysis of effects on local ground transportation of fogging and icing of the heat dissipation alternatives is based on the procedural methods described in section 2.6. As indicated in the same section, natural-draft cooling towers would affect ground transportation 80 hours per year. Closed-cycle mechanical-draft towers could affect ground transportation 495 hours per year. In the combined cycle, mechanical-draft cooling towers should affect ground transportation less often, or about 90 hours per year. Operation of spray canals in the closed cycle could affect ground transportation 530 hours per year. In the combined cycle, spray canal operation should affect ground transportation less, or about 82 hours per year. Fogging from operation of the cooling lake should affect ground transportation 4,068 hours per year.

(b) Effects on air transportation - Analysis of Paradise Steam Plant natural-draft cooling tower plume behavior shows that the maximum extent of plumes or fogs from cooling tower systems is about 5 miles. Since the nearest airport is located at Fort Payne, Alabama, about 20 miles southeast of the site, no interference with commercial airport operation is anticipated from any heat dissipation alternative.

(c) Local effects on water transportation - Closed-cycle natural-draft cooling towers should have no effects on water transportation and because of the distance from the river, the cooling lake should have no effect. Analysis of the effects of mechanical-draft towers on river fogging are based on the procedural methods described in section 2.6. These analyses showed that river traffic could be affected 240 hours per year when operating with closed-cycle mechanical-draft cooling towers. Spray canals operating in the closed cycle could affect water transportation 305 hours per year. In addition to plume effects, water transportation could be affected by fogs resulting from heated water releases during combined cycle operation of cooling towers or spray canals. Water transportation could be affected 221 hours, 183 hours, and 231 hours for combined-cycle operation of mechanical-draft cooling towers, natural-draft cooling towers, and spray canals, respectively.

(d) Effects on plants - Vegetation should not be damaged by fogs or plumes generated by the alternative cooling systems because daily exposure to excessive moisture should be of short duration (5 hours or less for all alternative schemes) and should occur most frequently during predawn and postdawn hours, periods when vegetation is normally exposed to naturally occurring high relative humidities and dew.

(2) Chemical discharge to ambient air - Resulting annual average ambient pollutant levels due to gaseous emissions from the plant's auxiliary boilers and diesel generators have been estimated assuming combustion of 4.8×10^6 gallons per year of fuel oil with 0.5 percent sulfur content. Resulting annual average ambient levels for shorter averaging time periods assume a consumption rate of 1,815 gallons per hour. The maximum levels, as percents of the ambient air quality standards, are listed below:

Pollutant	Percent of Secondary Ambient Air Quality Standard	Emissions in Tons per Year
Particulates	0.38	64.0
Sulfur dioxide	0.16	62.6
Carbon monoxide	3.63×10^{-7}	0.3
Hydrocarbons	0.31	16.1
Nitrogen oxides	0.14	252.0

No odor originating from normal operation of the plant should be perceptible at any point offsite.

(3) Radionuclides discharged to ambient air -

(a) People - external - Individual and population external dose rates from the nuclides expected to be released to the air are computed as described in Appendix I. The maximum external dose to any organ, including the whole body, is the dose delivered to the skin. This dose rate is presented for all alternatives.

(b) People - ingestion - Individual and population thyroid doses from the ingestion of iodine released to the air are computed as described in Appendix I. This dose rate is presented for all alternatives.

(c) Plants and animals - The dose rate to plants and animals from radionuclides expected to be discharged to the air is assumed to be the same as the external dose rate to people.

(4) Other impacts on air - No other significant impacts on the air have been identified.

4. Effects on land -

(1) Preemption of land - Site land requirements are about 1,500 acres for the base plant. Feasible alternatives for heat dissipation requiring additional land are discussed in section 2.6.

(2) Plant construction -

(a) Noise effects on people - Ambient noise levels due to construction of the Bellefonte plant are not expected to pose any problems to the surrounding population. The surrounding land has a low population density which will minimize the effects of construction noise.

(b) Accessibility of historical sites - Old-town Bellefonte is west of the site. Its potential historical and archaeological significance is now being explored by the Alabama Historical Commission. Access to Bellefonte will not be affected by the location of the plant at this site.

(c) Accessibility of archaeological sites - The potential archaeological significance of the site is now being investigated. Two sites have been identified for further investigation; however, no access restrictions are contemplated.

(d) Wildlife - No effects on wildlife are expected except for the dislocation of wildlife in the immediate site area.

(e) Erosion effects - The average amount of soil displaced by erosion due to construction activities at the Bellefonte site is estimated to be about 600 tons per year throughout the construction period. This estimate includes the effects of direct erosion of cleared land and also the displacement of dredge material in Guntersville Reservoir.

(3) Plant operation -

(a) Noise effects on people - Operation of the plant is essentially noiseless at the site boundary except for the very infrequent operation of the air blast circuit breakers.

(b) Aesthetic effects on people - Aesthetics cannot be quantified. The design of the Bellefonte Nuclear Plant has as one objective the creation of harmony between plant and environment. The architectural design and site development should provide an aesthetically pleasing appearance and mitigate the transition in land use of the project area from agricultural to industrial.

(c) Wildlife - No effects on wildlife are expected except for the dislocation of wildlife in the immediate site area.

(d) Flood control - The Bellefonte project has no implication for flood control.

(4) Salts discharged in drift from cooling towers - During normal operation the cooling water chemical content will be approximately double the chemical content of the makeup water. However, for the proposed method of operation following periods of low or no streamflow when blowdown is withheld, the total dissolved solids concentrations within the cooling tower system are not expected to exceed about 500 mg/l. No significant effects are expected from drift discharges from the towers.

(5) Transmission route selection -

(a) Preemption of land - The Bellefonte plant will require 110 miles of new transmission lines. New land area required for transmission line right of way is estimated to be 2,910 acres.

(b) Land use and land value - TVA attempts to locate new transmission lines so as to minimize the total effect of the lines on the environment. As planned at Bellefonte, no visually sensitive areas or areas of high population density are to be crossed.

At this time none of the transmission line rights of way for Bellefonte Nuclear Plant site has been acquired. Because of the location of the site, only rural farm, some rural nonfarm, and minor lake resort property will be affected by lines emanating from the plant. On the basis of continuing studies, these transmission lines will have no unusual impact on property values.

Recent investigations revealed no discernible loss in value attributable to the transmission lines outside the right of way proper. The only measurable impact occurs within the right of way where buildings are prohibited. Investigations in other agricultural, residential, and industrial areas throughout the TVA power service area show similar land value behavior characteristics, and TVA anticipates no adverse effects by transmission lines on land values from the Bellefonte Nuclear Plant. TVA can find no evidence that the presence of the transmission line system will inhibit orderly land development and normal transition in highest and best use from agricultural use to residential, commercial, and industrial use when future demands require such transition.

(c) Aesthetic effects on people - In the siting of new transmission lines for Bellefonte, the minimum of undesirable features has been sought. Unavoidable state, U.S., and interstate highway crossings will number 6, and major river crossings will number 5. However, no crest, ridge, or other high point crossings are expected. Also, no long views of transmission lines, either perpendicular or parallel to major roadways, are anticipated.

(6) Transmission facilities construction -

(a) Land adjacent to rights of way - No permanent access roads are normally installed in conjunction with transmission line construction. Some existing field roads and lanes are improved and are left for use by the landowners. The lengths of such improved roads cannot be determined until lines are designed, right of way easements are acquired, and the possibilities of such roadways are discussed with the individual landowners.

(b) Land erosion - The removal of existing trees and shrubs will increase the potential for erosion until new ground cover is planted and is well established. TVA minimizes this potential by a policy of minimum soil disturbance and speedy ground cover replacement during the transmission line construction phase.

(c) Wildlife - As indicated earlier in section 2.2, the interface between a transmission line right of way and forested land will often produce or attract more kinds and numbers of animals than would occur in either habitat alone. No lasting adverse effects on animal species or populations are anticipated during the brief construction period.

(7) Transmission line operation -

(a) Land use - Approximately 25 percent of the new transmission line rights of way are now under cultivation and can remain in this use if the individual owners so desire. An additional 50 percent is uncultivated open land. The remaining 25 percent is woodland which is in general in poor quality timber. As indicated in section 2.2, various uses of cleared rights of way are permitted. The percentage of rights of way for which no multiple-use activities are planned cannot be estimated since individual landowners have this option on their individual land holdings.

(b) Wildlife - Section 2.2 provides a discussion of wildlife effects. In summary, wildlife habitat is increased because of the interface between differing types of vegetation on the rights of way and off.

(8) Other land impacts - In a recently completed study for the Browns Ferry Nuclear Plant site, no significant changes to land values were discovered after 5 years of activity which included the major construction period for the plant. Investigations revealed no adverse effect on real estate values within 5 miles of the Browns Ferry Nuclear Plant site. Sale prices for farmland and rural residential properties equal or exceed prices of comparable properties in other areas of Limestone County. Lakefront subdivision lots in the 5-mile zone apparently are not as desirable as those downstream on the Elk River embayment, and any difference in value is attributable to

such factors as silt problems, prevailing winds, dock damage on the main channel, and poor road access. In no event did the investigations show any discernable effect, either adverse or otherwise, attributable to proximity to the nuclear plant site.

(9) Combined or interactive effects - There is no evidence to indicate that the combined effects of a number of impacts on any population or resource is not adequately indicated by the measures of the separate impacts listed above.

(10) Net effects on land - The net effect of the Bellefonte Nuclear Plant on the land resources is the commitment of about 1,500 acres of land for the use of power production during the plant's lifetime and the restriction on the use of about 2,910 acres of transmission line rights of way during the lifetime of these lines.

5. Cross category effects -

(1) Transportation - In a normal year Bellefonte will receive about 12 truck shipments of new fuel; will make about 140 truck, or from 10 to 14 rail, shipments of spent fuel; and will make about 25 shipments of radioactive wastes. In addition, deliveries of fuel oil and chemicals will require receiving about 486 tank-truck shipments. The transportation requirements for offsite disposal of tritium would be about 13 tank-truck shipments per year, after its disposal is required around the seventh to twelfth year of plant operation. The environmental review has demonstrated that the transportation shipments to and from the plant, considering normal and accident conditions, can be accomplished with a minimum impact.

(2) Accidents - A spectrum of postulated accidents ranging in severity from trivial to very serious has been divided into 9 classes by AEC. This characterization of accidents by classifications brackets the qualitative assessment of environmental costs and benefits. Table 2.2-3 of section 2.3 gives a summary of the radiological consequences of the postulated accidents. This environmental risk, for the range of postulated accidents, considering the probability of occurrence indicates that the annual potential exposure to the population from all postulated accidents is a very small fraction of the exposure of the same population from natural background radiation and, in fact, is well within naturally occurring variations in background radiation levels.

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS

Alternative	Plant with Minimal Environmental Impact	Current Plant Design
Subsystems		
Cooling	Closed-Cycle Natural Draft Cooling Towers	Closed-Cycle Natural Draft Cooling Towers
Gaseous Radwaste Treatment	Gas Absorption[a] or Cryogenic Distillation	60-Day Holdup
Liquid Radwaste Treatment	Filtration and Evaporation	Filtration and Evaporation
Chemical Treatment	Evaporation of Spent Demineralizer Regenerant Solutions	Neutralization of Spent Demineralizer Regenerant Solutions
Generating Cost — Total Value (1973 Dollars)	$959.33 x 10^6	$958.95 x 10^6
Generating Cost — Annualized	$ 82.31 x 10^6	$ 82.28 x 10^6
Environmental Effects		
1. Natural Surface Water Body — Guntersville Reservoir		
1.1 Cooling Water Intake Structure — 1.1.1 Fish Mortality	None Expected	None Expected
1.2 Passage through the Condenser and Retention in Closed-Cycle Cooling System of — 1.2.1 Primary Producers and Consumers - Pounds per Year	See Text	
1.2 (cont.) — 1.2.2 Fish Mortality - Pounds per Year as Adults	See Text	

a. Minimum system with respect to primary impacts to offsite population due to plant gaseous releases.

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative				Plant with Minimal Environmental Impact	Current Plant Design
1.3	Discharge Area and Thermal Plume	1.3.1	Physical Water Quality - Btu/h Heat Rejection	3.5×10^8	3.5×10^8
			Acre-Feet of Water Affected - 5^oF Isotherm	See Text	
		1.3.2	Oxygen Depletion - mg/l Decrease from Ambient Dissolved Oxygen Concentrations	See Text	See Text
		1.3.3	Aquatic Biota	See Text	
		1.3.4	Wildlife - Acres Affected by Thermal Discharge	0	0
		1.3.5	Fish Migration	No Thermal Barrier	No Thermal Barrier
1.4	Chemical Effluents	1.4.1	Chemical Water Quality - Dilution Volume to Meet Standards	0	0
		1.4.2	Aquatic Biota - Affected Population	0	0
		1.4.3	Wildlife - Acres Affected by Chemical Discharges	0	0

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative				Plant with Minimal Environmental Impact	Current Plant Design
		1.4.4	People - Lost User Recreational Days	0	0
1.5	Radionuclides Discharged to Water Body	1.5.1	Aquatic Organisms - rad/yr	1.2×10^{-1}	1.2×10^{-1}
		1.5.2	People, External - rem/yr man-rem/yr	1.5×10^{-6} 2.2×10^{-1}	1.5×10^{-6} 2.2×10^{-1}
		1.5.3	People, Ingestion - rem/yr man-rem/yr	3.5×10^{-5} 7.9	3.5×10^{-5} 7.9
1.6	Consumptive Use (Evaporative Losses)	1.6.1	People - Acre-Feet of Water Evaporated per Year	4.5×10^{4}	4.5×10^{4}
		1.6.2	Property - Acre-Feet of Water Evaporated per Year	Same as 1.6.1	Same as 1.6.1
1.7	Plant Construction	1.7.1	Physical Water Quality - Dilution Volume	0	0
		1.7.2	Chemical Water Quality - Dilution Volume	0	0
1.8	Other Significant Impacts			See Text	

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
1.9 Combined or Interactive Effects		See Text	
1.10 Net Effect		None Noticeable	None Noticeable
2. Ground Water			
2.1 Raising/Lowering of Ground Water Levels	2.1.1 People - Gallons of Water Affected	0	0
	2.1.2 Plants - Acres Affected	0	0
2.2 Chemical Contamination of Ground Water	2.2.1 People - Gallons of Water Contaminated	0	0
	2.2.2 Plants - Acres Affected	0	0
2.3 Radionuclide Contamination of Ground Water	2.3.1 People rem/yr man-rem/yr	1.7×10^{-5} 1.3×10^{-1}	1.7×10^{-5} 1.3×10^{-1}
	2.3.2 Plants and Animals	See Text	
2.4 Other Impacts on Ground Water		None	None
3. Air			
3.1 Fogging and Icing Caused by Heat Dissipation System Evaporation and Drift	3.1.1 Ground Transportation - Hours per Year	80	80
	3.1.2 Air Transportation - Hours per Year	0	0

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative				Plant with Minimal Environmental Impact	Current Plant Design
		3.1.3	Water Transportation - Hours per Year	0	0
		3.1.4	Plants - Acres Affected	0	0
3.2	Chemical Discharge to Ambient Air	3.2.1	Air Quality, Chemical	0.38% of standard	0.38% of standard
		3.2.2	Air Quality, Odor	No offsite odor	No offsite odor
3.3	Radionuclides Discharged to Ambient Air	3.3.1	People, External rem/yr man-rem/yr	 1.0×10^{-3} 3.9	 1.7×10^{-3} 7.9
		3.3.2	People, Ingestion rem/yr man-rem/yr	 3.1×10^{-5} 2.2×10^{-1}	 4.5×10^{-5} 3.3×10^{-1}
		3.3.3	Plants and Animals - rad/yr	1.0×10^{-3}	1.7×10^{-3}
3.4	Other Impacts on Air			None	None
4.	Land				
4.1	Preemption of Land	4.1.1	Land, Amount, in Acres	1,500	1,500
4.2	Plant Construction	4.2.1	People, Noise	No effects expected	No effects expected
		4.2.2	People, Accessibility of Historical Sites	No access restriction	No access restriction
		4.2.3	People, Accessibility of Archaeological Sites	No access restriction	No access restriction
		4.2.4	Wildlife	Site area only	Site area only
		4.2.5	Land, Erosion T/yr	600	600

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
4.3 Plant Operation	4.3.1 People, Noise	See Text	
	4.3.2 People, Aesthetics	See Text	
	4.3.3 Wildlife Affected Area	Site area only	Site area only
	4.3.4 Land, Flood Control	No implication	No implication
4.4 Salts Discharged from Cooling Towers	4.4.1 People	See Text	
	4.4.2 Plants and Animals, Acres Affected	0	0
	4.4.3 Property Resources - Effect in Dollars per Year	0	0
4.5 Transmission Route Selection	4.5.1 Land, Amount, in Acres	2,910	2,910
	4.5.2 Land Use and Land Value	Restriction on right of way use No expected change in value outside right of way	
	4.5.3 People, Aesthetics	See Text	
4.6 Transmission Facilities Construction	4.6.1 Land Adjacent to Right of Way	See Text	
	4.6.2 Land, Erosion	See Text	
	4.6.3 Wildlife	Habitat modification	Habitat modification
4.7 Transmission Line Operation	4.7.1 Land Use, right of way	Multiple use permitted	Multiple use permitted
	4.7.2 Wildlife	Habitat change	Habitat change

Table 8.2-1

BELLEFONTE NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
4.8 Other Land Impacts - Land Value Effects		None	None
4.9 Combined Interactive Effects		See Text	
4.10 Net Effects	Commitment of 1,500 acre site and 2,910 acres of TVA right of way		
5. Cross Category Effects			
5.1 Transportation	5.1.1 Transport of Fuels and Radioactive Material	See Text	
5.2 Accidents	5.2.1 Radiological Effects	See Text	

Table 8.2-2

BELLEFONTE NUCLEAR PLANT

ALTERNATIVES FOR GASEOUS RADWASTE SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Gaseous Radwaste System	60-Day Holdup	Cyrogenic Distillation	Gas Absorption
Incremental Generating Cost (thousands of dollars)	base	650	425
Dosage Rates to People from External Contact			
rem/yr	1.7×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
man-rem/yr	7.9	3.9	3.9
Dosage Rates to People from Ingestion			
rem/yr	4.5×10^{-5}	3.1×10^{-5}	3.1×10^{-5}
man-rem/yr	3.3×10^{-1}	2.2×10^{-1}	2.2×10^{-1}
Dosage Rate to Plants and Animals			
rad/yr	1.7×10^{-3}	1.0×10^{-3}	1.0×10^{-3}

Table 8.2-3

BELLEFONTE NUCLEAR PLANT

ALTERNATIVES FOR HEAT DISSIPATION SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Heat Dissipation System	Cooling Lake	Spray Canal (Combined)	Spray Canal (Dosed)	Mechanical Draft Towers (Combined)	Mechanical Draft towers (Closed)	Natural Draft Towers (Combine d)	Natural Draft Towers (Closed)
Estimated Incremental Generating Cost (thousands of dollars)	3,040	8,630	11,630	13,380	5,950	10,850	Base
Reservoir Heat Input (Btu/h)							2.0×10^8
Water Consumed (acre-feet/day)	139	143	143	141	141	147	147
Transportation Affected (h/yr)							
Ground	4,068	82	530	90	495	12	80
Water	0	231	305	221	240	183	0
Additional Land Required (acres)	7,000	480	0	0	0	0	0
Estimated Structure Relocations	140	0	0	0	0	0	0
Erosion (tons/yr)	1,000	800	700	700	600	700	600

8.3 Weighing and Balancing of Alternative Generation, Alternative Sites, and Alternative Subsystems - In planning for a power system electrical capacity addition, the alternatives which are usually available are alternative forms of generating capacity, alternative sites for locating the capacity addition, and alternative design concepts in major plant systems.

1. Alternative generating capacity - An analysis of the alternatives for generating capacity addition in the time period when the Bellefonte plant is planned is given in section 4.1. The alternatives available were hydro, pumped-storage hydro, gas turbine, fossil steam, and nuclear generating units. Since base-load generation was required, the pumped-storage and gas turbine alternatives were eliminated since they are suitable for peaking only. Hydro units were not feasible because of a lack of sites for base-load generation of the amount required. Oil-fired and gas-fired units were rejected because an adequate fuel supply could not be assured.

The analyses showed that fossil steam and nuclear generation were the feasible alternatives for the required amount of base-load capacity. The analysis further showed that nuclear generation offered substantial advantages over the fossil generation both environmentally and economically. Based on this analysis, TVA decided that the nuclear generating capacity addition was more acceptable from the standpoint of economic and environmental impacts.

2. Alternative sites - From preliminary investigations of 30 potential sites for the proposed plant, eight sites were identified that had the desirable characteristics to warrant further

and more detailed study. Two of these sites (sites A and B) are located in the western portion of the TVA service area where the seismic conditions are not clearly defined. Therefore, these sites were eliminated from consideration as potential sites for the proposed plant pending a determination of the seismic design criteria. Of the six remaining sites four are located on Guntersville Reservoir (sites C, D, E, and F), one is located on Chickamauga Reservoir (site G), and one is located on Watts Bar Reservoir (site H). Conflicts or questions existed at three of the sites that made them less acceptable than the other three proposed sites. These included a conflict with the urbanizing growth of a local town at site D, the encroachment on an important wildlife sanctuary and the depth of rock at site F, and the lack of information indicating the suitability of the rock for a nuclear plant foundation at site H.

A detailed evaluation of sites C, E, and G was made considering the economic and environmental cost of locating the proposed plant at each of these alternative sites. It was concluded that each of these three sites was suitable for a nuclear plant.

A summary of the site evaluation factors is presented in Table 4.2-1, and a summary of the site-related economic costs is presented in Table 4.2-2 for these three sites.

Site G was found to have the greatest economic cost and the greater potential for land use conflicts because of its close proximity to the Hiwassee Island Game Management and Waterfowl Refuge Area and its more extensive transmission line and access facilities.

Sites C and E are both on Guntersville Reservoir approximately 23 miles apart, and many impacts would be very similar at each site. Land use plans indicated both sites are compatible for use as a nuclear plant; however, site E is in an area with no developed public recreation areas near the site, and site C is located within 3 to 5 miles of boat docks, private clubs, and a group camp.

Site E has an economic advantage of approximately $5 million when compared to site C and over $11 million when compared to site G. The population within 30 miles of site E is significantly less than the other two sites.

When considering the economic advantage of site E along with the less extensive access facilities, lower populations within 30 miles of the site, and the greater land use compatibility, TVA selected site E, Bellefonte, as the preferred site for the proposed plant.

3. Heat dissipation - The alternatives analyzed for heat dissipation were natural draft and mechanical draft wet cooling tower systems, spray canal systems, a once-through system utilizing bottom diffusers, dry cooling towers, and a cooling lake system. Analyses were performed using the following factors as a basis: feasibility, environmental considerations, and economic considerations. The analyses were carried to the extent required to determine the acceptability of each alternative when considering these factors.

Because there were some periods of insufficient riverflows by the plant site, it was determined that the temperature rise after mixing by a diffuser system would not meet applicable thermal standards a sufficient amount of time to justify a completely open-cycle system. Thus a once-through cooling system utilizing only bottom diffusers was eliminated due to infeasibility. Dry cooling towers were not considered as an acceptable alternative because of lack of demonstrated feasibility for power plants of the size considered. Engineering details of turbine design, condenser design, and large dry tower designs are yet to be worked out. In addition, substantial economic penalties are associated with the use of dry towers and only insignificant environmental advantages could be realized at the proposed site. Details and environmental impacts for seven schemes for the remaining alternatives are discussed in section 2.6.

Estimates of environmental impacts were made as discussed above in section 8.2. The results are summarized in Table 8.2-3.

The cooling lake alternative would involve a lake of about 5,650 acres with a 29,000-foot-long dike dividing the lake and three dikes to impound the lake which would be 1,000, 4,000, and 6,000 feet long. The lake formed would be some 35 feet above the normal elevation of Guntersville Reservoir. While requiring the use of considerable land, the lake would provide the water cooling requirements of the proposed Bellefonte plant and could support a sizable sport fishery with reasonably intensive management. Such a lake would have the potential of attracting up to a quarter million fishing trips per year. In addition, the protective land, about 1,350 acres, adjacent to the lake necessarily acquired with that which would be inundated could be used to supply the desired access to the lake and could be managed as a wildlife area. This land would have the potential to attract several thousand nonconsumptive wildlife users annually.

Selection of the cooling lake alternative would displace about 140 occupied structures. It is expected that fogs developed over the lake would frequently create a serious road hazard to travel on Highway 72. The cooling lake alternative would cost some $3 million more than the proposed alternative.

A spray canal system would require a canal approximately 12,800 feet long and 200 feet wide. Three different arrangements and locations on the plant site were evaluated. One of the arrangements would require purchase of 480 additional acres of land. Blowdown holdup time would be longer for this alternative than for cooling towers because of the larger quantity of water in the system. One canal arrangement involved an intake located in Town Creek which might produce undesirable changes in the aquatic environment of the creek. Atmospheric plume lengths should be greater for spray canals than for cooling towers because the effluent would be dispersed much lower to the ground. As a result the spray canal alternative would cause the most fogging on Alabama Highway 40. A minor fogging potential would also exist for Alabama Highway 35. The spray canal schemes cost about $8 to $11 million more than the proposed alternative.

The mechanical draft cooling tower alternative would require four wood-filled cooling towers, each approximately 50 feet wide by 60 feet high by about 600 to 700 feet long. Selection of mechanical draft cooling towers would involve possible higher frequency of fogging and icing near ground level than the natural draft towers but possibly less than for the spray canal alternatives. A smaller potential for fogging would exist for Alabama Highway 40, and an extremely small potential would exist for Alabama Highway 35. The use of mechanical draft towers would involve higher noise levels than the other alternatives. The two mechanical draft schemes would cost about $6 million and $13 million more than the proposed natural draft cooling system.

The use of natural draft cooling towers would require two towers about 500 feet in diameter and about 500 feet high. Use of natural draft towers would involve some increased ground-level and localized surface fogging and icing, but the effect on Alabama Highway 40 and U.S. Highway 72 would be less for this alternative.

However, a fogging potential associated with the roadway on Sand Mountain would exist for this alternative. The selection of natural draft towers has a $3 million evaluated cost advantage over the next lowest cost alternative.

It was concluded that of the schemes considered for dissipating heat from the Bellefonte plant the closed-cycle natural draft cooling tower scheme resulted in the best balance of feasibility, environmental impact, and economic cost. Thus TVA has tentatively selected this method of heat dissipation for this plant and preliminary design is proceeding on this basis.

4. Chemical discharges - As discussed in Section 2.5, Nonradioactive Discharges, alternatives were considered for treatment of the regenerant solutions from the makeup demineralizer and the condensate demineralizer. The proposed system consists of neutralization of the chemical wastes from the makeup and condensate demineralizers and discharging them along with the other chemical wastes with the cooling

tower blowdown. The amounts and concentrations of the discharges from this system are given in Tables 2.5-1 and 2.5-2. The other alternatives would treat the chemical wastes from the makeup demineralizer and/or the condensate demineralizer by evaporation with the evaporator bottoms being disposed of by either onsite or offsite burial. The distillates would be recycled in the plant. Details of these systems are given in section 2.5.

The reduction of wastes discharged to the cooling tower blowdown and the relative costs of these alternatives are given in Tables 2.5-3 and 2.5-4. The implementation of any of these alternatives would result in an increase in impacts in other areas, such as an increase of materials usage and an increase in transportation.

There would be no significant reduction in environmental impacts by the implementation of any of these alternatives. The maximum reduction in the concentration of the affected parameters in the reservoir is less than the variation between the average and maximum concentrations naturally occurring at TRM 385.9. This reduction could only be achieved during a 4-hour period on those days that the demineralizer regenerant wastes would normally be discharged. It is concluded, therefore, that the additional expenditure of resources and increased impacts in other areas associated with the implementation of any of the alternatives considered is not justified. Thus TVA is proceeding with preliminary plant design based on providing neutralization of makeup and condensate demineralizer wastes and subsequent discharge of these treated plant wastes to Guntersville Reservoir.

5. Gaseous radwaste system - As discussed in section 2.4, alternatives for a gaseous radwaste treatment system were analyzed

during the environmental review process to determine the best system with respect to expected performance, proven reliability, and cost. The following alternatives were evaluated:

1. 60-day holdup
2. Cryogenic distillation
3. Gas absorption

Table 8.2-2 presents an evaluation of these alternatives. As shown in the table, the 60-day holdup system, assuming 0.25 percent fuel defects, results in an external annual dose rate to people of 1.7 mrem. The use of a cryogenic distillation system at a cost of $650,000, or of a gas absorption system at $425,000, would result in decreases to dosage rates to 1.0 mrem for each alternative. Neither the cryogenic distillation or gas absorption system has demonstrated performance and reliability in nuclear plant service. The cryogenic distillation system is a complex system compared to the gas decay system and could experience operating problems and presents the potential for accidental release of concentrated waste to the environment. The only experience to date with the gas absorption system has been with bench and pilot size systems.

Based on this analysis TVA has concluded that the 60-day holdup alternative, which results in a dose rate of 1.7 mrem per year, represents the best balance of economic cost, reduction in environmental impact, and feasibility. TVA believes the benefits to be gained by further reducing the radioactive gaseous releases are not commensurate with the cost associated with the reduction. The very low "fence post dose" is less than the numerical guidance provided by the proposed

Appendix I to 10 CFR Part 50. It also represents only about 1 percent of the naturally occurring background dose.

6. Liquid radwaste systems - Investigation of means to further reduce release of radioactive liquids to the environment and the subsequent weighing and balancing of alternatives resulted in the adoption of the proposed methods as described in section 2.4.

It was judged that the offsite shipment of tritiated liquid would be preferable to releases of tritium to Guntersville Reservoir. It was further judged that evaporation of radioactive condensate demineralizer regenerant solutions was preferable to release.

Both procedures reduce doses to the population while resulting in some increased impacts due to inplant doses, transportation, and commitments of ultimate disposal facilities and materials.

9.0 CONCLUSION

This environmental statement reflects the manner in which TVA has incorporated environmental considerations into the decision-making process for the Bellefonte Nuclear Plant.

The plant will interact with the environment in three principal ways: (1) release of minute quantities of radioactivity to the air and water, (2) release of minor quantities of heat to Guntersville Reservoir and major quantities to the atmosphere, and (3) change in land use from farming to industrial. Alternatives to minimize adverse environmental impacts have been considered, and alternatives were chosen for heat dissipation and radioactive waste treatment systems to reduce impacts to a minimum practical level. In addition, construction methods will be employed which minimize adverse impacts.

The plant as now designed closely approaches a minimum impact plant and can be constructed and operated without significant risk to the health and safety of the public.

Addition of the Bellefonte Nuclear Plant to the TVA system will enable TVA to continue to carry out its statutory responsibility to provide an ample supply of electricity for the TVA region.

After weighing the environmental costs and the technical, economic, environmental, and other benefits of the project and adopting alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs, and that the action called for is the construction and operation of the Bellefonte Nuclear Plant.

TENNESSEE VALLEY AUTHORITY

DRAFT

ENVIRONMENTAL STATEMENT

BELLEFONTE NUCLEAR PLANT

VOLUME 2

Appendix A

LAND USE IN THE VICINITY OF THE BELLEFONTE SITE

This appendix is supportive of Section 1.2, subsection 7, Land Use, which contains additional discusssion of land uses in the vicinity of the Bellefonte site.

Figure A-1 is an annotated topographic land use map, and figure A-2 is an aerial photo of about the same area. Land use data for Jackson County has been presented since the area shown in the figures is generally representative of the whole county. According to the 1967 Conservation Needs Inventory of the total land area of 719,000 acres, about 63 percent (449,000 acres) of Jackson County was forested; 32 percent (237,000 acres) was in agricultural use (cropland, pasture and range, and other) and 1.4 percent (10,000 acres) urban and developed. (The remainder is composed of land in Federal owernship and small land areas covered by water.) For comparison, the Top of Alabama Regional Council of Governments (TARCOG) area (Limestone, Madison, Jackson, Marshall, and DeKalb Counties) was 44 percent forested, 46 percent agricultural, and 6 percent urban and built up ("Agricultural Opportunities in the TARCOG Area," TVA). (Remainder is Federal land and small water areas.) Thus, Jackson County was more forested, less agricultural, and less urban than this larger area of which it is a part.

A more detailed discussion of individual land uses at the general area level follows.

1. Urbanized areas - Scottsboro, about 6 miles west-southwest of the site, is the nearest and most important emerging center with a 1970 population of 9,324. Hollywood is the town nearest the site with a 1970 population of 301. Recent annexations, which resulted in the city limits shown, increases the population to an estimated 865 (Preliminary Draft - "Sketch Development Plan - Town of Hollywood, Alabama," TARCOG). Other communities in the valley include Stevenson (1970 population - 2,390) and Bridgeport (1970 population - 2,908).

West of Scottsboro, on the Cumberland Plateau, are Woodville (1970 population - 322) and Paint Rock (1970 population - 226). East of Scottsboro, on Sand Mountain, are Section (1970 population - 702), Dutton (1970 population - 423), Pisgah (1970 population - 519), and Rainsville (1970 population - 2,099).

Most of these communities have boundaries far exceeding the actual developed area. Thus, they are in a position to accommodate additional development and, if they choose, to control it through an active planning program.

2. Industrial areas - The two most important industries in the area are located near Scottsboro. These are Revere Copper and Brass Corporation and Goodyear Tire and Rubber Company. Revere is on a 1,000-acre peninsula about 11 miles southwest of the site on the right bank of the Guntersville Reservoir. It employs approximately 1,100 people, but additional facilities are under construction which would bring the employment to 1,600. Goodyear now employs 200 people,

but tentative expansion plans indicate an eventual employment level of about 1,000. In addition, TVA's Widows Creek Steam Plant is about 15 miles northeast of the site with about 500 employees.

3. Forested land - In large measure, forested land is associated with either topographic or drainage features. On the Cumberland Plateau to the north and west of the site, the steep mountainous terrain has helped keep the land in forest production. To the south and east of the site, the escarpment reaching from Guntersville Reservoir to Sand Mountain is predominantly in forest. However, on the relatively flat Sand Mountain with soils suitable for agriculture, much of the forest has been cleared except in the natural stream banks.

4. Agriculture and open land - This category of land use is a mixture of cultivated, pastured, and unused land. Most of the cultivated land is located on Sand Mountain while the predominant use of agricultural land on Cumberland Plateau and in the valley is for pasture.

5. Site land use - Figure A-3 is a topographic map of the site vicinity. Land use of the site and the immediate vicinity is predominantly agriculture with some forested areas along the reservoir. Most of the land on the site was in pasture while about 65 percent of the surrounding agricultural land was cultivated based on photo interpretation of a 1971 aerial photograph. The photograph is reproduced as figure A-4.

A number of significant cultural features are also shown on figure A-4 which help reveal the character of the site and surrounding area. They are discussed as features of Old Town Bellefonte, the site, and the surrounding area. These are shown in figures A-5 through A-7, respectively.

(1) Old Town Bellefonte - Figure A-4 shows the location of the Old Town Bellefonte with respect to the proposed site. Figure A-5 shows low and ground-level shots of the whole area and individual structures. The structures have not been inhabited for a long time, nor has there been any apparent effort toward maintaining them.

(2) Features of the site - Figure A-6 shows the items located on the site. They include an old chapel, three frame dwellings, and two old family cemeteries.

An old chapel, known as Shipps Chapel, (item No. 8, figure A-6) has been most recently used as a residence. Based on its structural condition, it is clearly in a state of disrepair and has not been occupied for some time.

Items No. 7, 9, 10, and 11 of figure A-6 show former dwellings located on the site. At one time, they were suitable for occupation, but lack of maintenance and changing housing standards find them no longer acceptable abodes. None of them were occupied at the time acquisition proceedings began.

Two old family cemeteries are located within the bounds of the property being acquired by the project. Both are inactive with no evidence of upkeep or interments in several decades. The most recent tombstone inscription found in the Finnell Cemetery is 1872. Field estimates place the number of graves in Shipp and Finnell Cemeteries at four and six, respectively.

The Finnell Cemetery (item No. 12, figure A-6) is located in a pasture with no fence protecting it. It has obviously been used as pastureland. At least two monuments in this cemetery are broken.

The Shipps Cemetery (item No. 13, figure A-6) is surrounded, except for an entranceway, by a rock wall and located within lands that have been pastured. Cattle have grazed the cemetery area. At least one monument is broken and the entire cemetery is overgrown with weeds.

Under these conditions a substantially larger number of graves than indicated by the initial count could exist in each cemetery. However, it is impossible to make an exact determination without disturbing the cemetery areas.

(3) Surrounding area - Items of interest surrounding the site are indicated on figure A-7. Two exceptions to the generally rural development surrounding the plant site are the Town Creek Subdivision and Baker Sand and Gravel Company's loading facility, both of which are adjacent to the site. Farther away, near Hollywood, is a new technical-vocational school. Otherwise, the farmhouse and isolated store are generally typical cultural features of the site vicinity.

The subdivision is across the Town Creek embayment and is noted on figure A-4. Pictures of the types of structures contained in the subdivision are in fiugre A-7. They range from a mobile home found along the entrance road to small cabins to small "A-frames." This is a second-home development and is populated mostly on weekends and during summer vacations. The structures are not generally planned for year-round residency.

Baker Sand and Gravel loading facility is on the small peninsula adjacent to the southwestern corner of the site and noted as item 16 on figure A-4. A picture of this activity is on figure A-7. This facility is operated by only a small number of employees.

Item 15 on figure A-4 is the new Jackson County Technical School which opened in September 1972. The present enrollment is about 500 with 250 attending classes in the morning and 250 in the afternoon. The students are transported from the eight city and county high schools in Jackson County.

Figure A-8 indicates the projected major plant facilities, tentative highway and rail access connections, and approximate transmission line connections. Details of the impacts of these features of modified land use are discussed in sections 2.7, 2.9, and 2.2, respectively.

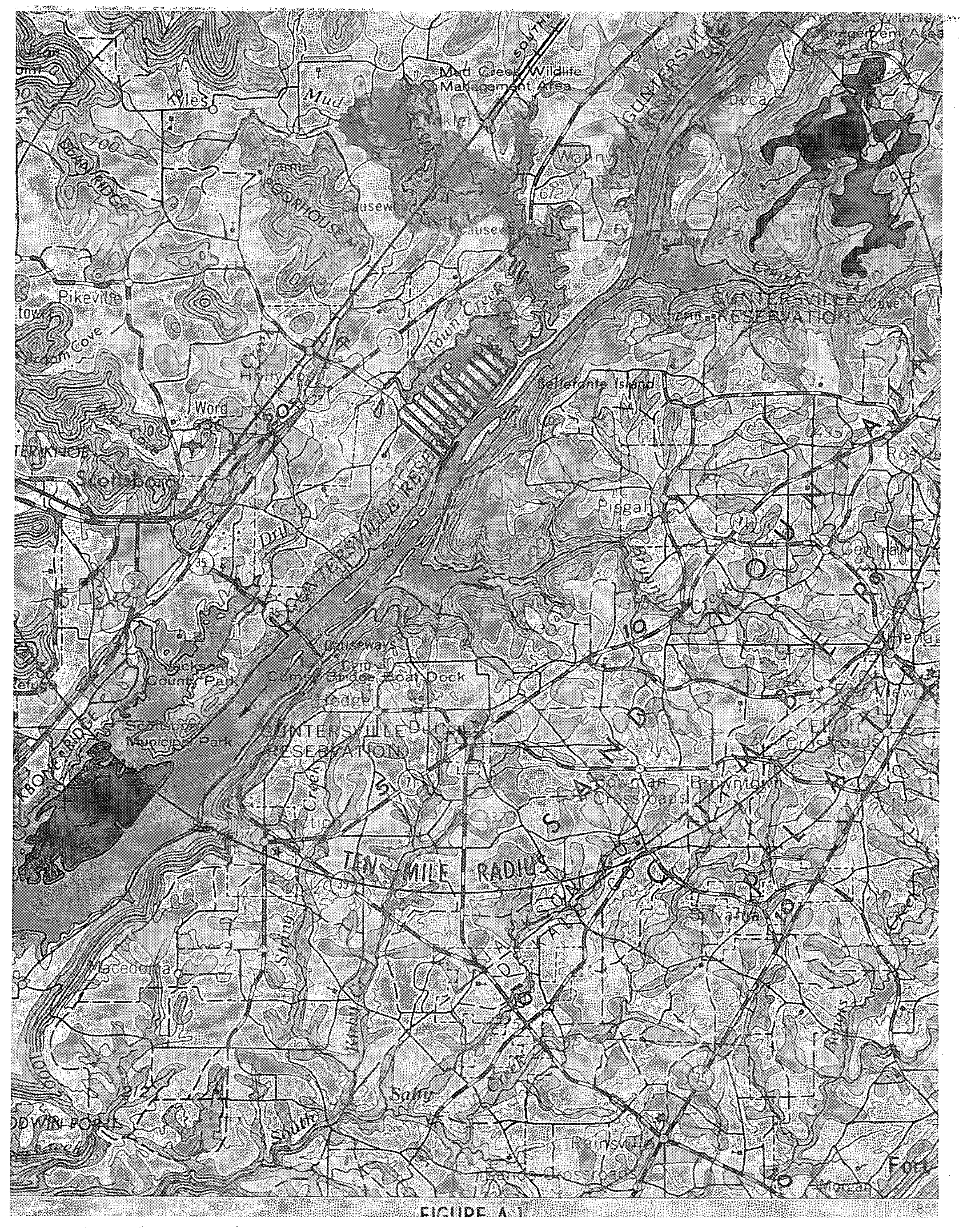
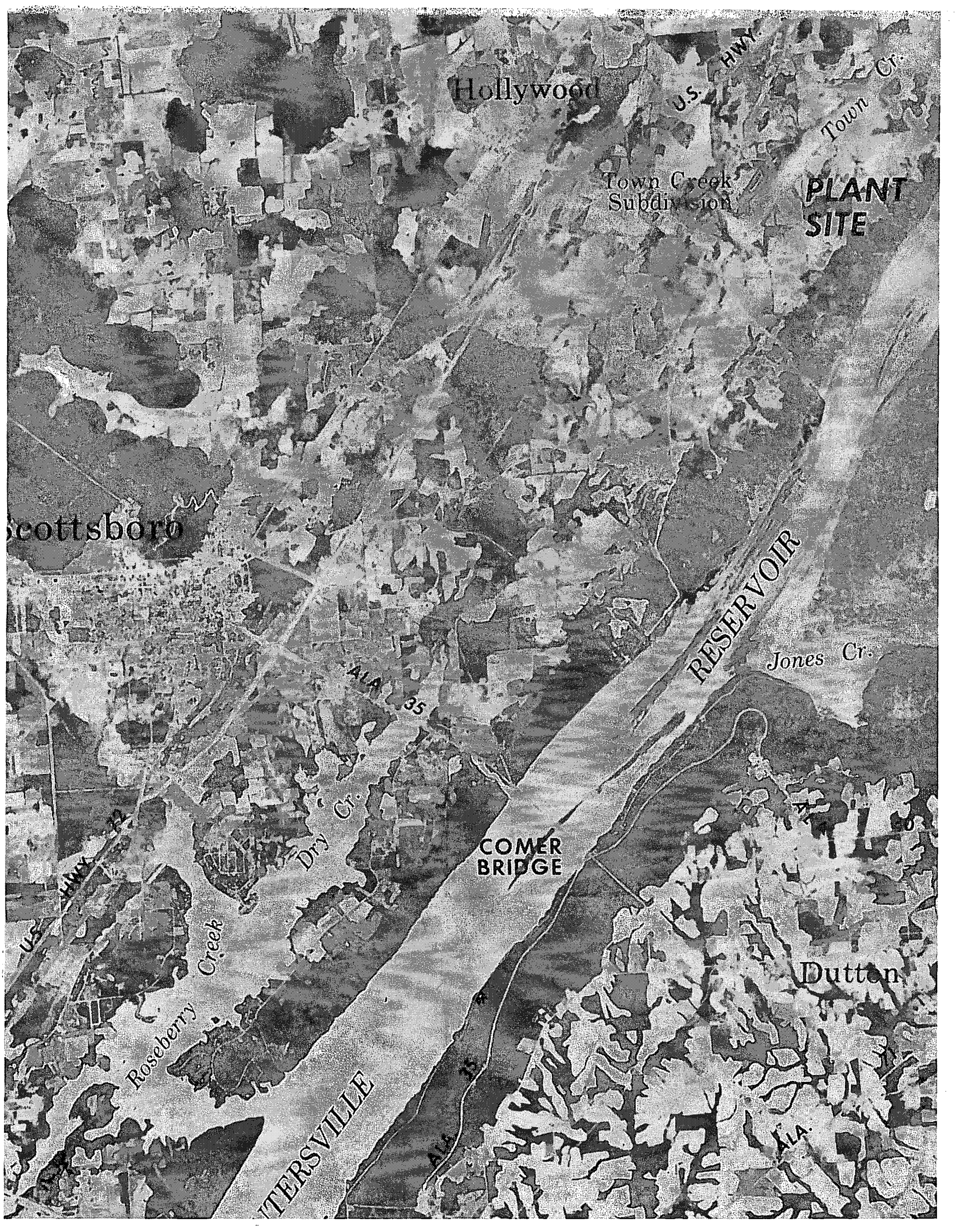
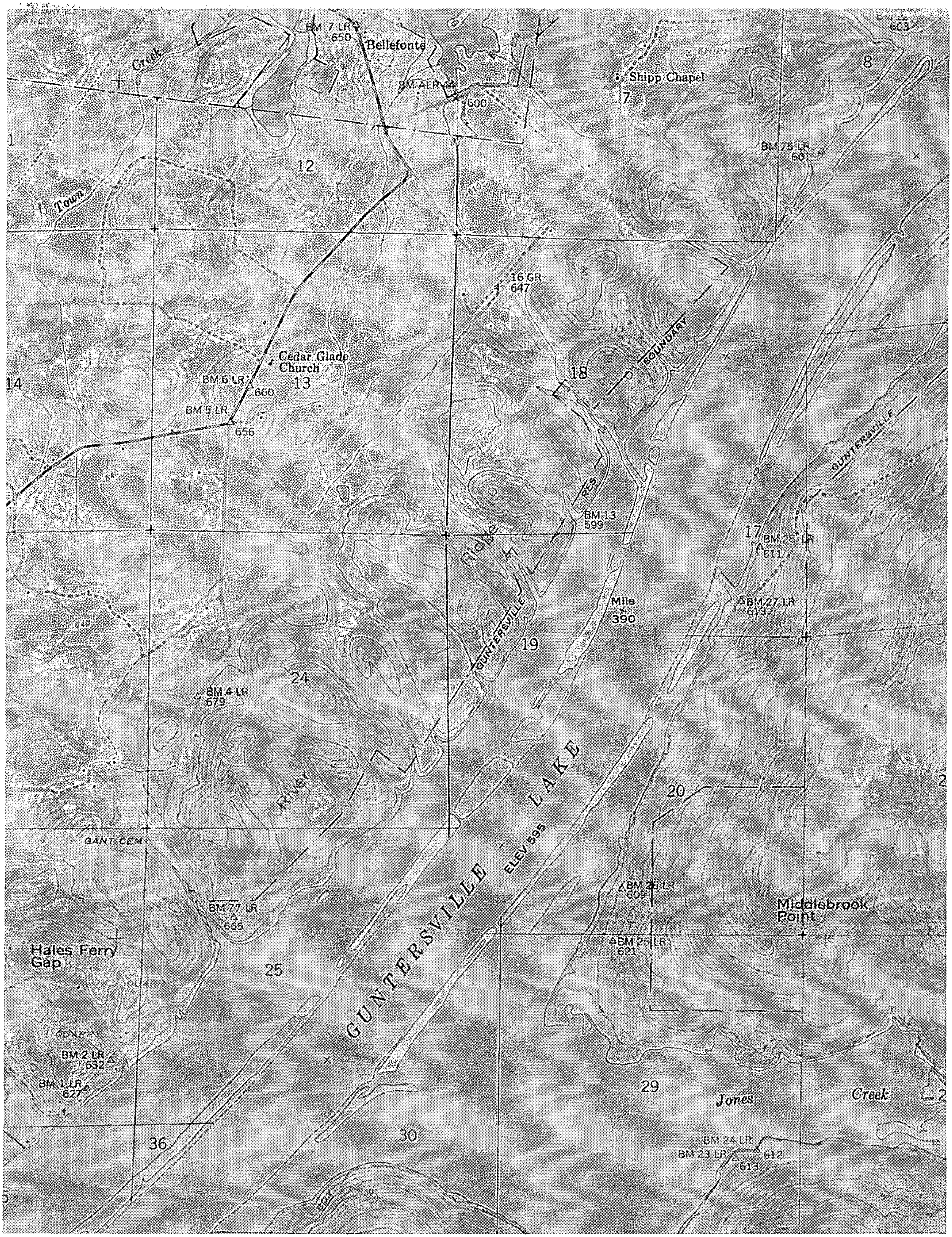
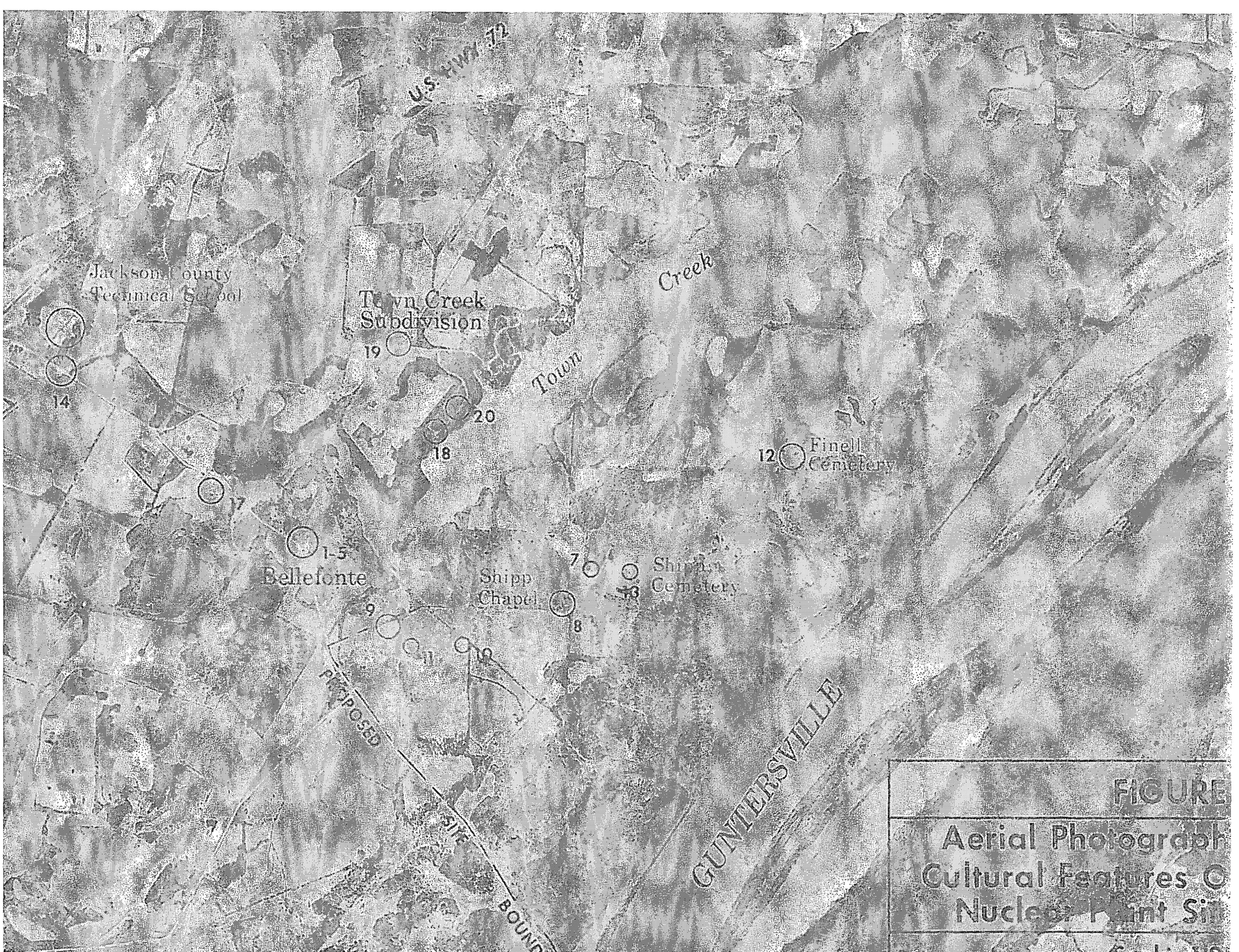

Mud Creek Wildlife Management Area
Kyles
Pikeville
Hollywood
Word
Bellefonte Island
Pisgah
Causeways
Jackson County Park
Comer Bridge Boat Dock
Hodge
GUNTERSVILLE RESERVATION
Scottsboro Municipal Park
TEN MILE RADIUS
Macedonia
Rainsville
Sylvania

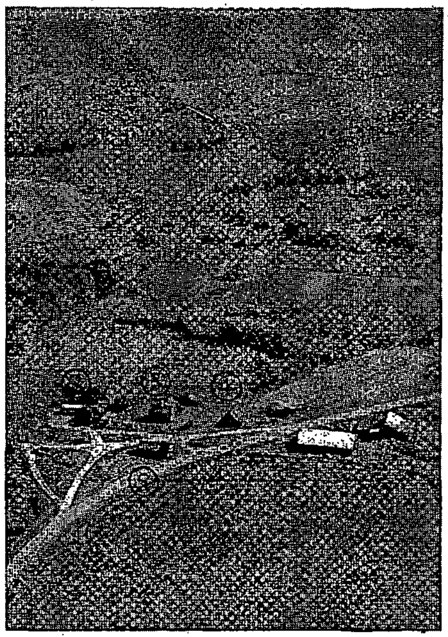
FIGURE A.1


Hollywood
U.S. HWY.
Town Cr.
Town Creek Subdivision
PLANT SITE
Scottsboro
RESERVOIR
Jones Cr.
ALA. 35
Dry Cr.
COMER BRIDGE
U.S. HWY. 72
Creek
Roseberry
Dutton
ALA. 35
ALA.
ITERSVILLE


BM 7 LR
650
Bellefonte
Creek
BM AER 44
600
Shipp Chapel
7
8
BM 75 LR
601
12
Town
16 GR
647
BOUNDARY
Cedar Glade
Church
BM 6 LR
660
13
14
18
BM 5 LR
656
RES
BM 13
599
Ridge
GUNTERSVILLE
17
BM 28 LR
611
Mile
390
BM 27 LR
613
19
24
BM 4 LR
679
River
LAKE
ELEV 595
GUNTERSVILLE
20
GANT CEM
BM 26 LR
609
BM 77 LR
665
Middlebrook
Point
BM 25 LR
621
Hales Ferry
Gap
25
BM 2 LR
632
BM 1 LR
627
29
Jones
Creek
30
36
BM 24 LR
BM 23 LR
612
613

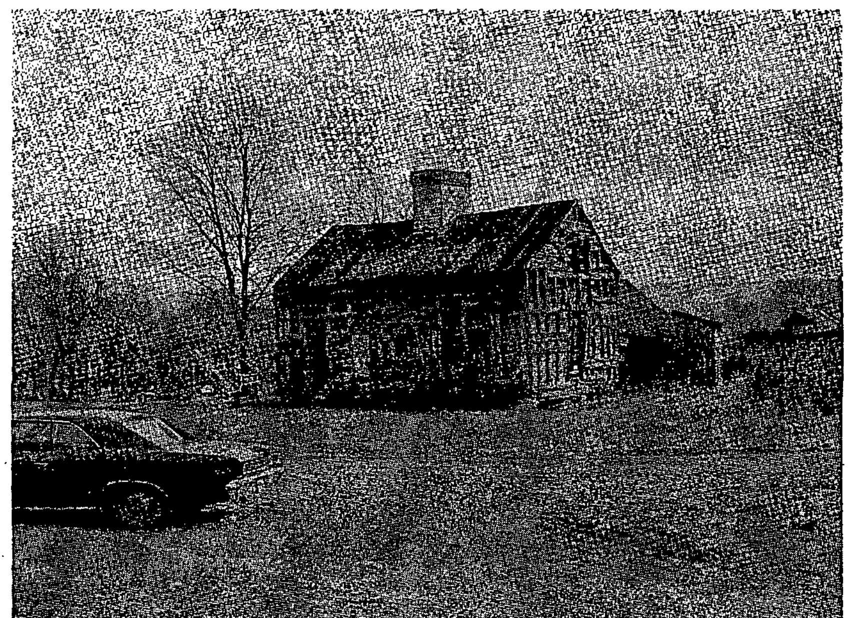


U.S. HWY 72
Jackson County
Technical School
15
14
Town Creek
Subdivision
19
20
18
Town
Creek
17
1-5
Bellefonte
12
Finell
Cemetery
7
13
Cemetery
Shipp
Chapel
8
9
11
10
PROPOSED
SITE
BOUND
GUNTERSVILLE
FIGURE
Aerial Photograph
Cultural Features O
Nuclear Plant Si
Scale: 1:2



No. 1
al View
y of Bellefonte

No. 2
Old Bellefonte Hotel
and New Mobile Home



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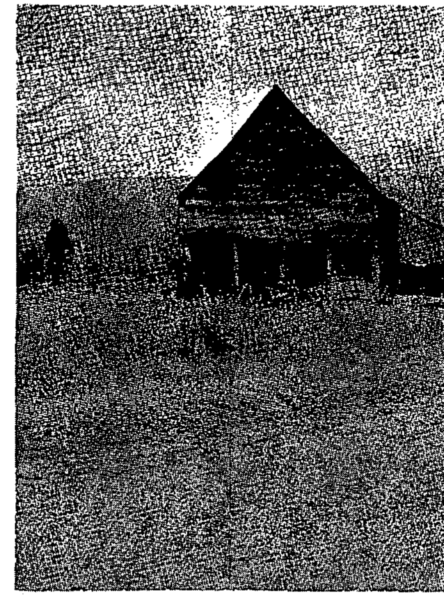
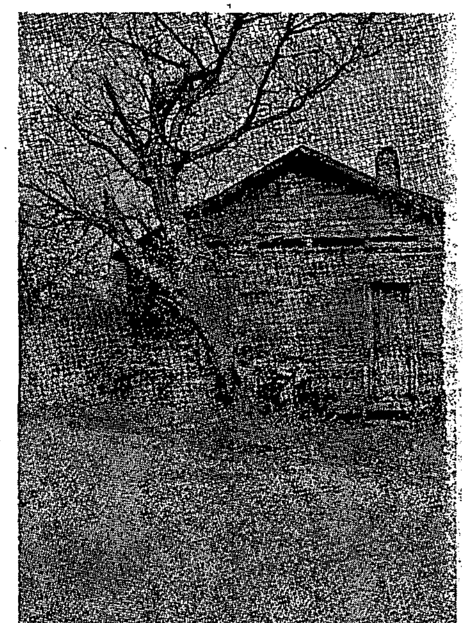
Old Bellefonte Hotel



No.
Old Bellefo



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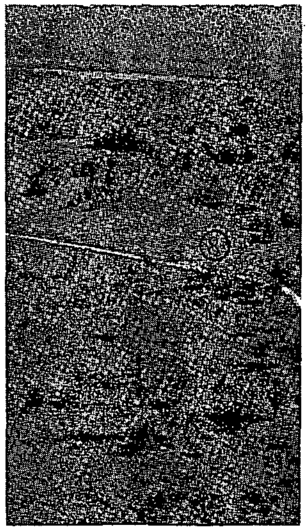
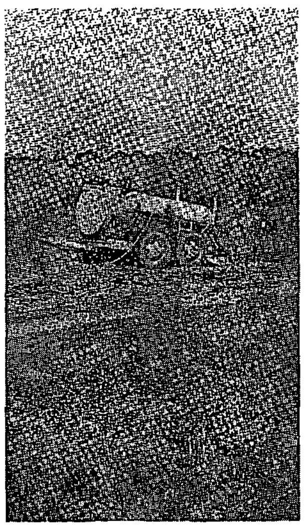
Old Bellefc



ınt Site



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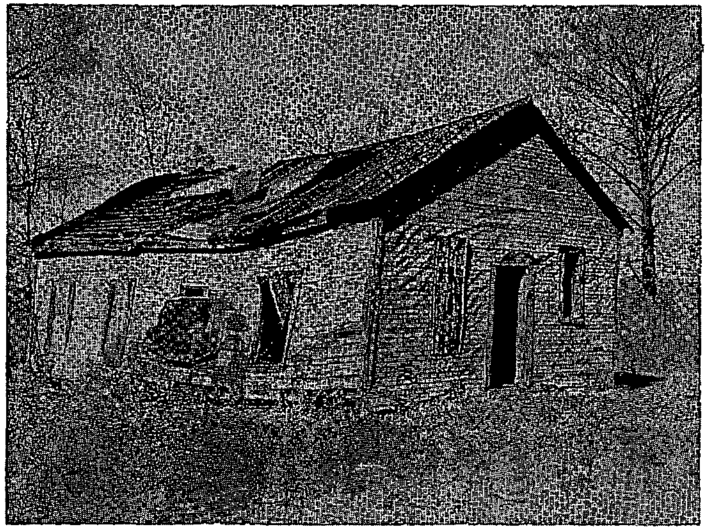
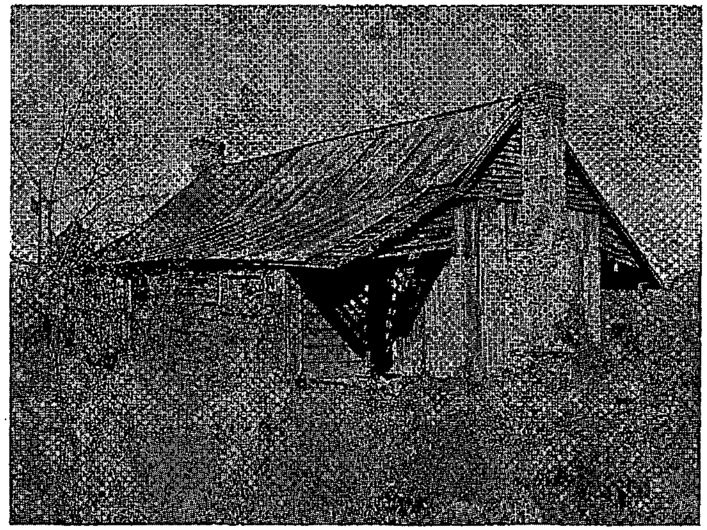


No. 8
Old Shipp Chapel

No. 9
Structure on Plant Site



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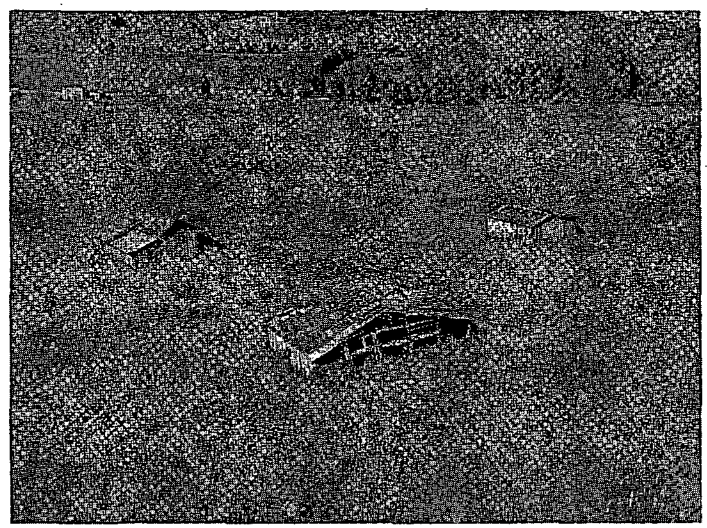
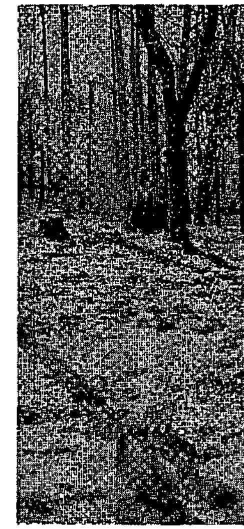
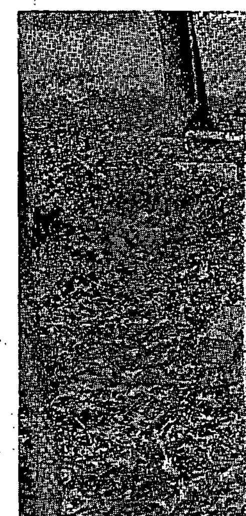
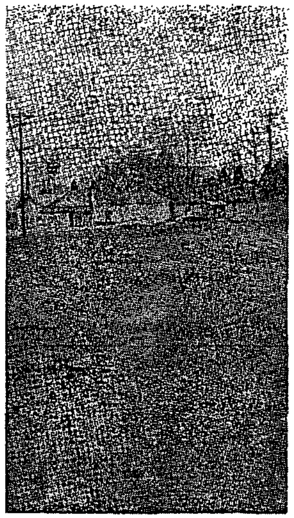
Structure on Plant Site



No. 11
Structures on Plant Site

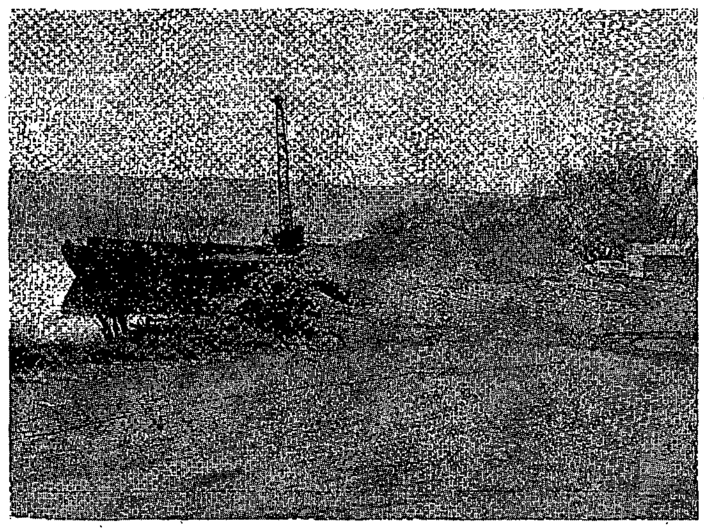




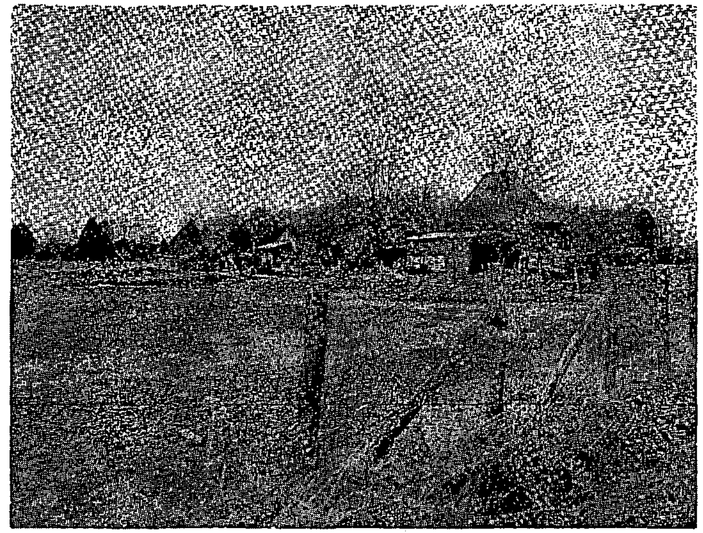


72
ersection

No. 15
Jackson County
Technical School

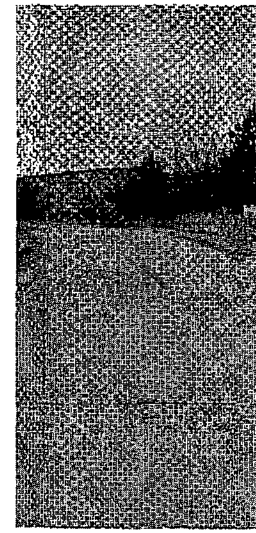


No. 16
Sand and Gravel
Operation



No. 17
Farm House and Out Buildings

No. 18
Town Creek Subdivision



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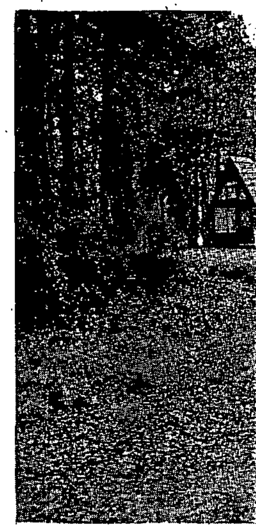

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Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

FIGURE A-8

Aerial Photography Showing Bellefonte Nuclear Plant Layout, Access Road And Railroad, And Approximate Transmission Line Routes

APPENDIX B

Ecological Surveys

Appendix B1

FISH AND OTHER AQUATIC LIFE

The fishery resource of Guntersville Reservoir has been surveyed in 1971 and 1972. The 1971 survey consisted of three cove-rotenone samples in each of four areas of the reservoir. Areas were defined as follows: Area I, TRM 349.4 to 350.0; Area II, TRM 361.0 to 364.1; Area III, TRM 372.0 to 382.3; Area IV, TRM 388.0 to 397.6. Area IV, which includes the Bellefonte site, is the area of principal interest in this discussion. Complete details are available in a report (Sheddan, 1972) from which data were extracted for presentation here.[1] A second survey, specifically designed to evaluate the fishery resource in the near vicinity of the Bellefonte site and employing several types of samping gear, was performed in June 1972. Sampling stations and gear employed in the vicinity of the site (1971 and 1972) are shown in figure B1-1.

The two surveys yielded 50 species among 27 genera belonging to 14 families of fish (Table B1-1). For purposes of simplified presentation of data and general discussion, three conventions were adopted: (1) species were grouped into the six most common and important families and the remainder assigned to a seventh (other) category; (2) all fish exceeding 1 year of age were combined as adults except (3) species of genera commonly referred to as forage species, e.g.; *Notropis*, *Fundulus*, *Percina*, were combined in the young-of-the-year (YOY) category.

Of the six families, the Clupeidae represent important, primarily planktivorous and herivorous forage species, the Centrarchidae and Percichthyidae represent predatory omnivorous or piscivorous sport species, and the Ictaluridae, Catostomidae, and Scianidae represent important omnivorous or piscivorous "rough" or commercial species.

In 1971, Area III dominated numerical and biomass standing stocks of adult fish (figures B1-2 and B1-3), the dominance being primarily due to the Clupeidae. Standing stocks of sport species were lowest in Areas II and III and highest in Areas I and IV. Area IV yielded the highest percentage of sport standing stocks and the lowest percentage of clupeid standing stocks.

Area II dominated standing stocks of young-of-the-year (YOY) fish; Area IV ranked second to Area II in standing stocks of sport species and first in percentage of sport standing stocks.

Standing stocks of white crappie (all ages) decreased downstream from Area IV through Area I, while standing stocks of YOY freshwater drum and channel catfish increased. Largest standing stocks of bluegills and largemouth bass were noted in Areas IV and II, largest standing stocks of redear sunfish were noted in Areas IV and I, and largest standing stocks of longear sunfish were found in Areas II and I.

Sheddan (1972) compared the results of this survey with the most recent surveys performed on four other lower main stream TVA reservoirs (Chickamauga, Wheeler, Pickwick, and Kentucky) and concluded that Guntersville ranks first in numerical standing stocks of harvestable sport species and fourth in commercial species.

Results of the 1972 cove surveys are presented in figures B1-4 and B1-5. The main stream cove, TRM 392, was also sampled as part of the Area IV survey in 1971 and is included for comparative purposes.

The 1972 survey confirms the observations of 1971 regarding the relative importance of sport species in Area IV.

The main stream cove (TRM 392) yielded greater standing stocks of adult fish than did the embayments with one exception. The large biomass contributed by catostomids in Town Creek is due to entrapment in the sample cove of a large school of adult smallmouth buffalo. Town Creek contained fewer fish than did Mud Creek, but these were of larger size.

The main stream cove contained more numbers, but significantly less biomass, of young fish than did the embayments. Town Creek contained the greatest numbers and biomass of young centrarchids in 1972.

An analysis by species of the standing stocks of the three coves is presented in Table B1-2, B1-3, and B1-4. The category of species, i.e., game, rough, forage, are those commonly used in the southeastern United States. Size categories, i.e., young, intermediate, adult, are arbitrary classifications. In general, the intermediate category is applied only to game and rough species and includes those fish of a species older than 1 year but which are not usually harvested by anglers or commercial fishermen.

Tables B1-5 through B1-8 present data obtained by electrofishing and gill netting concurrent with the standing stock estimates. Tables B1-9 and B1-10 present results of horizontal meter-net tows for larval and young fish. All tows were made after sunset and were of 5-minute duration using a 1-m diameter net. Three samples each were taken at the following locations:

1. Main channel (TRM 393) - Shoreline-surface
2. Main channel (TRM 393) - Channel-surface

3. Main channel (TRM 393) - Channel-5m depth
4. Secondary channel (TRM 393) - Channel-surface
5. Secondary channel (TRM 393) - Channel-5m depth
6. Mud Creek embayment - Channel-surface

Highest concentrations of larval and young fish were noted in shallower waters, i.e., Mud Creek embayment and shoreline-surface tows in the reservoir proper. Shad (Dorosoma spp.) and freshwater drum (Aplodinotus) dominated the main stream; shad and Lepomis spp. dominated the embayment sample. The secondary channel (that adjacent to the plant site) yielded higher concentrations of fish and eggs than did the main channel. These differences may be associated with production arising from the Crow Creek, Mud Creek, and Town Creek embayments. Town Creek was not sampled owing to navigational uncertainties at night, but based on the other results of the 1972 survey, larval fish samples from Town Creek would be expected to be roughly comparable to those of Mud Creek in numbers, with some variation in species concentration.

Shoreline-surface samples taken here are not directly comparable to those taken in Wheeler Reservoir and reported previously (TVA, 1972).[2] Most of the main stream shoreline area supports dense growths of Myriophyllum sp. and rendered meter-net sampling impossible in the strictly littoral zone. Observations made of these areas at sunset indicated that large numbers of fish either inhabit the vegetation or utilize it as a feeding area, where young fish and macroinvertebrates serve as the prey.

A short-term creel census was performed in the vicinity of the proposed site; results are summarized in Tables B1-11 through B1-14.

A survey of commercial fish landings from Guntersville Reservoir was performed in 1971 and appears as Table B1-15. Results of both the sport and commercial surveys are considered representative descriptions of the fishery resource of Guntersville Reservoir and of the lower main stream reservoirs of the TVA system.

1. Creel census report - Guntersville Reservoir - April 16 through July 1, 1972 -

(1) Introduction - An 11-week assessment of the sport fishing effort was made in two embayments in the vicinity of the proposed site. The selected survey areas (figure B1-1) were in the Town Creek, TRM 393, and Raccoon Creek, TRM 396, embayments having surface areas of 260 and 230 acres, respectively.

Data was collected between mid-April and July 1972. The survey was adjudged to begin at the peak of the spring fishing season.

(2) Methods - Since only one count could be made in each area in an 8-hour workday, the sample use count method was used to determine estimates of total fishing pressure and total catch. One 2-hour count period was assigned for each embayment for each day of a 5-day workweek. Fisherman interviews were conducted both before and after use counts.

For each week in the survey period 5 sample days and a fisherman-use count time (2-hour periods) for each of these days were systematically drawn. Nonuniform values based on knowledge of the fishery and the random selection process, were assigned to each possible sample period, each day of the week, and time of day (a.m. or p.m.) in which the use counts were made.

These values were then used to estimate the total pressure for the 5 days selected in a week by:

$$F_d = \frac{C/P_t}{P_p}$$

where

F_d = estimated total angler hours for the day

C = fisherman count for the day

P_t = probability of use count time

P_p = probability of period of day (a.m. or p.m.)

Estimates of fishing pressure for the week were calculated by:

$$F_w = \frac{\Sigma\ F_d}{\Sigma\ P_d}$$

where

F_w = estimated total angler hours for 5 days in a week

P_d = probability of fisherman use on the selected count day

The estimated total catch was determined by the product of the weekly estimated total pressure (angler hours) and the mean daily catch rate (catch per hour).

The estimated weight of each species harvested was the average weight of that fish in all creels times the estimated total catch of the species.

The average expenditure per trip was calculated from data collected from a 10 percent sample of all interviews.

(3) <u>Results</u> -

(a) <u>Fishing pressure</u> - Estimated total fishing effort in the two survey areas over an 11-week period was 9,222 hours. The Town Creek embayment survey showed 4,860 hours fished and 1,043 trips, and the Raccoon Creek survey 4,362 hours in 1,136 trips (Table B1-11). Length of completed trips were 4.7 and 3.8 hours, respectively. Other fisherman-use characteristics were similar in both areas (Table B1-12). Fishing success averaged 70 percent; average party size was 2.2 persons.

(b) <u>Catch</u> - The survey results showed the catch composition in each cove to be very similar. The two areas combined, 198 hectares, yielded an estimated 12,310 fish weighing 2,829 kg. Catch per trip was 5.4 fish weighing 1.3 kg.

Seven species of fish were identified in the creel from each area. White crappie was the dominant species, making up 53 percent of the catch by number and 52 and 57 percent by weight (Tables B1-13 and B1-14). Bluegill, redear sunfish, and largemouth bass combined with white crappie made up more than 95 percent of the catch.

In spite of the relatively short survey period, the rate statistics presented should aptly describe the spring fishery.

REFERENCES FOR APPENDIX B1

1. Sheddan, T. L. 1972. Fish inventory data. Guntersville Reservoir, 1971. TVA Fisheries and Waterfowl Resources Branch. 16 pp. mimeo.

2. Tennessee Valley Authority, 1972. Environmental Impact Statement, Browns Ferry Nuclear Steam Plant Units 1, 2, and 3. 3 vols.

Table B1-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN GUNTERSVILLE RESERVOIR, 1971 AND 1972*

Family Lepisosteidae

Spotted gar - *Lepisosteus oculatus*
Longnose gar - *L. osseus*
Shortnose gar - *L. platostomus*

Family Amiidae

Bowfin - *Amia calva*

Family Clupeidae

Skipjack herring - *Alosa chrysochloris*
Gizzard shad - *Dorsoma cepedianum*
Threadfin shad - *D. petenense*

Family Cyprinidae

Goldfish - *Carassius auratus*
Carp - *Cyprinus carpio*
Golden shiner - *Notemigonus crysoleucas*
Emerald Shiner - *Notropis atherinoides*
Whitetail shiner - *N. galacturus*
Spotfin shiner - *N. spilopterus*
Bluntnose minnow - *Pimephales notarus*
Fathead minnow - *P. promelas*

Family Catostomidae

Quillback - *Carpiodes cyprinus*
Smallmouth buffalo - *Ictiobus bubalus*
Bigmouth buffalo - *I. cyprinellus*
Black buffalo - *I. niger*
Spotted sucker - *Minytrema melanops*
Golden redhorse - *Moxostoma erythrurum*

Family Ictaluridae

Blue catfish - *Ictalurus furcatus*
Black bullhead - *I. melas*
Yellow bullhead - *I. natalis*
Channel catfish - *I. punctatus*
Flathead catfish - *Pylodictis olivaris*

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*Nomenclature that of American Fisheries Society Spec. Pub. No. 6, 3rd ed., 1970.

Table B1-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN GUNTERSVILLE RESERVOIR, 1971 and 1972*
(continued)

Family Cyprinodontidae

Blackstripe topminnow - *Fundulus notatus*
Black spotted topminnow - *F. olivaceus*

Family Poeciliidae

Mosquitofish - *Gambusia affinis*

Family Atherinidae

Brook silverside - *Labidesthes sicculus*

Family Percichthyidae

White bass - *Morone chrysops*
Yellow bass - *M. mississippiensis*

Family Centrarchidae

Green sunfish - *Lepomis cyanellus*
Pumpkinseed - *L. gibbosus*
Warmouth - *L. gulosus*
Orangespotted sunfish - *L. humilis*
Bluegill - *L. macrochirus*
Longear sunfish - *L. megalotis*
Redear sunfish - *L. microlophus*
Smallmouth bass - *Micropterus dolomieui*
Spotted bass - *M. punctulatus*
Largemouth bass - *M. salmoides*
White crappie - *Pomoxis annularis*
Black crappie - *P. nigromaculatus*

Family Percidae

Fantail darter - *Etheostoma flabellare*
Redline darter - *E. rufilineatum*
Logperch - *Percina caprodes*
Sauger - *Stizostedion canadense*

Family Scianidae

Freshwater drum - *Aplodinotus grunniens*

Family Cottidae

Banded sculpin - *Cottus carolinae*

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*Nomenclature that of American Fisheries Society Spec. Pub. No. 6, 3rd ed., 1970.

Table B1-2

DISTRIBUTION PER HECTARE BY SPECIES, MUD CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of-year		Intermediate		Adult	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Game						
Yellow bass	33.0	.8	77.7	2.9	61.7	3.2
Green sunfish	-	-	3.2	t	1.1	.1
Warmouth	1.1	t	3.2	.1	-	-
Bluegill	421.3	3.8	171.3	4.7	60.6	5.0
Longear	-	-	6.4	.1	1.1	t
Redear	44.7	.4	135.1	3.2	206.4	19.5
Largemouth bass	290.4	.4	13.8	.6	10.6	3.0
White crappie	19.1	t	33.0	.9	18.1	2.7
Sauger	-	-	-	-	2.1	.9
Total	809.6	5.3	443.7	12.5	361.7	34.4
Rough						
Spotted gar	-	-	-	-	3.2	1.6
Longnose gar	12.8	t	-	-	-	-
Skipjack herring	-	-	-	-	5.3	1.1
Smallmouth buffalo	-	-	-	-	26.6	46.0
Spotted sucker	-	-	-	-	3.2	2.8
Black bullhead	-	-	1.1	.1	-	-
Yellow bullhead	36.2	.1	1.1	.1	2.1	1.0
Channel catfish	2.1	t	1.1	.1	4.3	.9
Drum	102.1	3.1	309.6	24.0	189.4	27.8
Total	153.2	3.3	312.9	24.3	234.1	81.2
Forage						
Gizzard shad	268.1	.2	-	-	1,221.3	58.4
Goldfish	-	-	-	-	1.1	t
Golden shiner	-	-	-	-	23.4	.9
Emerald shiner	-	-	-	-	35.1	.1
Fathead minnows	-	-	-	-	34.0	.1
Mosquitofish	-	-	-	-	1.1	t
Orangespotted sunfish	1.1	t	-	-	16.0	.1
Total	269.2	.2	-	-	1,332.0	59.6
All Fish	1,232.0	8.9	756.6	36.8	1,927.8	175.2

t = less than 0.1 kilogram

Table B1-3

DISTRIBUTION PER HECTARE BY SPECIES, TOWN CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of year		Intermediate		Adult	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Game						
Yellow bass	-	-	9.2	0.3	18.4	1.1
Green sunfish	-	-	5.7	.1	6.9	.2
Warmouth	-	-	5.7	.2	11.5	1.4
Bluegill	916.1	3.9	311.5	3.7	77.0	4.3
Redear	165.5	1.1	112.6	1.0	55.2	8.7
Largemouth bass	350.6	.4	19.5	1.1	14.9	4.3
White crappie	27.6	t	-	-	6.9	.6
Black crappie	-	-	1.1	.2	-	-
Total	1,459.8	5.4	465.3	6.6	190.8	20.6
Rough						
Spotted gar	-	-	-	-	46.0	31.3
Carp	-	-	-	-	19.5	41.3
Smallmouth buffalo	-	-	-	-	101.1	176.0
Bigmouth buffalo	-	-	-	-	1.1	3.8
Yellow bullhead	100.0	.1	1.1	.1	-	-
Channel catfish	-	-	-	-	13.8	6.4
Drum	2.3	.1	57.5	5.1	65.5	29.5
Total	102.3	.2	58.6	5.2	247.0	288.3
Forage						
Gizzard shad	12.6	t	-	-	155.2	17.1
Goldfish	-	-	-	-	8.0	t
Goldenshiner	-	-	-	-	49.4	2.1
Emerald shiner	-	-	-	-	26.4	t
Fathead minnow	-	-	-	-	16.1	t
Mosquitofish	-	-	-	-	25.3	t
Brook silverside	-	-	-	-	2.3	t
Orangespotted sunfish	-	-	-	-	36.8	.2
Total	12.6	t	-	-	319.5	19.5
All Fish	1,574.7	5.6	523.9	11.8	757.3	328.4

t = less than 0.1 kilogram

Table B1-4

DISTRIBUTION PER HECTARE BY SPECIES, TRM 392, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Young-of-year		Intermediate		Adult	
	No.	Wt. (kg)	No.	Wt. (kg)	No.	Wt. (kg)
Game						
White bass	1.8	t	-	-	-	-
Yellow bass	-	-	18.5	.4	121.3	5.5
Green sunfish	-	-	6.5	.2	1.8	.2
Warmouth	-	-	11.1	.3	13.9	1.4
Bluegill	-	-	584.6	18.9	338.9	26.8
Redear	-	-	410.2	14.9	80.6	9.4
Largemouth bass	204.6	.4	75.0	4.6	18.5	7.0
White crappie	406.5	.4	18.5	1.1	34.3	5.5
Sauger	-	-	-	-	.9	.1
Total	612.9	.8	1,124.4	40.4	610.2	55.9
Rough						
Spotted gar	5.6	t	2.8	1.9	16.7	9.2
Bowfin	-	-	-	-	.9	1.7
Skipjack	4.6	t	-	-	-	-
Carp	.9	t	-	-	8.3	17.2
Quillback	-	-	-	-	.9	.9
Smallmouth buffalo	1.8	t	11.1	2.8	32.4	19.1
Spotted sucker	-	-	-	-	7.4	2.2
Black bullhead	983.3	1.0	-	-	3.7	1.8
Yellow bullhead	-	-	13.9	.6	7.4	1.6
Channel catfish	-	-	-	-	8.3	5.2
Drum	-	-	307.4	18.9	148.5	21.4
Total	996.2	1.1	335.2	24.2	234.5	80.3
Forage						
Gizzard shad	1.8	t	-	-	1,378.6	113.2
Threadfin shad	13.9	t	-	-	-	-
Golden shiner	-	-	-	-	2.8	.1
Emerald shiner	-	-	-	-	39.8	.1
Fathead minnow	-	-	-	-	5.6	.3
Mosquitofish	-	-	-	-	31.5	t
Orangespotted sunfish	-	-	-	-	21.3	.4
Logperch	-	-	-	-	1.8	t
Total	15.7	t	-	-	1,479.6	114.2
All Fish	1,624.8	1.9	1,459.6	64.6	2,324.3	250.4

t = less than 0.1 kilogram

Table B1-5

FISH CATCH BY ELECTRO-FISHING, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	Mud Creek		Town Creek		River Channel		Totals	
	No.	Catch per hour	No.	Catch per hour	No.	Catch per hour	Mean Catch per hour	Percent of catch
Game								
White bass	-	-	-	-	1	1	0.3	0.1
Yellow bass	29	29	16	21.4	-	-	16.8	6.2
Green sunfish	-	-	1	1.3	-	-	0.4	0.1
Bluegill	92	92	54	72.0	58	58	74.0	27.9
Longear	2	2	-	-	2	2	1.3	0.5
Redear	42	42	20	26.7	9	9	25.9	9.7
Spotted bass	2	2	1	1.3	-	-	1.1	0.4
Largemouth bass	17	17	18	24.0	7	7	16.0	5.8
Black crappie	-	-	-	-	1	1	0.3	0.1
Sauger	1	1	-	-	-	-	0.3	0.1
Total	185	185	110	146.6	78	78	136.5	50.9
Rough								
Spotted gar	5	5	2	2.7	1	1	2.9	1.1
Carp	2	2	3	4.0	4	4	3.3	1.2
Smallmouth buffalo	9	9	2	2.7	6	6	5.9	2.3
Spotted sucker	1	1	-	-	4	4	1.7	0.7
Yellow bullhead	-	-	1	1.3	-	-	0.4	0.1
Channel catfish	2	2	1	1.3	-	-	1.4	0.4
Drum	8	8	12	16.0	3	3	9.0	3.2
Total	27	27	21	28.0	18	18	24.3	9.0
Forage								
Gizzard shad	150	150	60	80.0	75	75	101.7	39.0
Emerald shiner	-	-	-	-	3	3	1.0	0.4
Brook silverside	-	-	-	-	5	5	1.7	0.7
Logperch	1	1	-	-	-	-	0.3	0.1
Total	151	151	60	80.0	83	83	104.7	40.2
All Fish	363	363	191	254.6	179	179	265.5	

Table B1-6

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), MUD CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	2	0.1	0.5	t	0.9	0.5
Yellow bass	1	.1	.2	t	.4	.2
Warmouth	3	.2	.5	t	1.3	.5
Bluegill	15	1.0	1.6	.1	6.4	1.5
Redear	18	1.2	2.4	.2	7.7	2.3
Largemouth bass	4	.3	1.4	.1	1.7	1.4
White crappie	1	.1	.2	t	.4	.2
Total	44	3.0	6.8	.4	18.8	6.6
Rough and Forage						
Spotted gar	38	2.5	25.4	1.7	16.3	24.5
Longnose gas	9	.6	11.6	.8	3.9	11.2
Shortnose gas	2	.1	1.7	.1	.9	1.6
Skipjack herring	12	.8	3.8	.3	5.2	3.7
Gizzard shad	64	4.3	10.8	.7	27.5	10.4
Carp	2	.1	2.8	.2	.9	2.7
Quillback	3	.2	2.9	.2	1.3	2.8
Smallmouth buffalo	8	.5	13.5	.9	3.4	13.0
Spotted sucker	3	.2	2.2	.1	1.3	2.1
Black bullhead	1	.1	.2	t	.4	.2
Yellow bullhead	3	.2	.9	.1	1.3	.9
Channel catfish	42	2.8	19.0	1.3	18.0	18.4
Flathead catfish	1	.1	1.7	.1	.4	1.6
Drum	1	.1	.2	t	.4	.2
Total	189	12.6	96.7	6.5	81.2	93.4
All Fish	233	15.6	103.5	6.9		

t = less than 0.1 kilogram

Table B1-7

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), TOWN CREEK, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	2	0.1	0.7	t	1.7	1.3
Yellow bass	-	-	-	-	-	-
Warmouth	6	.4	.7	t	5.0	1.3
Bluegill	4	.3	.5	t	3.3	.9
Redear	16	1.1	2.0	.1	13.3	3.7
Largemouth bass	-	-	-	-	-	-
White crappie	9	.6	1.7	.1	7.5	3.1
Total	37	2.5	5.6	.4	30.8	10.3
Rough and Forage						
Spotted gar	6	.4	4.6	.3	5.0	8.4
Longnose gar	13	.9	24.7	1.6	10.8	45.2
Shortnose gar	-	-	-	-	-	-
Skipjack herring	9	.6	3.1	.2	7.5	5.7
Gizzard shad	31	2.1	5.0	.3	25.8	9.2
Carp	-	-	-	-	-	-
Quillback	1	.1	1.1	.1	.8	2.0
Smallmouth buffalo	-	-	-	-	-	-
Spotted sucker	4	.3	3.3	.2	3.3	6.0
Black bullhead	-	-	-	-	-	-
Yellow bullhead	-	-	-	-	-	-
Channel catfish	18	1.2	7.0	.5	15.0	12.8
Flathead catfish	-	-	-	-	-	-
Drum	1	.1	.2	t	.8	.4
Total	83	5.5	49.0	3.2	69.2	89.7
All Fish	120	8.0	54.6	3.6		

Table B1-8

FISH CATCH WITH GILL NETS (15 NET-NIGHTS), TRM 394, GUNTERSVILLE RESERVOIR, JUNE 1972

Species	No.	No. per Net-Night	Wt., kg	Wt. per Net-Night kg	Percent of Catch No.	Percent of Catch Wt.
Game						
White bass	5	0.3	1.3	.1	2.1	1.2
Yellow bass	-	-	-	-	-	-
Warmouth	-	-	-	-	-	-
Bluegill	18	1.2	2.0	.1	7.7	1.8
Redear	84	5.6	12.4	.8	35.9	11.4
Largemouth bass	1	.1	.3	t	.4	.3
White crappie	11	.7	1.8	.1	4.7	1.7
Total	119	7.9	17.8	1.1	50.9	16.4
Rough and Forage						
Spotted gar	5	.3	3.2	.2	2.1	3.0
Longnose gar	41	2.7	68.0	4.5	17.5	62.7
Shortnose gar	-	-	-	-	-	-
Skipjack herring	22	1.5	8.8	.6	9.4	8.1
Gizzard shad	27	1.8	4.4	.3	11.5	4.1
Carp	-	-	-	-	-	-
Quillback	-	-	-	-	-	-
Smallmouth buffalo	-	-	-	-	-	-
Spotted sucker	3	.2	2.5	.2	1.3	2.3
Black bullhead	-	-	-	-	-	-
Yellow bullhead	-	-	-	-	-	-
Channel catfish	2	.1	.7	t	.9	.6
Flathead catfish	1	.1	.8	t	.4	.7
Drum	14	.9	2.2	.1	6.0	2.0
Total	115	7.7	90.6	6.1	49.1	83.6
All Fish	234	15.6	108.4	7.2		

t = less than 0.1 kilogram

Table B1-9

TOTAL CATCH BY SPECIES, LARVAL FISH
GUNTERSVILLE RESERVOIR, JUNE 21, 1972

	Sample Location (See Text)					
	1	2	3	4	5	6
Total Volume, M^3*	1114.4	1122.8	1104.8	1198.3	1138.4	1131.2
Mean Volume, M^3	371.5	374.3	368.3	399.4	379.5	377.1
Species						
Dorsoma spp	4067	37	181	69	295	10080
D. cepedianum	18	15	42			
D. petenense	2	16	2	24	6	634
Lepomis spp	37	7	2	6	2	197
Pomoxis sp	1					1
Ictalurus punctatus				1	2	1
I. furcatus		3	3	1	1	
Aplodinotus grunniens	723	32	77	171	519	6
Cyprinus carpio	7	1	1	6	2	
Notropis spp	122	2	5	3	7	4
Unidentified fish			16	2	11	
Eggs	11	123	22	2035	1722	16
Total Fish	4977	113	329	283	845	10923
Number/100 m^3	446.6	10.1	29.8	23.6	74.2	965.6
Eggs/100 m^3	1.0	11.0	2.0	169.8	151.3	1.4

*Triplicate samples each station

Table B1-10

CATCH/100 m^3, LARVAL FISH, GUNTERSVILLE RESERVOIR JUNE 21, 1972 - FIGURES IN PARENTHESES INDICATE RANGE

Sample Location	Shad	Non-Shad	Total Catch
1	366.7 (254.1-546.6)	79.9 (44.7-124.9)	446.6 (298.8-670.5)
2	6.1 (2.6-11.3)	4.0 (3.4-4.5)	10.1 (7.1-14.7)
3	20.4 (16.0-24.7)	9.4 (5.9-14.8)	29.8 (23.3-39.6)
4	7.8 (7.7-7.9)	15.9 (10.7-23.2)	23.6 (18.4-31.1)
5	26.4 (13.8-41.1)	47.8 (40.8-55.0)	74.2 (61.8-81.8)
6	947.2 (556.3-1177.3)	18.5 (15.3-21.4)	965.6 (571.6-1198.7)

Table B1-11

WEEKLY TRIP AND FISHING-HOUR ESTIMATES FROM TWO EMBAYMENTS ON GUNTERSVILLE RESERVOIR - APRIL 16-JULY 1, 1972

Week	Town Creek Trips	Town Creek Hours Fished	Raccoon Creek Trips	Raccoon Creek Hours Fished
4/16-4/22	270	1,258	220	1,025
4/23-4/29	151	704	276	1,286
4/30-5/6	180	839	179	834
5/7-5/13	39	182	80	373
5/14-5/20	90	419	68	317
5/21-5/27	69	322	65	303
5/28-6/3	101	471	94	438
6/4-6/10	76	354	44	205
6/11-6/17	41	191	38	177
6/18-6/24	14	65	33	154
6/25-7/1	12	56	39	182
Total	1,043	4,860	1,136	4,362

Table B1-12

USE-RATE CHARACTERISTICS AND EXPENDITURES OF FISHERMEN IN TWO GUNTERSVILLE RESERVOIR EMBAYMENTS

Item	Embayment	
	Town Creek	Raccoon Creek
Percent successful trips	71.8	70.0
Length completed trip (hours)	4.7	3.8
Average party size	2.2	2.1
Trips per acre (weekly average)	0.37	0.45
Expenditures per trip	$6.69	$7.13

Table B1-13

ESTIMATED CATCH BY SPECIES, WEIGHT, AND NUMBER FISH CAUGHT PER HOUR FROM TOWN CREEK EMBAYMENT - APRIL 16-JULY 1, 1972

Species	Total Number	Total Weight kg	Average Weight kg	Number Per Hour	Estimated Total Number	Estimated Total Weight
White crappie	740	170.2	0.23	0.68	3,304	766.1
Bluegill	331	37.1	0.11	0.31	1,506	171.2
Redear sunfish	176	21.7	0.12	0.16	777	95.5
Largemouth bass	145	66.9	0.46	0.13	631	290.1
White bass	9	2.6	0.29	0.01	48	13.9
Black crappie	7	2.1	0.29	0.07	37	10.9
Yellow bass	1	0.2	0.23	Tr.	5	1.2
Total	1,402	300.8			6,308	1,348.9

Table B1-14

ESTIMATED CATCH BY SPECIES, WEIGHT AND NUMBER FISH
CAUGHT PER HOUR FROM RACCOON CREEK EMBAYMENT - APRIL 16-JULY 1, 1972

Species	Total Number	Total Weight kg	Avg. Weight kg	Number per hour	Estimated Total Number	Estimated Total Weight
White crappie	775	185.2	0.24	0.73	3,184	761.1
Bluegill	320	36.2	0.11	0.30	1,308	148.7
Largemouth bass	183	100.4	0.55	0.17	741	404.5
Redear sunfish	151	19.4	0.13	0.14	610	77.7
White bass	20	5.3	0.26	0.02	87	23.0
Channel catfish	5	6.6	1.32	0.01	43	57.2
Black crappie	2	0.7	0.34	<0.01	22	7.6
Total	1,456	353.8			5,995	1,479.8

Table B1-15

COMMERCIAL FISHERMAN SURVEY - 1971
GUNTERSVILLE RESERVOIR*

Species	Total Kilograms Caught	Total Kilograms to Dealers
Catfish	300,500	294,300
Buffalo	315,700	315,400
Carp	97,400	71,000
Drum	24,200	22,500
Spoonbill	13,600	13,600
Others**	64,700	64,700
Total	816,100	781,500

*Source: Fisheries and Waterfowl Resources Branch, TVA. Data correlated with Regional Office, National Marine Fisheries Survey, NOAA.

**Includes quillback, sucker, gizzard shad, and turtles.

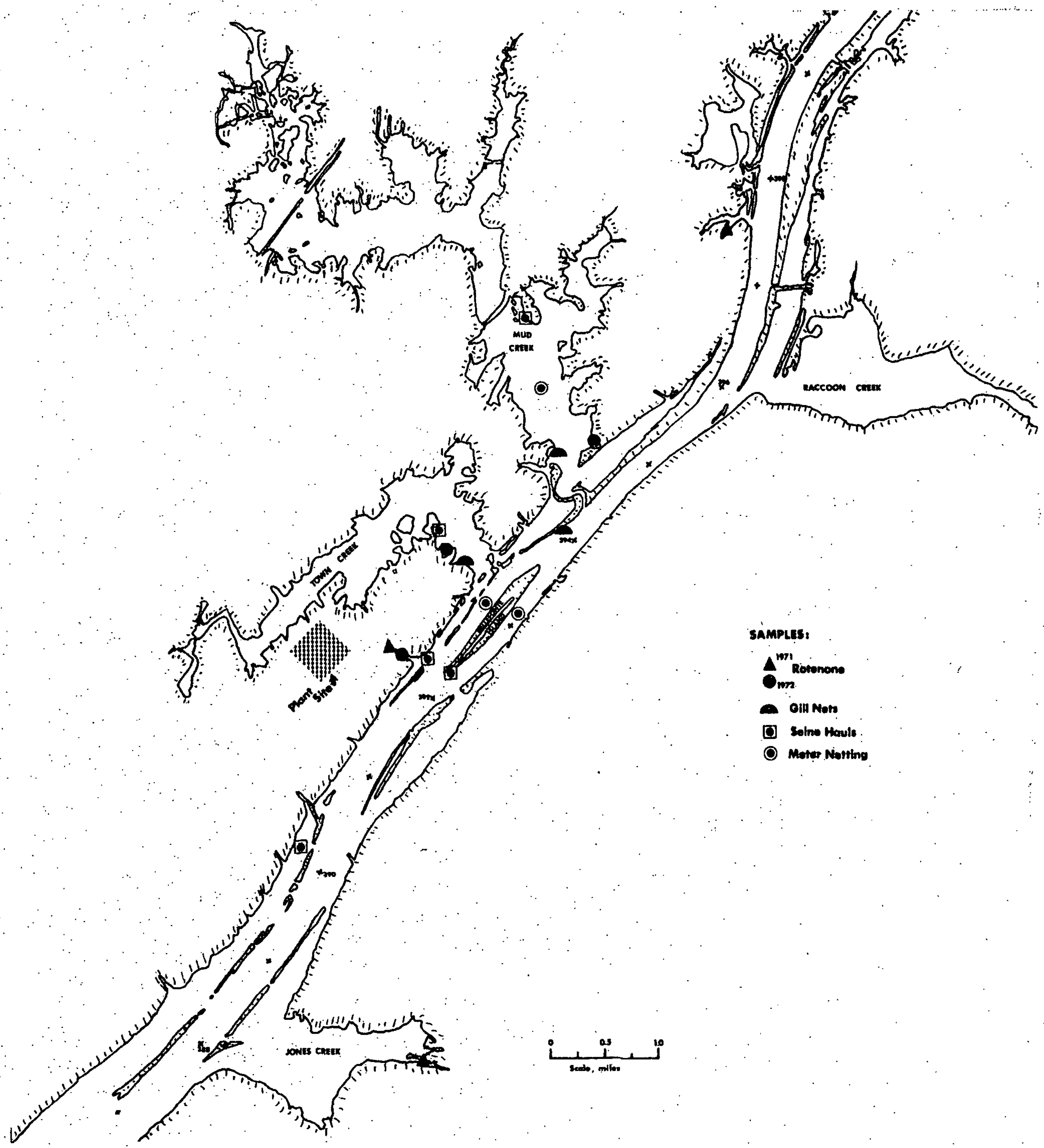
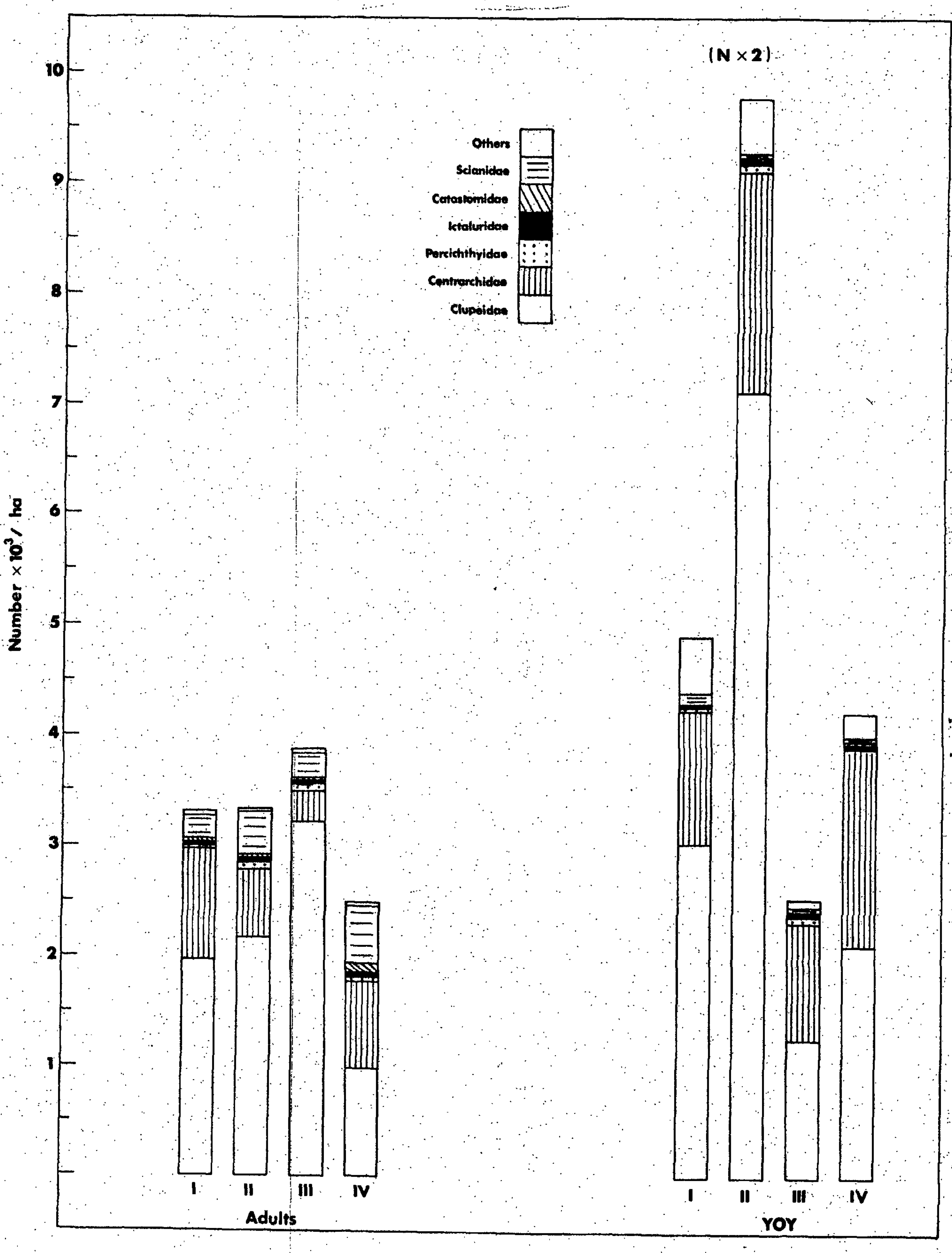


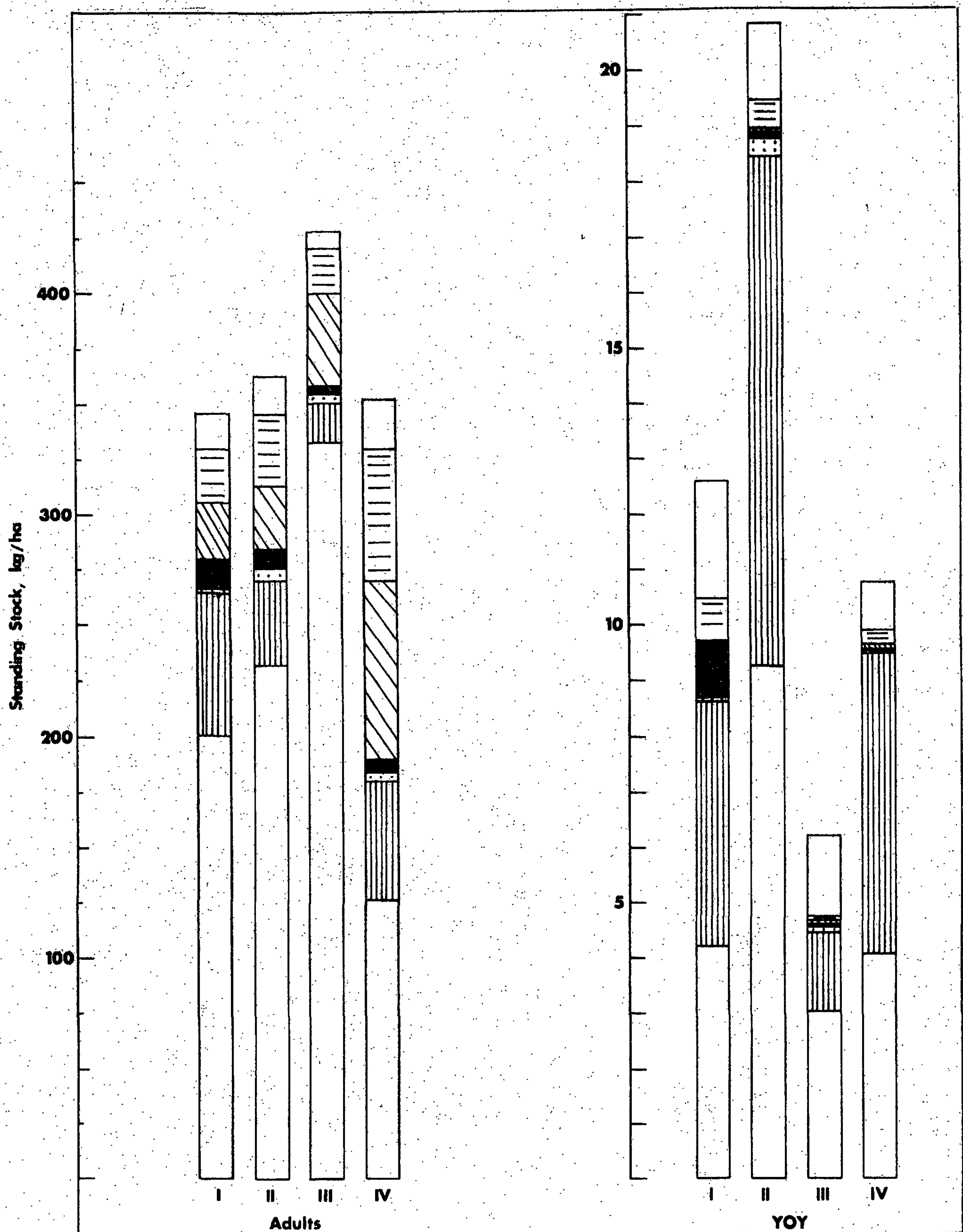
Figure B1-1

SAMPLING STATIONS FOR GUNTERSVILLE RESERVOIR FISH SAMPLING (1972) AND ROTENONE SAMPLING (1971)



Roman Numerals refer to areas defined in the text. YOY = Young of the Year. Adults = Juveniles and Adults.

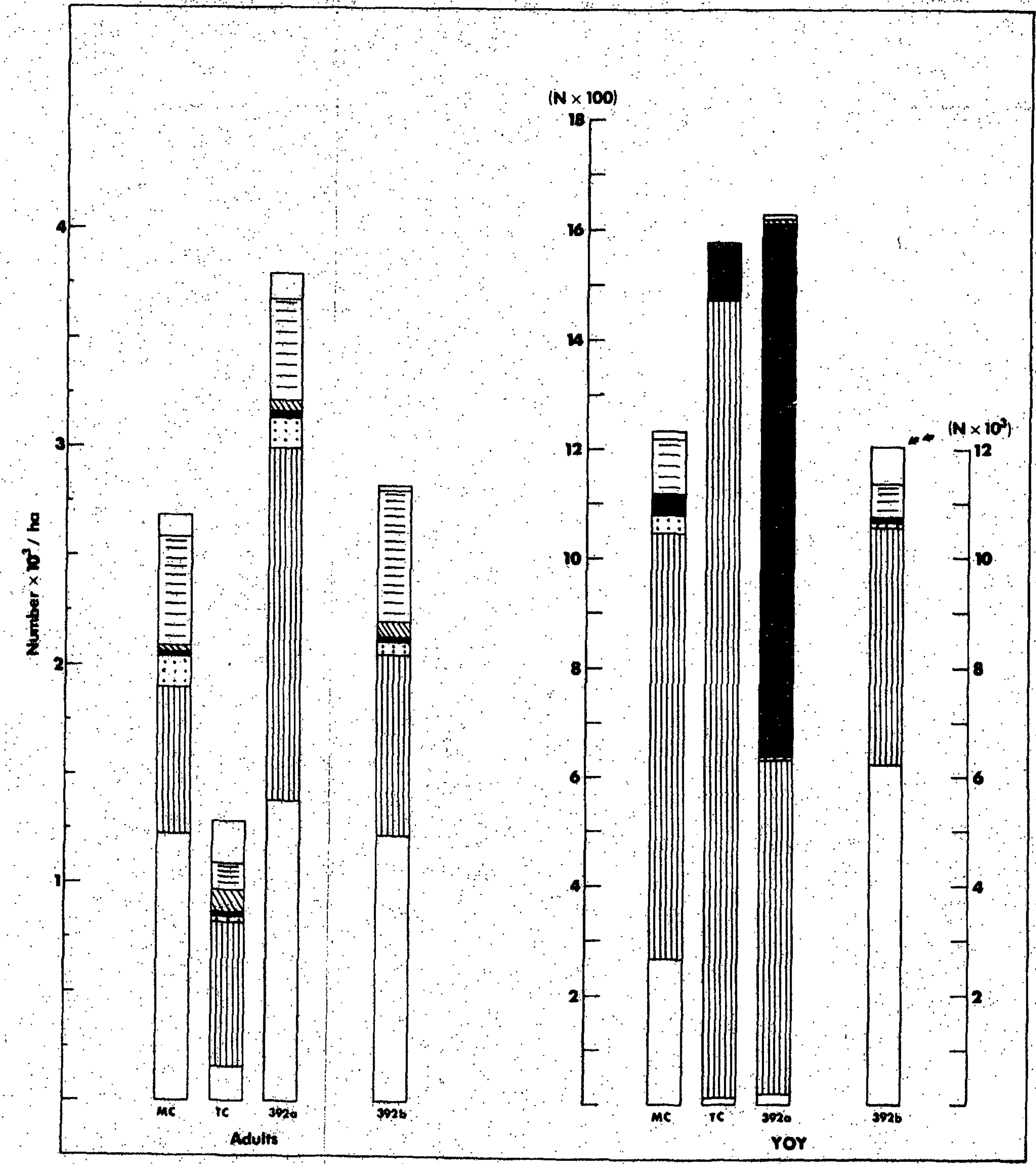
Figure B1-2
NUMBERS OF FISH PER HECTARE TAKEN IN COVE ROTENONE SAMPLES, GUNTERSVILLE RESERVOIR JULY-AUGUST, 1971



Roman Numerals refer to areas defined in text. YOY = Young of the Year. Adults = Juveniles and Adults.

Figure B1-3

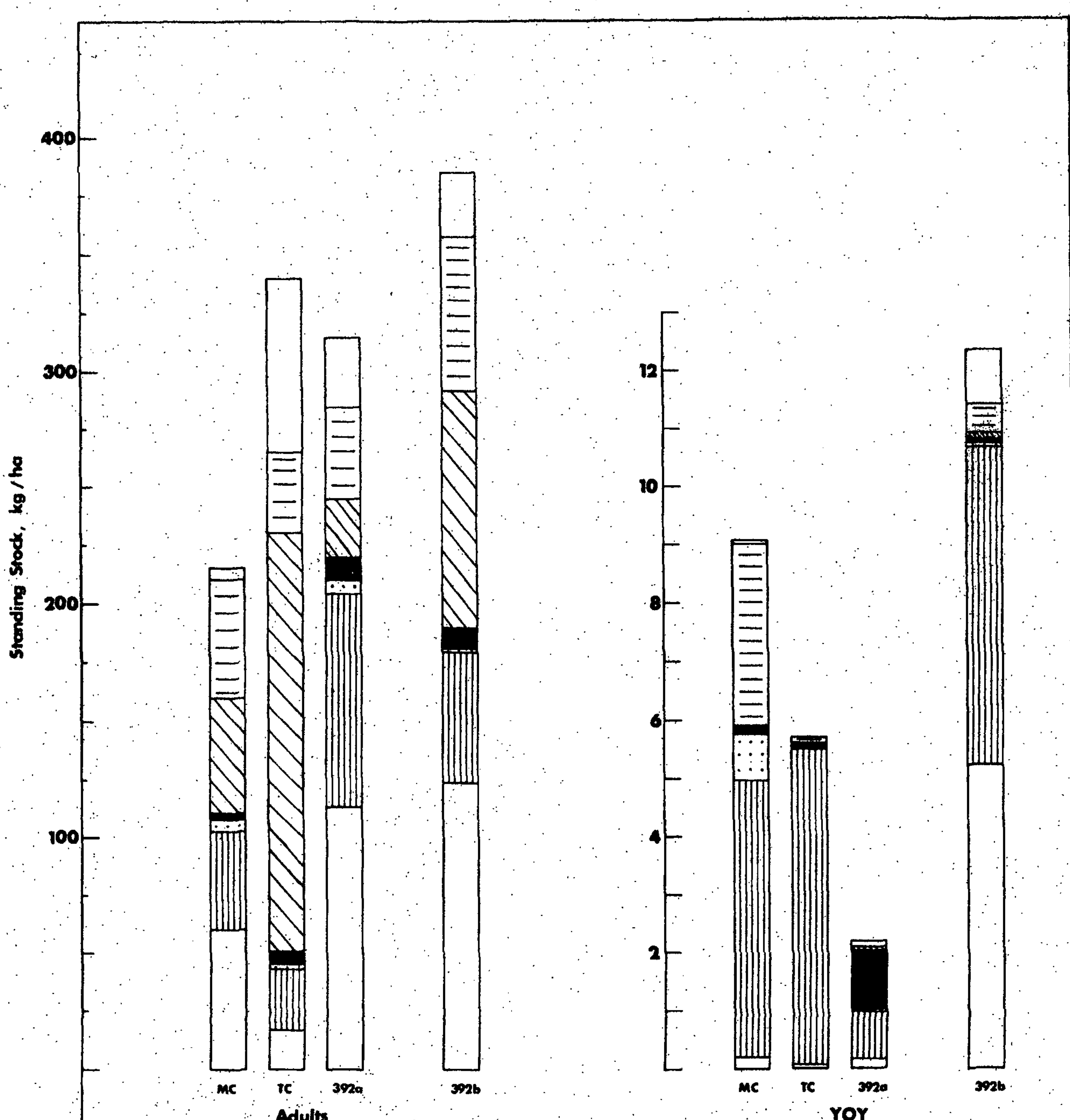
STANDING STOCK BIOMASS OBTAINED FROM COVE ROTENONE SAMPLES, GUNTERSVILLE RESERVOIR, JULY-AUGUST, 1971



Roman Numerals refer to areas defined in text. YOY = Young of the Year. Adults = Juveniles and Adults. MC = Mud Creek, TC = Town Creek. 392a = TRM 392, sampled in 1972. 392b same cove sampled in 1971 survey as part of area IV.

Figure B1-4

NUMBERS OF FISH PER HECTARE TAKEN IN COVE ROTENONE SAMPLES IN THE VICINITY OF THE BELLEFONTE SITE, JUNE, 1972



Roman Numerals refer to areas defined in the text. YOY = Young of the Year. Adults = Juveniles and Adults. MC = Mud Creek. TC = Town Creek. 392a = TRM 392, sampled in 1972. 392b = same cove sampled in 1971 survey as part of area IV.

Figure B1-5
STANDING STOCK BIOMASS OBTAINED FROM COVE ROTENONE SAMPLES IN THE VICINITY OF THE BELLEFONTE SITE, JUNE, 1972

Appendix B2

TERRESTRIAL AND AMPHIBIOUS FAUNA

1. Introduction - There is a paucity of scientifically documented information concerning the terrestrial and amphibious fauna of either the Bellefonte site area or of the Jackson County, Alabama, area. As is the case throughout much of the Tennessee Valley, lists of species on a county-by-county basis are not available. Counties having large metropolitan areas and communities where colleges or universities are located are more likely to have been inventoried by botanists, zoologists, and ecologists.

Time limitations preclude an intensive terrestrial faunal assessment of the plant site; however, a compilation of species lists was accomplished from review of literature based on study of the entire state and areas near the proposed site that are physiographically and ecologically similar. Lists of mammals and birds found in Wheeler National Wildlife Refuge and expected to be found in northeastern Alabama are listed with annotations. Herptiles expected to frequent the area are listed and discussed by Dr. Bob Mount of Auburn University. Due to the location of this plant site relative to state and Federal waterfowl areas, a separate section dealing with waterfowl is included. Much of it is based on the North Alabama Land Use Study accomplished by TVA Division of Forestry, Fisheries, and Wildlife Development by Klein, et al., with specific waterfowl inputs by J. H. Burbank, TVA Waterfowl Biologist.

The proximity of the plant site to Wheeler National Wildlife Refuge affords the oportunity to generalize on the fauna of the area based on species lists compiled on the refuge. It cannot be categorically assumed that any species known at Wheeler Refuge will occur 30 miles up the Valley on the plant site. Some species listed, especially certain birds, are not likely to be seen in northeastern Alabama, but their distributional limits encompass the plant site area and they therefore are included. Those that have been seen in the area and likely to nest there are annotated.

No lists of insects or microfauna are available.

2. Endangered species - After careful review of fauna suspected to inhabit or migrate through the Bellefonte site and those animals whose distributional limits encompass the site, it was found that several species listed by the Department of the Interior Office of Rare and Endangered Species as threatened with extinction could conceivably be found in the area at certain times during the year. The Southern Bald Eagle (Haliaeetus leucocephalus leucocephalus) is commonly seen on Watts Bar and Chickamauga Lakes upstream from Guntersville, and these birds are occasionally seen at Wheeler National Wildlife Refuge. The American Peregrine Falcon (Falco peregrinus arrotum) and Red-cockaded Woodpecker (Dendrocopos borealis) have been seen on Wheeler refuge. These two species are rare. Bachman's Warbler (Vermivora bachmanii) and Kirtland's Warbler (Dendroica kirtlandii) could conceivably migrate through the area, but neither have been recorded at the Wheeler refuge. The Indiana Bat (Myotic sodalis), another endangered species, is a cave dweller and would be unlikely in

the area. No known caves are located on the plant site. Rare and endangered species are listed in Table B2-1.

3. Mammals - A qualitative assessment of Bellefonte site mammal populations was made based on a comprehensive vegetative analysis of the area, knowledge of past area land use practices, review of a list of mammals found on Wheeler National Wildlife Refuge, and Burt's A Field Guide to the Mammals. Species known to occur at Wheeler refuge and those whose distributional limits include the plant site area are listed in Table B2-2.

Of larger mammals, the White-tailed Deer (Odocoileus virginianus) is an important resident and is abundant based on browse sign and random pellet group counts. The majority of the 640 acres of wooded area has been subjected to cutting during the past few years, creating a lush growth of hardwood sprouts, herbaceous plants, and shrubs, thus producing an ideal habitat situation for deer. Opening of forested areas through cutting has doubtless benefited myriad other species of mammals such as the Gray Fox (Urocyon cinereoargenteus), Raccoon (Procyon lotor), Woodchuck (Marmota monax), Red Fox (Vulpes fulva), Opossum (Didelphis virginiana), and Cottontail Rabbit (Sylvilagus floridanus). Gray Squirrel (Sciurus carolinensis) appears to be present in good numbers even though forested areas have been heavily cut.

About 530 acres of the Bellefonte site are now in an "open" stage either as pasture or early successional old fields. The ragweed type and to a lesser extent broom sedge-lespedeza provide rabbits with a fairly favorable food and cover situation and should improve as the plant association naturally changes from annuals to perennials.

Populations of small mammals on the Bellefonte site are probably high, both in wooded and open areas, with such species as Shorttail Shrew (Blarina brevicauda), Pine Vole (Pitymys pinetorum), Golden Mouse (Peromyscus nuttalli), and Eastern Wood Rat (Neotoma floridana) being common residents. Several species of bats, namely Gray Myotis (Myotis grisescens), Red Bat (Lasiurus borealis), and Eastern Pipistrel (Pipistrellus subflovus) are common to Wheeler Refuge and probably frequent the plant site environs. Muskrat (Ondatra zibethica), Mink (Mustela vison), and an occasional River Otter (Lutra canadensis) frequent the littoral areas, Muskrat being the most numerous and the Otter extremely rare. The variety of habitat niches within the several open and forested types provides a wide range of food and habitat situations for a diverse and abundant mammalian fauna.

4. Birds - The list of birds given in Table B2-3 is a composite listing of species which likely nest and winter in the Bellefonte area and those that migrate through Jackson County. Some dominant year-round residents include the Crow (Corvus brachyrhynchos), Blue Jay (Cyanocitta cristata), Cardinal (Richmondena cardinalis), Red-tailed Hawk (Buteo jamaicensis), Sparrow Hawk (Falco sparverius), Mourning Dove (Zenaidura macroura), Screech Owl (Otus asio), Belted Kingfisher (Megaceryle alcyon), Pileated Woodpecker (Dendrocopus pileatus), Downy Woodpecker (Dendrocopus pubescens), Tufted Titmouse (Parus bicolor), Starling (Sturnus vulgaris), and Field Sparrow (Spizella pusilla). The variety of wooded and open areas and extensive edge create favorable habitats for a wide variety of avian species.

5. Waterfowl - The principal wintering grounds for migrant waterfowl in north Alabama are on Guntersville and Wheeler Lakes, and the bulk of wintering geese and ducks use the state and Federal waterfowl and wildlife management areas where food is plentiful and they are afforded some measure of protection. Roughly one-third of Alabama's wintering ducks and over 95 percent of the state's total wintering Canada Goose (*Branta canadensis*) population are found on the area from Guntersville to the upper end of Pickwick Lake.

The Wood Duck (*Aix sponsa*) is the only duck that nests in significant numbers in the state of Alabama. Black Ducks (*Anas rubripes*) and Mallards (*Anas platyrhynchos platyrhynchos*) are conspicuously present in the region during the breeding season, and both species successfully nest albeit in considerably less numbers than the wood duck; however, the potential for increasing nesting populations for these two species exists; Canada geese are present in the region only during the winter months. Free-flying Canadas that nest and spend the entire year on reservoirs such as Guntersville and Wheeler may become a reality in the near future as TVA continues its resident Canada goose program throughout the Valley. Seventy-five percent of ducks wintering in north Alabama are "puddle ducks," namely, mallards, black ducks, wood ducks, teal, and gadwall. Shallow bays, mud flats, sloughs, wooded bottom lands, and conterminous farming lands both on refuges and private areas provide for a fairly attractive habitat situation on these reservoirs.

Public management and refuge areas comprise about 34 percent of the total TVA land and water acreage in north Alabama. Table B2-4 lists major waterfowl areas on Pickwick, Wheeler, and

Guntersville Lakes, their size, and governing agency. These areas are leased from TVA with the single exception of Wheeler Refuge which is completely controlled by the Bureau of Sports Fisheries and Wildlife.

The Bellefonte plant site is located less than 1/2 mile from the State of Alabama Mud Creek waterfowl area which includes over 8,000 acres of land and water. Mud Creek affords sportsmen some 23,000 man-days of recreational activity annually, 1,200 of which are waterfowl and over 3,000 upland game. The other areas on Guntersville and Wheeler are heavily used by both hunter and nonhunter alike as shown in Table B2-5.

Town Creek embayment of Guntersville Lake borders the northern periphery of the peninsula on which the site is located while a series of narrow, linear islands border the area on the south side. Up-to-date assessment of year-round waterfowl use of the plant site environs is not possible because of time limitations. Several waterfowl float counts have been conducted around the peninsula from Town Creek embayment bridge to a point on the main channel side of the area about 1/4 mile upstream from the old ferry crossing. These float trips have revealed that wood ducks are nesting successfully on or near the peninsula, but five float trips in May and June of 1972 and again in late August and September indicate that the immediate area is not a significant wood duck nursery. Littoral area associated vegetation appears to afford birds fairly good brood habitat, but there is a paucity of large trees (>14 inches d.b.h.), thus suggesting that nesting habitat may be a limiting factor. Additional studies will be needed, however, before conclusive data can be gathered and conclusions drawn regarding the complete waterfowl resource of the area. Emergent, submersed and floating aquatic macrophytes are discussed elsewhere in this survey, and a partial list is also included in Table B2-6. Presence of these plants insofar as waterfowl are concerned is important particularly in view of the value of many of these species as waterfowl food plants. Aquatic plant life can provide escape and loafing cover as well as a direct source of food and also increase numbers of aquatic invertebrates which are an important waterfowl dietary item.[1]

6. The reptiles and amphibians of Jackson County, Alabama - a summary of current knowledge - Jackson County, Alabama in the northeastern corner of the state, lies wholly within the Tennessee River drainage. The topography varies from nearly flat to mountanious and the soil from heavy clay to sandy loam. The Tennessee River flows through the county from near the northeastern corner to the southwestern corner and is the county's dominant feature. Sand Mountain, the uppermost element of the Appalachian Ridge and Valley Province in Alabama, parallels the river on the southeast and rises rather abruptly from the river valley. In the northern portion of the county, the valley interdigitates with broad fingers of the Cumberland Plateau.

There are no published accounts dealing specifically with the reptiles and amphibians of Jackson County. An account by Penn (1940) provided an annotated list of species and subspecies collected in Mentone, DeKalb County, and vicinity, and this was used for many years as a source of reference to the herpetology of northeastern Alabama. Within recent years, field crews from Auburn University have made a number of trips to Jackson County for the purpose of making comprehensive collections of reptiles and amphibians. Most of the specimens obtained have been placed in the Auburn University Museum. These collections together with some made in nearby areas and some in other museums, provide the basis for this report. The report is in the form of an annotated checklist. Literature citations on individual forms are included where appropriate.

Following is a summary listing of the forms, an indication of their current status in the county, and the probable effects of various environmental modifications on their relative abundance. A total of 81 species, representing 20 families, are thought to occur in Jackson County.

Amphibians - Class Amphibia

Frogs and Toads - Order Anura

Spadefoot Toads - Family Pelobatidae

Eastern Spadefoot Toad - Scaphiopus holbrooki

Not recorded from Jackson County but almost certainly present. Breeds in flooded depressions of a temporary nature following heavy rains. Seldom seen except at night during wet weather. Nearest recorded locality: 0.5 mi. N of Ider, DeKalb County.

Toads - Family Bufonidae

American Toad - Bufo americanus americanus

Fairly common throughout, breeding during late winter and early spring, mostly in wet-weather pools and ponds. Not often seen during months of June through January.

Fowler's Toad - Bufo woodhousei fowleri

Abundant throughout, breeding from April through July in streams, lakes, and ponds. Hybridizes occasionally with Bufo americanus.

Treefrogs - Family Hylidae

Northern Cricket Frog - Acris crepitans crepitans

Common throughout where permanent water occurs. Breeds over a long period in a variety of habitats, ranging from small ponds to large streams.

Northern Spring Peeper - Hyla crucifer crucifer

Common throughout, but breeding only in late winter and spring. Seldom seen at other times. Breeding habitats usually consist of transient pools and ponds formed by heavy rains.

Mountain Chorus Frog - Pseudacris brachyphona

Although not recorded from Jackson County, this species almost certainly occurs there. Breeds in upland situations in temporary accumulations of water during winter. Seldom seen except at the breeding sites.

Upland Chorus Frog - Pseudacris triseriata feriarium

Common throughout, breeding during winter and early spring in shallow, flooded ditches and depressions. Seldom seen during summer months.

Gray Treefrog - Hyla versicolor (or H. chrysocelis)

Abundant throughout, breeding during spring and summer in temporary or semi-permanent ponds and pools. The common "treefrog" of Jackson County.

Barking Treefrog - Hyla gratiosa

This species is chiefly Coastal Plain in affinity, but it has been reported on several occasions in upland provinces, as far north as Kentucky. In Alabama a specimen from the vicinity of Ider, on Sand Mountain in DeKalb County, indicates the possibility of its occurrence in Jackson County also. This species breeds in permanent and semi-permanent ponds, preferably shallow ones.

Narrow-mouthed Toads - Family Microhylidae

Eastern Narrow-mouthed Toad - Gastrophryne carolinensis

Abundant throughout, breeding during warm, rainy weather in flooded fields, roadside ditches, and ponds, and around the heavily vegetated margins of lakes. Secretive and seldom seen abroad except during breeding.

True Frogs - Family Ranidae

Bullfrog - Rana catesbeiana

Common throughout the county in places where streams and permanent bodies of water provide suitable habitat.

Green Frog - Rana clamitans melanota

Common throughout. Inhabits streams, sloughs, and ponds with tree-lined margins.

Leopard Frog - _Rana_ _Pipiens_ _sphenocephala_ (X _pipiens?_)

Leopard frogs occur in Jackson County, but the few specimens examined do not permit precise subspecific allocation of the population. Leopard frogs breed in a variety of permanent and semi-permanent aquatic habitats.

Pickerel Frog - _Rana_ _palustris_

Fairly common throughout. Breeds in woodland pools, quiet areas in small streams, and occasionally in other aquatic situations.

Salamanders - Order Caudata

Giant Salamanders - Family Cryptobranchidae

Hellbender - _Cryptobranchus_ _alleganiensis_ _alleganiensis_

This large aquatic salamander, declining throughout its range, has not been recorded from Jackson County in recent years, but its presence is likely. Optimal habitats are clean, free-flowing streams with large rocks or underwater crevices to provide hiding and nesting sites. Channelization and impoundment of streams are almost certainly detrimental to hellbenders and in some cases may eliminate them entirely. The ecology and status of this remarkable animal are now under investigation by Dr. Max Nickerson, Milwaukee Public Museum.

Waterdogs - Family Necturidae

Mudpuppy - _Necturus_ _maculosus_ _maculosus_

Occurs in the Tennessee River and several of its tributaries in Jackson County. Usually collected by fishing at night. Channelization and "snagging" are detrimental to this animal, as are most forms of water pollution.

Newts - Family Salamandridae

Red-spotted Newt - Notopthalmus viridescens viridescens

Records are lacking, but this form is almost certainly present in the county. Woodland pools and ponds, especially those without fish, are the most favorable habitats, but some other aquatic environments, such as streams, may support newt populations.

Mole Salamanders - Family Ambystomatidae

Members of this family breed almost altogether in temporary pools and ponds that fill during winter and spring rains. Alterations which drain or fill such places are extremely detrimental to these animals and entire populations can be eliminated by depriving them of their breeding sites. They cannot breed in ponds stocked with predatory fish.

Spotted Salamander - Ambystoma maculatum

Locally common where breeding sites are available nearby. It is a woodland species.

Small-mouthed Salamander - Ambystoma texanum

Occurs in the Tennessee Valley eastward at least to Marshall County. It is not recorded from Jackson County, but it can easily escape detection because of its secretive nature. It should be considered problematical.

Marbled Salamander - Ambystoma opacum

Inhabits wooded floodplains and is locally common in the county.

Eastern Tiger Salamander - Ambystoma tigrinum tigrinum

A secretive, burrowing form, seldom encountered except at the breeding sites. Although there are no records from Jackson County, its presence is a virtual certainty. Tolerates land-clearing better than most other members of its genus.

Woodland Salamanders - Family Plethodontidae

Norther Dusky Salamander - *Desmognathus fuscus fuscus*

Common throughout the county along small shaded watercourses, springs, and seepage areas. Probably the most common salamander in Jackson County.

Appalachian Seal Salamander - *Desmognathus monticola monticola*

A form inhabiting the margins of small, rocky streams, this salamander occurs locally in Jackson County. Records from north of the Tennessee River are confined to a few small tributaries of the Paint Rock River near the Tennessee-Alabama boundary.

Blue Ridge Mountain Salamander - *Desmognathus ochrophaeus* ("*D. ocoee*")

Initially reported in Alabama from near Higdon in Jackson County by Valentine (1961), this species has now been recorded from several other Sand Mountain localities by Folkerts (1968). This form is restricted to shaded, wet cliff faces, especially near waterfalls.

Zigzag Salamander - *Plethodon dorsalis dorsalis*

A small, completely terrestrial salamander of the shaded forest floor, this form is common throughout most of the county where suitable habitat permits its existence. Land-clearing and tree harvesting by clear-cutting are thought to be detrimental to this salamander.

Slimy Salamander - Plethodon glutinosus

Common throughout the county, where it lives in forested areas. Capable of surviving in drier habitats than most salamanders of Alabama. Does not need water to breed.

Spring Salamander - Gyrinophilus porphyriticus porphyriticus

Local in Jackson County below the Tennessee River. Inhabits springs and small brooks in moist woods. Likely to be found near the edge of Sand Mountain in the vicinity of waterfalls.

"Tennessee Cave Salamander" - Gyrinophilus palleucus ssp.

This aquatic salamander is known in Alabama from a few caves north of the Tennessee River, including McFarland's Cave, Lim Rock Blowing Cave, Jessee Elliot Cave, Blowing Cave, and Saltpeter Cave in Jackson County. The last two are the lower and upper entrances respectively of a cave system in the base of Cave Mountain on the edge of North Sauty Creek. The Jackson County specimens are intergrades between the subspecies G. p. palleucus and G. p. necturoides (Brandon, 1966). This salamander listed in Rare and Endangered Vertebrates of Alabama (1972).

Northern Red Salamander - Pseudotriton ruber ruber

Common in most of the moist, forested habitats in Jackson County. Breeds in springs and small streams.

Green Salamander - Aneides aeneus

An inhabitant of moist cliff faces and rock exposures, this salamander spends most of its daylight hours secreted in narrow crevices. Exposing its habitats to full sunlight for long periods of the day by cutting the sheltering trees is detrimental to this species. A completely terrestrial species, the cliff salamander nests in rock crevices or, less frequently, in rotting trees. It is locally common in Jackson County.

Long-tailed Salamander - Eurycea longicauda longicauda

A species usually associated with damp woodlands in the vicinity of creeks and springs, which apparently serve as breeding sites. Locally common in Jackson County.

Cave Salamander - Eurycea lucifuga

Inhabits damp, rocky woodlands, where it is most common in the vicinity of caves, bluffs, and coves. Locally common in Jackson County.

Two-lined Salamander - Eurycea bislineata ssp.

A common salamander in Jackson County, where it may be found around small streams, springs, and seepages in forested areas. The subspecific allocation of the Jackson County populations, as well as most others in Alabama, must await a taxonomic reconsideration of the species complex.

Four-toed Salamander - Hemidactylium scutatum

Not recorded from Jackson County but may occur there. An elusive species, it is found around boggy areas and woodland pools. It is not known to be abundant anywhere in Alabama.

Reptiles - Class Reptilia

Turtles - Order Testudinata

Snapping Turtles - Family Chelydridae

Alligator Snapping Turtle - Macroclemys temmincki

Occurs infrequently in streams in the Tennessee River system but has not been reported in Jackson County. Its occurrence in the county is questionable.

Snapping Turtle - _Chelydra serpentina_

Common in Jackson County, where it occurs in a variety of permanently aquatic habitats.

Mud and Musk Turtles - Family Kinosternidae

Common Musk Turtle (Stinkpot) - _Sternothaerus odoratus_

A common turtle in Jackson County, occurring in ponds, lakes, and sluggish streams.

Stripe-necked Musk Turtle - _Sternothaerus minor peltifer_

This predominantly stream-dwelling turtle is uncommon in Jackson County.

Eastern Mud Turtle - _Kinosternon subrubrum subrubrum_

A fairly common resident of the county, this turtle inhabits ponds, lakes, and swamps. It is seldom found in streams.

Common Turtles - Family Testudinidae

Eastern Box Turtle - _Terrapene carolina carolina_

A common terrestrial turtle in Jackson County, preferring wooded or partially wooded habitats.

Map Turtle - _Graptemys geographica_

A stream-dwelling species, the map turtle may be found in the Tennessee River and some of its tributaries in Jackson County. The adult females feed almost exclusively on molluscs.

Ouachita False Map Turtle - *Graptemys pseudogeographica oauchitensis*

Common in Jackson County, but confined to the Tennessee River.

Painted Turtle - *Chrysemys picta dorsalis* X *marginata*

Common in the Tennessee River and in some of the ponds and backwater lakes in Jackson County. As is indicated by the scientific name, the Jackson County populations are intergradient between two subspecies.

Pond Slider - *Pseudemys scripta* ssp.

Common in the Tennessee River and in many other permanently aquatic habitats in Jackson County. The populations of the area have been placed in the subspecies *P. s. troosti*, but Davidson (1971) has recently questioned the validity of that subspecies.

River Cooter - *Pseudemys concinna concinna*

Fairly common in the Tennessee River in Jackson County. Not known to occur in other streams within the county.

Softshell Turtles - Family Trionychidae

Midland Smooth Softshell - *Trionyx muticus muticus*

Occurs in Jackson County in the Tennessee River where it is fairly common.

Eastern Spiny Softshell - *Trionyx spiniferus spiniferus*

Infrequent in the Tennessee River and possibly other streams in Jackson County.

Snakes and Lizards - Order Squamata

Iguanid Lizards - Family Iquanidae

Green Anole - *Anolis carolinensis carolinensis*

Uncommon in Jackson County below the Tennessee River, rare above the river. Mostly arboreal, feeds on a variety of insects.

Northern Fence Lizard - *Sceloporus undulatus hyacinthinus*

Common in forested areas and woodlots throughout the county.

Whiptail Lizards - Family Teidae

Six-lined Racerunner - *Cnemidophorus sexlineatus sexlineatus*

Common in the county, where it frequents open areas such as field roads, roadside right of ways, and weedy waste places.

Lateral-fold Lizards - Family Anguidae

Eastern Slender Glass Lizard - *Ophisaurus attenuatus longicaudus*

Infrequent in the county. Occurs in a variety of habitats but most likely to be found in weedy forest-edge habitat and waste places.

Skinks - Family Scincidae

Ground Skink - *Scinella laterale*

Common in forest communities throughout the county. A ground-dwelling species.

Five-lined Skink - *Eumeces fasciatus*

The most abundant "blue-tailed lizard" in Jackson County, this skink is found chiefly in forested areas and along watercourses.

Broad-headed Skink - Eumeces laticeps

Uncommon in the county, this skink tends to be arboreal and inhabits forested areas with large trees and those which have cavities. Land-clearing, conversion of hardwood forests to pine, and removal of "wolf trees" and den trees from timber stands are particularly detrimental to this species.

Southeastern Five-lined Skink - Eumeces inexpectatus

A "Blue-tailed lizard" of ridge tops and dry woods. Infrequent in most of Jackson County.

Common Snakes - Family Colubridae

Eastern Smooth Earth Snake - Virginia valeriae valeriae

Although not reported from Jackson County, this small, forest-floor snake is thought to occur there.

Northern Red-bellied Snake - Storeria occipitomaculata occipitomaculata

Occurs infrequently in Jackson County, where it inhabits forested areas and waste places and hides under rocks, logs, and piles of debris.

Brown Snake - Storeria dekayi dekayi X wrightorum

A common snake in Jackson County, this species is found in a variety of habitats, including open forests, forest-edges, and waste places. It also occurs in residential areas in cities and towns, and is capable of maintaining itself in vacant lots, weedy lawns, and parks.

Midland Water Snake - Natrix sipedon pleuralis

Common in most kinds of permanently aquatic habitats in Jackson County. Usually termed "water moccasin" by residents.

Yellow-bellied Water Snake - <u>Natrix erythrogaster flavigaster</u>

Infrequent in Jackson County, this snake occurs in streams and around the margins of lakes and ponds, especially if they are tree-lined.

Queen Snake - <u>Regina</u> (=<u>Natrix</u>) <u>septemvittata</u>

Common in the Tennessee River and most other streams in Jackson County. Feeds almost exclusively on crawfish and requires overhanging vegetation.

Eastern Garter Snake - <u>Thamnophis sirtalis sirtalis</u>

Abundant in Jackson County, where it occurs in most kinds of terrestrial habitats. Especially favored are forest-edges, stream-edges, and waste places.

Eastern Ribbon Snake - <u>Thamnophis sauritis sauritis</u>

Relatively common in Jackson County, this semi-aquatic form is found most frequently in the vicinity of water. Stream-edge habitat is favored, along with marshy places and the weedy or brushy margins of ponds and lakes.

Eastern Hog-nosed Snake - <u>Heterodon platyrhinos</u>

Relatively common in the county, this snake prefers open woods, fields, and waste places. Feeds almost exclusively on toads. Called "spreading-adder" by local residents.

Ring-necked Snake - <u>Diadophis punctatus</u> ssp.

One of the most common snakes in Jackson County, this species is found in forested areas, forest-edges, and waste places. It hides beneath rocks, logs, and piles of debris. The Jackson County populations are derived from an intermixture of three subspecies - punctatus, edwardsi, and stictogenys.

Worm Snake - Carphophis amoenus ssp.

This worm snake is common in the county and is usually found hiding under logs, rocks, and piles of debris in forested areas. The populations above the Tennessee River in Jackson County are predominantly C. a. amoenus in genetic constitution, those below mostly C. a. helenae.

Northern Black Racer - Coluber constrictor constrictor

Common in the county in waste places, old fields, open forests, and forest-edge habitat.

Eastern Coachwhip - Masticophis flagellum flagellum

Not recorded from Jackson County but thought to be present in small numbers below the Tennessee River. This snake has not been found above the Tennessee River in Alabama. Favored habitats are dry, open woods and broken terrain, especially where the soil is sandy.

Rough Green Snake - Opheodrys aestivus

Common in Jackson County, where it occurs in a variety of habitats. Especially favored are heavily vegetated margins of streams and lakes.

Northern Pine Snake - Pituophis melanoleucas melanoleucas

This large snake, rare throughout much of its range, persists in considerable numbers on Sand Mountain and on the Cumberland Plateau of Jackson County.

Rat Snake - <u>Elaphe obsoleta obsoleta</u> X <u>spiloides</u>

Common in the county around waste places, old-house sites, and in other habitats where small rodents are likely to abound. Most terrestrial habitats with at least some cover can support rat snake populations.

Corn Snake - <u>Elaphe guttata guttata</u>

Relatively common in Jackson County, this largely nocturnal species is most likely to be found in areas where small rodents are abundant. Abandoned farm land offers optimal habitat.

Northern Scarlet Snake - <u>Cemophora coccinea copei</u>

Infrequent in Jackson County above the Tennessee River, relatively common below the river. This secretive snake is seldom encountered except at night.

Scarlet Kingsnake - <u>Lampropeltis triangulum elapsoides</u>

Not recorded from Jackson County but thought to occur there in small numbers. A small, secretive snake, it is mostly noctural in habits.

Milk Snake - <u>Lampropeltis triangulum triangulum</u> X <u>syspi</u>

Milk snakes have been collected in Jackson County from both sides of the Tennessee River but are uncommon in the area. The Jackson County milk snakes apparently prefer dry habitats with rock outcrops, such as the tops of the bluffs overlooking the Tennessee River. The population is intergradient between the eastern milk snake and red milk snake, as is indicated by the scientific name applied. The red milk snake is listed in <u>Rare and Endangered Vertebrates of Alabama</u> (1972). The subspecific status of the Jackson County population had not been determined at the time the list was prepared.

Mole Snake - Lampropeltis calligaster rhombomaculata

Although records of this secretive species from Jackson County are lacking, it is thought to occur there. It is a nocturnal, burrowing form, usually found in forested or broken terrain.

Black Kingsnake - Lampropeltis getulus niger

Common throughout the county where there is sufficient cover to permit the development of populations of small rodents and other small reptiles. Old house places, abandoned farms, and damp woods are favored habitats.

Southeastern Crowned Snake - Tantilla coronata coronata

Common on the tops of ridges and other dry, forested habitats in Jackson County. Usually found under rocks or in rotting pine logs.

Pit Vipers - Family Viperidae, Subfamily Crotalinae

Northern Copperhead - Agkistrodon contortrix mokeson

Common in forested areas and broken farmland throughout the county. The populations below the Tennessee River show some influence from the southern copperhead, A. c. contortrix.

Eastern Cottonmouth - Agkistrodon piscivorus piscivorus

Not recorded from Jackson County but thought to be present in small numbers in some of the low, swampy habitats in the Tennessee Valley portion. Nearest authenticated records are from DeKalb and Limestone Counties.

Carolina Pigmy Rattlesnake - Sistrurus miliarius miliarius

Not recorded from Jackson County but thought to be present in small numbers in some of the upland portions above and below the Tennessee River.

Canebrake (Timber) Rattlesnake - Crotalus horridus horridus X atricaudatus

Fairly common in some of the more remote areas of the county. Prefers heavily forested terrain and old house places and abandoned farms surrounded by forests.

Doubtful Form

Mud Salamander - Pseudotriton montanus ssp.

Although this salamander is often stated to occur in northern Alabama, only one has been recorded and this one from Calhoun County. Until additional evidence is obtained to suggest its occurrence in extreme northeastern Alabama, it should be regarded doubtful for Jackson County.

REFERENCES FOR APPENDIX B2

1. Qualitative assessment of plant-waterfowl relationship based on information taken from following sources:

Fassett, N. C. 1957. A Manual of Aquatic Plants. U. Wisc. Press.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Plants. McGraw Hill, New York.

Rawls, C. K., Jr., Circu. 1958. Reelfoot Lake Waterfowl Research. Tennessee Game and Fish Commission.

Bibliography for Reptiles and Amphibians Section

Catalogue of North American amphibians and reptiles. (1963 et seq.) Am. Soc. of Ichth. and Herp. and Soc. for the study of Amph. and Rept. 125 acct.

Rare and endangered vertebrates of Alabama. (1972) Alabama Dept. of Cons. and Nat. Res., Game and Fish Division, 92 pp.

Bishop, S. C. (1943) Handbook of salamanders. The salamanders of the United States, Canada, and of Lower California. Comstock Publ. Co., Ithaca, New York. 555 pp.

Brandon, R. A. (1966) Systematics of the salamander genus Gyrinophilus. Illinois Biol. Monogr., 35:1-86.

Carr, A. F., Jr. (1952) Handbook of turtles. The turtles of the United States, Canada, and Baja California. Cornell Univ. Press, Ithaca, New York. 542 pp.

Davidson, John M. (1971) Geographic variation in the pond slider, Pseudemys scripta, in Alabama. M.S. Thesis, Auburn University, 56 pp.

Folkerts, George W. (1968) The genus Desmognathus Baird (Amphibia: Plethodontidae) in Alabama. Ph.D. Dissertation, Auburn University, 129 pp.

Smith, H. M. (1946) Handbook of lizards. Comstock Publ. Co., Ithaca, New York. 557 pp.

Valentine, B. D. (1961) Variation and distribution of Desmognathus ocoee Nichols. Copeia 1961:315-322.

Wright, A. H. and Anna H. Wright. (1949) Handbook of frogs and toads of the United States and Canada. Comstock Publ. Co., Ithaca, New York. 640 pp.

________. (1957) Handbook of snakes of the United States and Canada. 2 Vol. Cornell Univ. Press, Ithaca, New York. 1,105 pp.

Table B2-1

Rare and Endangered Vertebrates of Jackson County[a]

Species	Rare-1[b]	Rare-2[b]	Endangered[b]
Southeastern Shrew	X		
Southeastern Myotis		X	
Hoary Bat		X	
Indiana Myotis			X
Sharpshinned Hawk		X	
Cooper Hawk		X	
Golden Eagle		X	
Bald Eagle			X
Osprey			X
Peregrine Falcon			X
Bewick's Wren		X	
Ruffed Grouse			X
Red Milk Snake		X	
Tennessee Cave Salamander			X

a. From Rare and Endangered Vertebrates of Alabama, Alabama Department of Conservation and Natural Resources, Div. of Game and Fish, June 1972.

b. Rare-1: A rare species or subspecies that, although not presently threatened with extinction, is in such small numbers that it may be endangered if its environment worsens.

Rare-2: A species or subspecies that may be quite abundant where it occurs, but is known in only a few localities or in a restricted habitat within Alabama.

Endangered: An y species or subspecies occurring in Alabama threatened with extinction through (a) the destruction, drastic modification, or severe curtailment of its habitat; (b) its over-utilization for commercial or sporting purposes; (c) the effect on it of disease or predation; or (d) other natural or man-made factors affecting its continued existence.

Table B2-2

MAMMALS LIKELY TO BE FOUND ON THE BELLEFONTE NUCLEAR PLANT SITE[1] AND THOSE WITH RANGES ENCOMPASSING THE JACKSON COUNTY AREA

Common Name	Scientific Name
Virginia Opossum*	Didelphis virginiana
Eastern Mole*	Scalopus aquaticus
Least Shrew*	Cryptotis parva
Shorttail Shrew*	Blarina brevicauda
Southeastern Shrew	Sorex longirostris
Small Short-Tailed Shrew	Cryptotis parva
Smokey Shrew	Sorex fumeus
Keen Myotis	Myotis keeni
Little Brown Myotis	Myotis lucifugus
Indiana Myotis[2]	Myotis sodalis
Southeastern Bat	Myotis austroriparius
Gray Myotis*	Myotis grisescens
Evening Bat*	Nycticeius humeralis
Eastern Pipistrel*	Pipistrellus subflovus
Big Brown Bat*	Eptesicus fuscus
Red Bat*	Lasiurus borealis
Hoary Bat	Lasiurus cinereus
Silver-Haired Bat*	Lasionycteris noctivagans
Eastern Big-Eared Bat	Corynorhinus macrotis
Raccoon*	Procyon lotor
Lontail Weasel*	Mustela frenata
River Otter*	Lutra canadensis
Shorttail Weasel	Mustela erminea
Mink*	Mustela vison
River Otter	Lutra canadensis
Spotted Skunk*	Spilogale putorius
Striped Skunk*	Mephitis mephitis
Red Fox*	Vulpes fulva
Coyote*	Canis latrans
Gray Fox*	Urocyon cinereoargenteus
Bobcat*	Lynx rufus
Woodchuck*	Marmota monax
Eastern Chipmunk*	Tamias striatus
Eastern Gray Squirrel*	Sciurus carolinensis
Eastern Fox Squirrel*	Sciurus niger
Southern Flying Squirrel*	Glaucomys volans
Beaver*	Castor canadensis
Eastern Harvest Mouse*	Reithrodontomys humulis
White-Footed Mouse*	Peromyscus leucopus
Golden Mouse*	Peromyscus nuttalli
Deer Mouse*	Peromyscus maniculatus
Cotton Mouse*	Peromyscus gossypinus
Rice Rat*	Oryzomys palustris
Hispid Cottonrat*	Sigmodon hispidus
Eastern Woodrat*	Neotoma floridana
Southern Bog Lemming	Synaptomys cooperi
Oldfield Mouse	Peromyscus polionotus

Table B2-2 (continued)

Common Name	Scientific Name
Prairie Vole*	Pedomys ochrogaster
Pine Vole*	Pitymys pinetorum
Muskrat*	Ondatra zibethica
Norway Rat*	Rattus norvegicus
Cotton Rat	Sigmodon hispidus
Black Rat	Rattus rattus
House Mouse*	Mus musculus
Eastern Cottontail*	Sylvilagus floridanus
Swamp Rabbit*	Sylvilgus aquaticus
White-Tailed Deer*	Odocoileus virginianus
Feral Domestic Dog	Canis familiaris
Feral Domestic Cat	Felis domestica

1. Species determination based on information taken from a Field Guide to the Mammals by Burt and Mammals of Wheeler National Wildlife Refuge, Bureau of Sport Fisheries and Wildlife.

2. Endangered species as listed by USFWS, Office of Rare and Endangered Species.

*Asterisk denotes those species found on Wheeler National Wildlife Refuge.

Table B2-3

A CHECKLIST OF BIRDS WHOSE RANGES INCLUDE

THE BELLEFONTE NUCLEAR PLANT SITE[1]

Common Name	S	S	F	W	Scientific Name
Common Loon	u		u	u	Gavia immer
Horned Grebe			u	u	Podiceps auritus
Pied-billed Grebe*	c	r	c	u	Podilymbus podiceps
White Pelican	o		o	o	Pelecanus erythrorhynchos
Anhinga	r	r			Anhinga anhinga
Double-crested Cormorant			r	r	Phalacrocorax auritus
Great Blue Heron	c	u	c	c	Ardea herodias
Green Heron*	c	c	u		Butorides virescens
Louisiana Heron	r	r			Hydranassa tricolor ruficolis
Little Blue Heron	c	c			Florida caerulea
Common Egret	c	c	u	r	Casmerodius albus
Snowy Egret	u	c			Leucophoyx thula thula
Cattle Egret	c	c	u	r	Bubulcus ibis
Black-crowned Night Heron	c	c	c	u	Nycticorax nycticorax
Yellow-crowned Night Heron*	c	c	u		Nyctanassa violacea
Least Bittern*	u	u	r		Ixobrychus exilis
American Bittern	u		u		Botaurus lentiginosus
Glossy Ibis		r			Plegadis chihi
Wood Ibis		o	o		Mycteria americana
White Ibis	o	o	o		Eudocimus albus
Whistling Swan	o	o		o	Olor columbianus
Canada Goose	u	u	a	a	Branta canadensis
Snow Goose	r		c	c	Chen hyperborea
Brant	r			r	Branta lernicla
Blue Goose	r		c	c	Chen caerulescens
Mallard*	u	u	c	c	Anas platyrhynchos
Black Duck*	u	u	c	c	Anas rubripes
Gadwall	u		c	c	Anas strepera
Pintail	r		c	c	Anas acuta
Cinnamon Teal	r			r	Anas cyanoptera cyanoptera
Green-winged Teal	r		c	c	Anas carolinensis
Blue-winged Teal	c	r	c	u	Anas discors
American Widgeon	u		c		Mareca americana
Shoveler	c		c	c	Spatula clypeata
Wood Duck*	c	c	c	c	Aix sponsa
Redhead	r		u	u	Aythya americana
Ring-necked Duck	u		c	c	Aythya collaris
Canvasback	u		u	u	Aythya valisineria
Greater Scaup			o	o	Aythya marila
Lesser Scaup	u		c	c	Aythya affinis
Common Goldeneye			u	u	Bucephala clangula
Bufflehead	r		u	c	Bucephala albeola
Oldsquaw			u	u	Clangula hyemalis
White-winged Scoter				o	Melanitta fusca deglandi
Common Scoter		r			Oidemia nigra

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
urkey Vulture	u	u	u	u	Cathartes aura
lack Vulture*	u	u	u	u	Coragyps atratus
ississippi Kite	o		o		Ictinia misisippiensis
harp-shinned Hawk	u	u	c	c	Accipiter striatus
ooper's Hawk*	c	o	c	c	Accipiter cooperii
ed-tailed Hawk*	u	u	c	c	Buteo jamaicensis
ed-shouldered Hawk*	c	c	c	c	Buteo lineatus
road-winged Hawk	r		u		Buteo platypterus
ough-legged Hawk				o	Buteo lagopus
olden Eagle			r		Aquila chrysaetos
ald Eagle[2]	r	r	r	r	Haliaeetus leucocephalus
arsh Hawk	u		c	c	Circus cyaneus
wainson's Hawk			r		Buteo swainsonii
sprey	r	r	r	r	Pandion haliaetus
eregrine Falcon	r		r	r	Falco peregrinus
igeon Hawk	r		u	u	Falco columbaris
parrow Hawk*	c	c	c	c	Falco sparverius
ingnecked Pheasant*	u	u	u	u	Phasianus colchicus torquatus
obwhite*	c	c	c	c	Colinus virginianus
urkey	r	r	r	r	Meleagris gallopavo
andhill Crane	o		o	x	Grus canadensis
ing Rail*	c	c	u		Rallus elegans
irginia Rail	u	r	u		Rallus limicola
ora	u		c		Prozana carolina
ellow Rail			r		Coturnicops noveboracensis
urple Gallinule	r	r			Porphyrula martinica
ommon Gallinule	o	o	o		Gallinula chloropus
merican Coot	c	u	c	c	Fulica americana
emipalmated Plover	c		u		Charadrius semipalmatus
illdeer*	c	c	c	c	Charadruis vociferus
olden Plover	u		u		Pluvialis dominica
lack-bellied Plover	u		u		Squatarola scuatarola
uddy Turnstone	r		u		Arenaria interpres
himbrel	r		o		Numenius phaeopus
merican Woodcock*	u	u	u	u	Philohela minor
ommon Snipe	c		c	u	Capella gallinago
pland Plover	u		u		Bartramia longicauda
potted Sandpiper	c	c	c		Actitis mucularia
olitary Sandpiper	c		c		Tringa solitaria
aird's Sandpiper	r			r	Erolia bairdii
illet	o	o	o		Catoptrophorus semipalmatus
reater Yellowlegs	a		a	u	Totanus melanoleucus
esser Yellowlegs	a		a		Totanus flavipes
ectoral Sandpiper	c		c		Erolia melanotos
hite-rumped Sandpiper	o		o		Erolia fuscicollis

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Knot			o		Calidris canutus
Least Sandpiper	c	u	c	u	Erolia minutilla
Dunlin			u		Erolia alpina
Short-billed Dowitcher	o		o		Limnodromus griseus
Long-billed Dowitcher	x		o		Limnodromus scolopaceus
Stilt Sandpiper			u		Micropalama himantopus
Semipalmated Sandpiper	c		c		Ereunetes pusillus
Western Sandpiper	u		u		Ereunetes mauri
Buff-breasted Sandpiper			o		Tryngites subruficollis
Marbled Godwit	r				Limosa fedoa
Sanderling			u		Crocethia alba
American Avocet			o		Recurvirostra americana
Northern Phalarope				r	Lobipes lobatus
Wilson's Phalarope			r		Steganopus tricolor
Herring Gull	u		c	a	Larus argentatus
Ring-billed Gull	u		c	a	Larus delawarensis
Laughing Gull	o			o	Larus atricillas
Franklin's Gull		o		o	Larus pipixcan
Bonaparte's Gull	u		u	u	Larus philadelphia
Forster's Tern	u	u	u		Sterna forsteri
Common Tern	u	u	u		Sterna hirundo
Caspian Tern	u	u	u		Hydroprogne caspia
Sooty Tern		r			Sterna fuscata
Least Tern	u	u			Sterna albifrons
Black Tern	u	u	c		Chlidonias niger
Rock Dove*	c	c	c	c	Columba livia
Mourning Dove*	c	c	a	c	Zenaidura macroura
Ground Dove	o	o	o	o	Columbigallina passerina
Yellow-billed Cuckoo*	c	c	u		Coccyzus americanus
Black-billed Cuckoo	r	r			Coccyzus erythropthalmus
Barn Owl*	u	u	u	u	Tyto alba
Screech Owl*	c	c	c	c	Otus asio
Great Horned Owl	r	r	u	u	Bubo virginianus
Barred Owl*	u	u	u	u	Strix varia
Short-eared Owl	r		r	u	Asio flammeus
Chuck-will's-Widow*	c	c	u		Caprimulgus carolinensis
Whip-poor-will	r		r		Caprimulgus vociferus
Common Nighthawk*	c	c	c		Chordeiles minor
Chimney Swift*	c	c	c		Chaetura pelagica
Ruby-throated Hummingbird*	c	c	c		Archilochus colubris
Belted Kingfisher*	u	u	u	u	Megaceryle alcyon
Yellow-shafted Flicker*	c	c	c	c	Colaptes auratus
Pileated Woodpecker*	u	u	u	u	Dryocopus pileatus
Red-bellied Woodpecker*	c	c	c	c	Centurus carolinus
Red-headed Woodpecker*	c	c	u	r	Melanerpes erythrocephalus

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Yellow-bellied Sapsucker	u		c	c	_Sphyrapicus varius_
Hairy Woodpecker*	c	c	c	c	_Dendrocopos villosus_
Downy Woodpecker*	c	c	c	c	_Dendrocopos pubescens_
Eastern Kingbird*	c	c	c		_Tyrannus tyrannus_
Great-crested Flycatcher*	c	c	u		_Myiarchus crinitus_
Eastern Phoebe*	c	u	c	c	_Sayornis phoebe_
Yellow-bellied Flycatcher			r		_Empidonax flaviventris_
Acadian Flycatcher	c	c	u		_Empidonax virescens_
Traill's Flycatcher	o	o	o		_Empidonax traillii_
Least Flycatcher	u		u		_Empidonax minimus_
Eastern Wood Pewee*	c	c	u		_Contopus virens_
Olive-sided Flycatcher	o		o		_Nuttallornis borealis_
Vermilion Flycatcher			r		_Pyrocephalus rubinus_
Horned Lark*	u	u	c	c	_Eremophila alpestris_
Tree Swallow*	u		u		_Iridoprocne bicolor_
Bank Swallow	u	u	u		_Riparia riparia_
Rough-winged Swallow*	a	c	a		_Stelgidopteryx ruficollis_
Barn Swallow*	a	c	a		_Hirundo rustica_
Cliff Swallow	u		u		_Petrochelidon pyrrhonota_
Purple Martin*	c	c	a		_Progne subis_
Blue Jay*	c	c	c	c	_Cyanocitta cristata_
Common Crow*	c	c	a	a	_Corvus brachyrhynchos_
Carolina Chickadee*	c	c	a	a	_Parus carolinensis_
Tufted Titmouse*	c	c	a	a	_Parus bicolor_
White-breasted Nuthatch	u		u	u	_Sitta carolinensis_
Red-breasted Nuthatch (erratic)	r		u	u	_Sitta canadensis_
Brown Creeper			r	r	_Certhia familiaris_
House Wren	u	u	u		_Troglodytes aedon_
Winter Wren			u	u	_Troglodytes troglodytes_
Bewick's Wren	r	r	c	c	_Thryomanes bewickii_
Carolina Wren*	c	c	c	c	_Thryothorus ludovicianus_
Long-billed Marsh Wren			u		_Telmatodytes palustris_
Short-billed Marsh Wren	r		u	u	_Cistothorus platensis_
Mockingbird*	c	c	c	c	_Mimus polyglottos_
Catbird*	c	c	c	u	_Dumetella carolinensis_
Brown Thrasher*	c	c	c	u	_Toxostoma rufum_
Robin*	u	u	c	c	_Turdus migratorius_
Wood Thrush*	c	c	c		_Hylocichla mustelina_
Hermit Thrush			c	c	_Hylocichla guttata_
Swainson's Thrush	u		u	r	_Hylocichla ustulata_
Gray-cheeked Thrush	u		u	r	_Hylocichla minima_
Veery	u		r		_Hylocichla fuscescens_
Eastern Bluebird*	u	u	u	r	_Sialia sialis_
Blue-gray Gnatcatcher	c	r	c		_Polioptila caerulea_
Golden-crowned Kinglet					_Regulus satrapa_

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Ruby-crowned Kinglet	u		c	c	Regulus calendula
Water Pipit	u		c	c	Anthus spinoletta
Cedar Waxwing (erratic)	u		u	c	Bombycilla cedrorum
Loggerhead Shrike*	u	u	u	u	Lanius ludovicianus
Starling*	c	c	a	a	Sturnus vulgaris
White-eyed Vireo	c	c	u		Vireo griseus
Yellow-throated Vireo	c	c	u		Vireo flavifrons
Solitary Vireo			u		Vireo solitarius
Red-eyed Vireo*	c	c	u		Vireo olivaceus
Philadelphia Vireo					Vireo philadelphicus
Warbling Vireo			r	r	Vireo gilvus
Black-and-White Warbler	c	c	c		Mniotilta varia
Prothonotary Warbler*	c	u			Protonotaria citrea
Swainson's Warbler (tower kill)	r	r			Limnothlypis swainsonii
Worm-eating Warbler	r	r			Helmitheros vermivorus
Golden-winged Warbler	r				Vermivora chrysoptera
Blue-winged Warbler	r				Vermivora pinus
Tennessee Warbler	u		u		Vermivora peregrina
Orange-crowned Warbler	r		r		Vermivora celata
NashvilleWarbler			u		Vermivora ruficapilla
Parula Warbler	r	r	r		Parula americana
Yellow Warbler	c	u	c		Dendroica petechia
Magnolia Warbler	u		u		Dendroica magnolia
Cape May Warbler	u		u		Dendroica tigrina
Black-throated Blue Warbler	r				Dendroica caerulescens
Myrtle Warbler	c		c	u	Dendroica coronata
Black-throated Green Warbler	c		c		Dendroica virens
Cerulean Warbler	u		u		Dendroica cerulea
Blackburnian Warbler	u		u		Dendroica fusca
Yellow-throated Warbler	c		c		Dendroica dominica
Chestnut-sided Warbler	r		r		Dendroica pensylvanica
Bay-breasted Warbler	u		r		Dendroica castanea
Blackpoll Warbler	u				Dendroica striata
Pine Warbler	c	u	u	u	Dendroica pinus
Prairie Warbler	c	u	c		Dendroica discolor
Palm Warbler	c		u		Dendroica palmarum
Ovenbird	c		u		Seiurus aurocapillus
Northern Waterthrush	c		c	r	Seiurus noveboracensis
Louisiana Waterthrush	u	c			Seiurus motacilla
Kentucky Warbler	u	u			Oporornis formosus
Connecticut Warbler	r				Oporornis agilis
Mourning Warbler	r		r		Oporornis philadelphia
Yellowthroat*	c	c			Geothlypis trichas
Yellow-breasted Chat*	c	c			Icteria virens
Hooded Warbler	c	c	u		Wilsonia citrina

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Wilson's Warbler	r		r		*Wilsonia pusilla*
Canada Warbler	r		u		*Wilsonia canadensis*
American Redstart	a	c	u		*Setophaga ruticilla*
House Sparrow*	c	c	c	c	*Passer domesticus*
Bobolink	c		u		*Dolichonyx oryzivorus*
Eastern Meadowlark*	c	c	c	c	*Sturnella magna*
Western Meadowlark	r				*Sturnella neglecta*
Red-winged Blackbird*	c	c	a	a	*Agelaius phoeniceus*
Orchard Oriole*	c	c			*Icterus spurius*
Baltimore Oriole	r		r		*Icterus galbula*
Rusty Blackbird	u		c	a	*Euphagus carolinus*
Brewer's Blackbird			u	u	*Euphagus cyanocephalus*
Common Grackle*	c	c	a	a	*Quiscalus quiscula*
Brown-headed Cowbird	u	u	a	a	*Molothrus ater*
Scarlet Tanager	u		r		*Piranga olivacea*
Summer Tanager*	c	c	u		*Piranga rubra*
Cardinal*	c	c	c	c	*Richmondena cardinalis*
Rose-breasted Grosbeak	u	u			*Pheucticus ludovicianus*
Blue Grosbeak	u	u	u		*Guiraca caerulea*
Indigo Bunting*	c	c	u		*Passerina cyanea*
Dickcissel	u	c			*Spiza americana*
Evening Grosbeak	o		o	o	*Hesperiphona vespertina*
Purple Finch	u		u	c	*Carpodacus purpureus*
Common Redpoll				r	*Acanthis flammea*
Pine Siskin				o	*Spinus pinus*
American Goldfinch*	c	a	c	a	*Spinus tristis*
White-winged Crossbill	r			r	*Loxia leucopter*
Rufous-sided Towhee*	c	c	c	c	*Pipilo erythrophthalmus*
Savannah Sparrow	u		c	c	*Passerculus sandwichensis*
Grasshopper Sparrow*	u	c	u	r	*Ammodramus savannarum*
LeConte's Sparrow			r	r	*Passerherbulus caudacutus*
Henslow's Sparrow	r			u	*Passerherbulus henslowii*
Sharp-tailed Sparrow			r		*Ammospiza caudacuta*
Vesper Sparrow	u		u	u	*Pooecetes gramineus*
Lark Sparrow	r	r			*Chondestes grammacus*
Bachman's Sparrow	r	r			*Aimophila aestivalis*
Slate-colored Junco	u		c	a	*Junco hyemalis*
Oregon Junco				r	*Junco oreganus*
Tree Sparrow	o			o	*Spizella arborea*
Chipping Sparrow	c	u	c	c	*Spizella passerina*
Field Sparrow*	c	c	c	a	*Spizella pusilla*
White-crowned Sparrow	u		u	c	*Zonotrichia leucophrys*
White-throated Sparrow	u		c	c	*Zonotrichia albicollis*
Fox Sparrow	u		u	c	*Passerella iliaca*
Harris Sparrow				r	*Zonotrichia querula*

Table B2-3 (continued)

Common Name	S	S	F	W	Scientific Name
Swamp Sparrow	u		c	a	*Melospiza georgiana*
Song Sparrow	u		u	c	*Melospiza melodia*
Lapland Longspur				o	*Calcarius lapponicus*

1. List compiled using Birds of Wheeler National Wildlife Refuge, USFWS Refuge Leaflet 145-R4, 1969, and Alabama Birds by Imhof.

2. Classified as a threatened species by USFWS Office of Rare and Endangered Species.

*Birds nesting on Wheeler National Wildlife Refuge are denoted by an asterisk.

S March-May
S June-August
F September-November
W December-February

a Abundant
c Common
u Uncommon
o Occasional
r Rare

Table B2-4

STATE AND FEDERAL WATERFOWL MANAGEMENT AREAS - NORTH ALABAMA[1]

Area	Lake	Land and Water Acreage	Manager	Owner
Seven Mile Island--hunting	Pickwick	4,685	State	TVA
Mallard-Fox Creek--hunting	Wheeler	2,460	State	TVA
Swan Creek--hunting	Wheeler	6,242	State	TVA
Wheeler NWR--refuge	Wheeler	35,000	BSFW	BSFW
North Sauty Creek--refuge	Guntersville	5,200	State	TVA
Mud Creek--hunting	Guntersville	8,193	State	TVA
Crow Creek--refuge	Guntersville	2,512	State	TVA
Crow Creek--hunting	Guntersville	2,161	State	TVA
Raccoon Creek--hunting	Guntersville	7,080	State	TVA
Totals State		38,533		
Totals Federal		35,000		
Grand Total		73,533		

1. From North Alabama Land Use Plan by Klein, et al, TVA Division of Forestry, Fisheries, and Wildlife Development.

Table B2-5

PRESENT PUBLIC USE, NORTH ALABAMA STATE AND FEDERAL WATERFOWL AREAS (5-YEAR AVERAGE 1965-70)[1]

Use	Area									Total	Season Length (days)	Man-Day's Use Per Season-Day
	Seven-Mile Island	Swan Creek	Mallard-Fox	Mud Creek	Raccoon Creek	Crow Creek	Crow Creek Refuge	North Sauty Refuge	Wheeler NWR[2]			
	- - - - - - -in man-day's effort- - - - - - -											
Duck Hunting	350	10,100	2,050	700	600	100	200	300	-	14,400	40	360
Goose Hunting[3]	-	1,900	700	500	200	200	200	600	-	4,300	70	60
Upland Game Hunting	2,600	4,950	4,850	3,100	2,500	1,850	850	950	3,600	25,250	90	280
Trapping	1,500	6,200	3,800	450	350	450	-	-	-	12,750	90	140
Other Outdoor Recreation[4]	16,000	50,000	40,000	18,500	14,700	8,000	5,000	11,300	187,500	351,000	300	1,170
Total	20,450	73,150	51,400	23,250	18,350	10,600	6,250	13,150	191,100	407,700	-	-

1. From North Alabama Land Use Plan by Klein, et al, TVA Division of Forestry, Fisheries, and Wildlife Development

2. 1969-70 season only

3. For that part outside duck hunting season

4. Fishing, artifact hunting, picnicking, camping, birding, etc.

Table B2-6

Partial list of aquatic macrophytes near the proposed Bellefonte Nuclear Plant Site, Guntersville Reservoir[1]

Waterfowl* Cover	Waterfowl* Food	Scientific name	Common name	Growth form
7	6	Myriophyllum spicatum	Eurasian watermilfoil	Submersed
7	1	Ceratophyllum demersum	Coontail	Submersed
7	3	Potamogeton crispus	Crispyleaf pondweed	Submersed
7	2	Potamogeton nodosus	American pondweed	Submersed
7	4	Najas minor	Spinyleaf naiad	Submersed
7	1	Najas guadalupensis	Southern naiad	Submersed
7	6	Egeria densa	Egeria	Submersed
7	4	Elodea canadensis	Elodea	Submersed
7	2	Heteranthera dubia	Waterstargrass	Submersed
7	2	Chara sp.	Muskgrass	Submersed
3	7	Saururus cernuus	Lizardtail	Emergent
5	7	Alternanthera philoxeroides	Alligatorweed	Emergent, Floating Mat
1	3	Nelumbo lutea	American lotus	Emergent, Floating Leaf
1	2	Justicia americana	Waterwillow weed	Emergent
3	2	Eleocharis quadrangulata	Spikerush	Emergent
4	3	Eleocharis acicularis	Midget spikerush	Emergent
4	7	Ludwigia palustris	Waterpurslane	Emergent
1	5	Scirpus cyperinus	Woolgrass	Emergent
1	3	Scirpus validus	Softstem bulrush	Emergent
1	4	Scirpus americanus	Three-square	Emergent
3	4	Juncus effusus	Common bulrush	Emergent
3	5	Hibiscus militaris	Marshmallow	Emergent
2	2	Zizaniopsis miliacea	Giant cutgrass	Emergent
3	5	Polygonum sagittatum	Tear-thumb	Emergent
3	2	Polygonum hydropiperoides	Smartweed	Emergent
3	1	Polygonum pensylvanicum	Smartweed	Emergent
5	6	Echinodorus cordifolius	Burhead	Emergent
5	7	Carex sp.	Sedge	Emergent
5	5	Cyperus pseudovegetus	Sedge	Emergent
5	6	Cyperus sp.	Sedge	Emergent
2	4	Typha latifolia	Cattail	Emergent
2	4	Cephalanthus occidentalis	Buttonball	
7	3	Lemna perpusilla	Duckweed	Floating
7	2	Spirodela polyrhiza	Giant duckweed	Floating
7	4	Azolla caroliniana	Mosquito fern	Floating

*Ranking: 1 = High, 2 = Good, 3 = Fair, 4 = Low, 5 = Little, 6 = Unknown, 7 = No known use

Appendix B3

VEGETATION

1. Summary - The vegetation survey made in September 1972 encompasses an area of 1,090 acres at the proposed Bellefonte Nuclear Plant site. Boundaries of the study area are shown on the vegetation map (figure B3-1).

Acreages of the major vegetation types and their percents of the total study area are:

Type	Acreage	Percent
Cultivated land	228	21
Broom Sedge-Lespedeza	153	14
Ragweed	87	8
Elm-Ash-Soft Maple	185	17
Oak-Hickory	164	15
Mixed Conifers and Hardwoods	164	15
Black Locust	65	6
Oak-Gum	44	4

The cultivated land includes mostly fields of fescue and lespedeza, some of which have been gathered as hay in 1972. The two old field communities, broom sedge-lespedeza and ragweed, include small pockets of communities in which other species such as bitterweed or coreopsis may be dominant. Some of these enclaves may be separate communities while others may simply be manifestations of differential grazing by cattle.

Most of the forest land has been heavily logged in the last few years. The heavy logging, combined with the moderate to heavy grazing that has occurred in some strands, has been quite disruptive to the community structure. Opening up the canopy has allowed more light to filter down to the ground level with the result that average total ground cover percentages are relatively high. Similarly, the high level of grazing has tended to keep the shrub stratum percent cover comparatively low. In the table below are listed the average total percent covers for the ground vegetation and shrub stratum in each of the forest types and the percent of sampled plots that were logged in each type.

Type	Average Percent Ground Cover	Average Percent Shrub Cover	Percent of Plots Heavily Logged
Black Locust	77	10	75
Elm-Ash-Soft Maple	73	10	67
Oak-Hickory	46	17	60
Oak-Gum	45	7	0
Mixed Conifers and Hardwoods	34	24	40

With the exception of the oak-gum plots which were not cut but which are heavily grazed, there seems to be a good relationship between percent logging and total percent cover for ground vegetation. There is also an apparent inverse relationship between percent logging and percent shrub cover which at first glance seems conflicting since it might be expected that shrub cover would increase with the opening up of the canopy. At least three factors contribute to reducing the expected shrub cover level. First of all, logging is so recent that shrubs for the most part have not had time to become established in the stands. Secondly, the logging operation itself has opened up pathways to allow cattle easier entrance into the stands. Finally, the fallen brush makes ideal habitat for wildlife and encourages concentrations of deer which have been browsing heavily in the area.

As a whole, the Bellefonte site contains an average growing stock of 870 cubic feet of merchantable timber per acre and a sawtimber volume of 2,040 board feet per acre. (See Tables B3-1, B3-2, and B3-3 for a summary, broken down by hardwoods, softwoods, species, and diameter class.) These figures are below the averages of 950 cubic feet and 2,670 board feet, respectively, for Jackson County, Alabama[1] and 900 cubic feet and 3,230 board feet for the entire Tennessee River Valley.[2]

The vegetation on the plant site is typical of limestone valleys and hills throughout the region.[3,4]

Following construction of the nuclear plant, the impact area will be resurveyed periodically to assess vegetational changes. Some vegetational change is inevitable from the normal process of succession. The vegetation surveys planned as part of the scheduled monitoring program are expected to reveal any significant vegetational changes.

2. Site Description - The proposed Bellefonte Nuclear Plant site is on a peninsula, at about TRM 392, bounded by Guntersville Reservoir to the east and the Town Creek embayment to the west and north. The topography consists of river terrace and small hills. The elevation ranges from 595 feet at mean reservoir level to approximately 800 feet. Approximately 58 percent of the land is forested. The remaining portion has been used primarily for pasture and hay with fescue and lespedeza being the main crops.

Soils over the Bellefonte site show a highly mosaic pattern and do not correlate well with vegetation. Soils of the river terraces belong to the Etowah-Jefferson-Monogahela-Talbott association.

These are for the most part Alfisols and Ultisols[5] (Red-Yellow Podzols in the old Baldwin et al. classification system)[6,7] derived from limestone. Clay content is typically high. Fertility ranges from low to very high and is generally high where drainage is adequate. The cherty hills are covered by soils of the Fullerton-Clarksville-Greendale association. These soils are typically Alfisols and Ultisols derived from limestone. Fertility is low and presently the soils support only forest.

3. Field Procedures - A square grid was laid over the study area so that circular 1/5-acre plots were located at 1,035-foot intervals. Only plots falling in forest or abandoned fields were used. Thus, over the entire area 52 plots were sampled. Forested plots were permanently located so that the exact location could be resurveyed at later dates during the monitoring program. Old field plots were not permanently marked; however, their locations are noted by the intersection of the transect lines. Pole, sawtimber, and reproduction data were then collected.[8]

Four 1/100-acre subplots were located at the cardinal points around the periphery of each 1/5-acre plot. In each subject, all tree stems between 1 and 5 inches DBH were recorded and classified as "understory." All small tree species under 1 inch DBH and over 18 inches tall and all shrub species over 18 inches tall were noted and classified as "shrub stratum." Percent cover was recorded for each shrub stratum species according to the following code:

1 -- less than 5 percent

2 -- 5 to 25 percent

3 -- 26 to 50 percent

4 -- 51 to 75 percent

5 -- 76 to 95 percent

6 -- over 95 percent

In addition, the general condition of the dominant species collectively was noted with a small description given of any unusual or unhealthy patterns developing.

Beginning at the four cardinal points and moving toward the center of each plot, quadrats 10.75 feet long by 1 foot wide were established. In these quadrats the ground cover (including all tree and shrub species less than 18 inches high) was recorded by species and percent cover, and the general condition of the dominant species was noted (as was done for shrubs and small trees).

A vegetation type was subjectively determined for each plot in the field.

Data on solids were obtained from a Soil Conservation Service survey.[9]

4. Data Analysis - Plots were grouped according to the vegetation types established in the field. Within each type, frequencies were established for all species to estimate the importance of their occurrence in the type. Data from all plots in all types were then combined, and an importance value index was established for each species within each of the four vegetation strata (i.e., trees, understory, shrub stratum, and ground cover). The importance value (IV) was measured in three ways. For the trees:

$$IV = (\text{Relative Density} + \text{Relative Frequency} + \text{Relative Basal Area}) \div 3$$

where

$$\text{Relative Density} = \frac{\text{Number of trees of a single species}}{\text{Total number of all trees}} \times 100,$$

$$\text{Relative Frequency} = \frac{\text{Number of occurrences of a single species}}{\text{Total number of occurrences of all species}} \times 100,$$

$$\text{Relative Basal Area} = \frac{\text{Basal area of a single species}}{\text{Total basal area of all species}} \times 100.$$

For the understory:

$$IV = \frac{\text{Relative Density} + \text{Relative Frequency}}{2}$$

For shrub stratum and ground cover:

$$IV = \frac{\text{Relative Frequency} + \text{Relative Cover}}{2}$$

where

$$\text{Relative Cover} = \frac{\text{Percent cover of a single species summed over all subplots or quadrats}}{\text{Sum of the percent covers of all species in all subplots or quadrats}} \times 100.$$

By dividing the appropriate denominator Importance Values are assigned to a linear scale ranging from 0 to 100. Since the sum of IV's of all species within a particular stratum totals 100, each Value can be viewed as a measure of the relative percentage of importance of that species in the stratum.

Tables B3-4 through B3-7 list all of the species and their importance values in the order of the values for each of the four vegetation strata. These values will provide a simple index of change in species composition between surveys.

5. Community Types - Each plot was assigned a vegetation type in the field. The plots were then generalized to describe particular community stands, and the stands were lined out on a vegetation map of the Bellefonte site (figure B3-1). In nature, stand boundaries are generally diffuse or non-existent, and those shown on the map should not be construed as hard, permanent, and exact. The map boundaries

are merely attempts to compartmentalize and classify phenomena which are in reality continuously variable.

In some of the community types described below, percent frequencies for trees are often lower than might be expected for typical stands within the type. The reason for the lower values is that extensive logging has eliminated the merchantable timber within the stands and thereby reduced species frequencies.

(1) Elm-ash-soft maple - Twenty-nine percent of the forested plots were classified as elm-ash-soft maple. Winged elm, ash, and sweet gum were the remaining dominants in the heavily cut-over stands. These stands were found on all topographic sites within the Bellefonte region. Nine percent were in large sawtimber, 36 percent were in small sawtimber, 45 percent were in pole size stands, and 9 percent were classified as seedling and sapling stands. These figures reflect the fact that most of the forested land has been heavily logged. Species and frequencies of occurrence are listed in the table below.

Scientific Name	Common Name	Percent Frequency
Ulmus sp.	Elm	55
Fraxinus sp.	Ash	55
Liquidambar styraciflua	Sweet Gum	55
Lirodendron tulipifera	Yellow Poplar	46
Acer negundo	Box Elder	36
A. rubrum	Red Maple	36
Celtis occidentalis	Hackberry	36
Robinia pseudoacacia	Black Locust	18

Scientific Name	Common Name	Percent Frequency
Acer saccharum	Sugar Maple	18
Cercis canadensis	Redbud	18
Carya sp.	Hickory	9
Gleditsia triacanthos	Honey Locust	9
Juniperus virginiana	Eastern Red Cedar	9
Pinus taeda	Loblolly Pine	9
Quercus falcata	Southern Red Oak	9
Q. muehlenbergii	Chinquapin Oak	9
Q. prinus	Chestnut Oak	9
Salix nigra	Black Willow	9
Tilia heterophylla	Basswood	9

The dominant understory trees - elm, ash and red maple - suggested that the stands were relatively stable and regenerating themselves. Hickories, persimmon, elm, and hackberry were the more common shrub stratum species while grasses and assorted vines made up the bulk of the ground cover. Listed below are the more common species in each of the below-canopy strata, along with the percent frequencies of each.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	46
Fraxinus sp.	Ash	23
Acer rubrum	Red Maple	14
Ulmus alata	Winged Elm	11

Scientific Name	Common Name	Percent Frequency
Shrub Stratum:		
Carya sp.	Hickory	36
Diospyros virginiana	Persimmon	21
Ulmus sp.	Elm	16
Celtis sp.	Hackberry	14
Hydrangea arborescens	Wild Hydrangea	11
Berchemia scandens	Supplejack	11
Smilax rotundifolia	Catbrier	11
Vitis rotundifolia	Muscadine	11
Ground Cover:		
Poaceae	Grass	86
Parthenocissus quinquefolia	Virginia Creeper	18
Robinia pseudoacacia	Black Locust	11
Simlax rotundifolia	Catbrier	11
Vitis rotundifolia	Muscadine	11

(2) Oak-Hickory - Twenty-six percent of the forested land was classified in the oak-hickory type. These stands consisted of oaks and hickories with the more common associates including sweet gum, black locust, and sugar maple. Stands were found on moderate to well drained soils on the high terraces and hilly slopes. Twenty percent of the stands were in large sawtimber, 30 percent were in small sawtimber, 40 percent were in pole size timber, and 10 percent were in the seedling and sapling stand size. Listed below are the forest tree species and their frequencies of occurrence in the oak-hickory plots.

Scientific Name	Common Name	Percent Frequency
Quercus muehlenbergii	Chinquapin Oak	30
Q. shumardii	Shumard Oak	30
Liquidambar styraciflua	Sweet Gum	30
Carya sp.	Hickory	20
Quercus velutina	Black Oak	20
Robinia pseudoacacia	Black Locust	20
Acer saccharum	Sugar Maple	20
Fraxinus sp.	Ash	20
Quercus alba	White Oak	10
Q. coccinea	Scarlet Oak	10
Q. falcata var. *pagodaefolia*	Cherrybark Oak	10
Q. prinus	Chestnut Oak	10
Q. stellata	Post Oak	10
Tilia heterophylla	Basswood	10
Sassafras albidum	Sassafras	10
Ulmus alata	Winged Elm	10
Carpinus caroliniana	Blue Beech	10
Cercis canadensis	Redbud	10
Gleditsia triacanthos	Honey Locust	10

Ash, hickory, and elm were the most important understory species, with redbud, hickory, persimmon, and ash being the shrub stratum dominants. The ground cover was composed largely of assorted grasses, Virginia creeper, hackberry, and muscadine. The paucity of oaks in the lower strata suggested that the stands may have been moving away from a dominant oak-hickory type. Percent frequencies for the more common lower stratal species are listed below.

Scientific Name	Common Name	Percent Frequency
Understory:		
Fraxinus sp.	Ash	33
Carya sp.	Hickory	30
Ulmus sp.	Elm	23
Cornus sp.	Dogwood	18
Juniperus virginiana	Eastern Red Cedar	15
Ulmus alata	Winged Elm	15
Shrub Stratum:		
Cercis canadensis	Redbud	30
Carya sp.	Hickory	25
Diospyros virginiana	Persimmon	25
Fraxinus sp.	Ash	23
Robinia pseudoacacia	Black Locust	20
Ulmus Alata	Winged Elm	20
Vitis rotundifolia	Muscadine	18
Ground Cover:		
Poaceae	Grass	53
Parthenocissus quinquefolia	Virginia Creeper	50
Celtis occidentalis	Hackberry	33
Vitis rotundifolia	Muscadine	30
Campsis radicans	Trumpet Creeper	15

Scientific Name	Common Name	Percent Frequency
Sassafras albidum	Sassafras	13
Phytolacca americana	Poke	13
Fraxinus sp.	Ash	13

(3) Mixed Conifers and Hardwoods - Twenty-six percent of all forest stands were grouped as mixed conifers and hardwoods. These stands were found on well drained soils on all topographic sites. Some stands were dominated by red cedar, some by loblolly or Virginia pine, some by other species. The differences between plots were not significant, so for the purposes of this study they were combined into a single broad type. (Two, small, almost pure stands of pole size loblolly pine are shown in figure B3-1. Since the stands are small enough that no plots were located in them, they are not included as a separate type.)

In general, logging has been less intense in these mixed stands. Twenty percent were in large sawtimber and 60 percent were in small timber, while only 20 percent were pole size. The species found in the plots and their frequencies of occurrence are listed below.

Scientific Name	Common Name	Percent Frequency
Pinus virginiana	Virginia Pine	80
P. echinata	Shortleaf Pine	50
P. taeda	Loblolly Pine	50
Juniperus virginiana	Eastern Red Cedar	40

Scientific Name	Common Name	Percent Frequency
Liriodendron tulipifera	Yellow Poplar	40
Quercus nigra	Water Oak	30
Carya sp.	Hickory	20
Fraxinus sp.	Ash	20
Ulmus sp.	Elm	20
Cercis canadensis	Redbud	10
Maclura pomifera	Osage Orange	10
Prunus serotina	Black Cherry	10
Quercus coccinea	Scarlet Oak	10
Q. falcata	Southern Red Oak	10
Q. falcata var. *pagodaefolia*	Cherrybark Oak	10
Q. muehlenbergii	Chinquapin Oak	10
Q. stellata	Post Oak	10
Robinia pseudoacacia	Black Locust	10
Ulmus alata	Winged Elm	10

Elm, eastern red cedar, hickory, dogwood, and winged elm were the chief understory species. The shrub stratum was dominated by winged elm and redbud. Grasses and assorted vines were most prominant in the ground cover.

The mixed conifers and hardwoods type is a temporary type of diverse origins. The makeup of the understory and shrub layers suggest that the bulk of the stands will probably change toward the elm-ash-soft maple type rather than the oak-hickory type.

The more common species at each level in the community are listed below, along with their precent frequencies.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	38
Juniperus virginiana	Eastern Red Cedar	28
Carya sp.	Hickory	20
Cornus sp.	Dogwood	20
Ulmus alata	Winged Elm	20
Cercis canadensis	Redbud	18
Fraxinus sp.	Ash	18
Liquidambar styraciflua	Sweet Gum	15
Quercus muehlenbergii	Chinquapin Oak	13
Shrub Stratum:		
Ulmus alata	Winged Elm	45
Cercis canadensis	Redbud	35
Berchemia scandens	Supplejack	23
Juniperus virginiana	Eastern Red Cedar	23
Celtis occidentalis	Hackberry	23
Cornus sp.	Dogwood	23
Fraxinus sp.	Ash	23
Lonicera japonica	Japanese Honeysuckle	23
Ground Cover:		
Poaceae	Grass	55
Parthenocissus quinquefolia	Virginia Creeper	48
Berchemia scandens	Supplejack	38
Lonicera japonica	Japanese Honeysuckle	33
Cassia obtusifolia	Sicklepod	20

Scientific Name	Common Name	Percent Frequency
Celtis occidentalis	Hackberry	20
Anisostichus capreolata	Cross Vine	18
Prunus serotina	Black Cherry	18
Smilax glauca	Sawbrier	18
Ulmus alata	Winged Elm	18

(4) Black Locust - Eleven percent of all wooded stands were classified as black locust. These were found on the lower slopes and terraces on well drained soils. Half of the stands were in pole size timber while the remaining half were split equally between small sawtimber and seedling-sapling stand sizes. The frequencies of the few tree species present are listed below.

Scientific Name	Common Name	Percent Frequency
Robinia pseudoacacia	Black Locust	100
Diospyros virginiana	Persimmon	50
Celtis occidentalis	Hackberry	25
Pinus taeda	Loblolly Pine	25
Prunus serotina	Black Cherry	25

The understory was dominated by elm and hackberry with redbud and black cherry playing lesser roles. Black locust was the most important shrub stratum species while grasses almost totally dominated the ground vegetation. Below are the more common understory, shrub stratum, and ground vegetation species listed in order of their frequencies.

Scientific Name	Common Name	Percent Frequency
Understory:		
Ulmus sp.	Elm	38
Celtis occidentalis	Hackberry	31
Cercis canadensis	Redbud	19
Prunus serotina	Black Cherry	19
Quercus velutina	Black Oak	13
Sassafras albidum	Sassafras	13
Shrub Stratum:		
Robinia psuedoacacia	Black Locust	25
Carya sp.	Hickory	13
Diospyros virginiana	Persimmon	13
Lonicera japonica	Japanese Honeysuckle	13
Ground Cover:		
Poaceae	Grass	100
Campsis radicans	Trumpet Creeper	19
Polyganum sp.	Smartweed	19
Celtis occidentalis	Hackberry	13
Lonicera japonica	Japanese Honeysuckle	13
Parthenocissus quinquefolia	Virginia Creeper	13
Rubus sp.	Blackberry	13

(5) Oak-Gum - Eight percent of all sampled forest stands belonged to the oak-gum type. These stands were composed largely of cherrybark oak, water oak, and sweet gum. The stands were confined for the most part to bottom land sites on which

drainage is poor. Two-thirds of the stands were classified as small sawtimber and one-third were pole size stands. Listed below are the tree species and their percent frequencies.

Scientific Name	Common Name	Percent Frequency
Quercus falcata var. *pagodaefolia*	Cherrybark Oak	100
Q. nigra	Water Oak	67
Liquidambar styraciflua	Sweet Gum	67
Quercus phellos	Willow Oak	33
Carya sp.	Hickory	33
Celtis occidentalis	Hackberry	33
Fraxinus sp.	Ash	33
Juglans nigra	Black Walnut	33

Oaks, hackberry, and elm were typical understory dominants. Hickory and supplejack were characteristic shrub stratum species; while grasses, supplejack, and hackberry were most common in the ground vegetation. Species and frequencies in each stratum are listed below.

Scientific Name	Common Name	Percent Frequency
Understory:		
Quercus falcata var. *pagodaefolia*	Cherrybark Oak	25
Q. nigra	Water Oak	25
Celtis occidentalis	Hackberry	25
Ulmus sp.	Elm	25

Scientific Name	Common Name	Percent Frequency
Rhamnus caroliniana	Carolina Buckthorn	25
Carpinus caroliniana	Blue Beech	17
Cercis canadensis	Redbud	17
Cornus sp.	Dogwood	17
Juniperus virginiana	Eastern Red Cedar	17
Morus rubra	Mulberry	17
Ulmus alata	Winged Elm	17
Viburnum prunifolium	Black Haw	17
Shrub Stratum:		
Berchemia scandens	Supplejack	25
Carya sp.	Hickory	25
Simlax rotundifolia	Catbrier	17
Callicarpa americana	French Mulberry	17
Ground Cover:		
Poaceae	Grass	92
Berchemia scandens	Supplejack	50
Celtis occidentalis	Hackberry	50
Anisostichus capreolata	Cross Vine	42
Simlax bona-nox	Bullbrier	33
Callicarpa americana	French Mulberry	25
Lonicera japonica	Japanese Honeysuckle	25
Vitis rotundifolia	Muscadine	25

(6) Broom Sedge-Lespedeza - Nine plots representing 32 percent of the open land were classified as broom sedge-lespedeza. Broom sedge, sericea lespedeza, and assorted

other grasses dominated the communities. The average percent cover for all species was 94 percent. The more important species found in the sample plots are listed below with their frequencies of occurrence.

Scientific Name	Common Name	Percent Frequency
Lespedeza sp.	Lespedeza	89
Andropogon virginicus	Broom Sedge	81
Poaceae	Grass	50
Vernonia altissima	Ironweed	31
Coreopsis tripteris	Coreopsis	28
Solanum carolinense	Horse-nettle	22
Eupatorum coelestinum	Mistflower	17
Festuca sp.	Fescue	17
Rubus sp.	Blackberry	17
Ambrosia artemisiifolia	Ragweed	17
Eupatorum serotinum	Thoroughwort	14
Houstonia sp.	Bluets	11

(7) Ragweed - Eighteen percent of the open land was placed in the ragweed community type. Average percent cover for all species was 96 percent. Ragweed and grasses dominated the community. Below are listed the more common species and their frequencies of occurrence.

Scientific Name	Common Name	Percent Frequency
Poaceae	Grass	90
Ambrosia artemisiifolia	Ragweed	85

Scientific Name	Common Name	Percent Frequency
Helenium amarum	Bitterweed	65
Lespedeza sp.	Lespedeza	60
Andropogon virginicus	Broom Sedge	25
Cassia obtusifolia	Sicklepod	10
Festuca sp.	Fescue	10
Solanum carolinense	Horse-nettle	10
Vernonia altissima	Ironweed	10

6. Rare or Endangered Species - No plants found on the proposed Bellefonte Nuclear Plant site are classed as rare or endangered.[10] All of the species noted are fairly typical of the region and have generally broad distribution patterns.

7. Glossary - The following definitions are provided to define technical terms as they are used only herein.

Basal Area: The total cross-sectional area of all trees of a given species measured at 4.5 feet above ground, expressed on a cross-sectional area per unit area of land basis.

Cover: The area occupied by a plant or group of plants. Percent cover is determined by visually projecting the total area of a plant onto a horizontal plane surface (such as the ground) of fixed dimensions and then estimating what percentage of that plane is occupied by the aerial projection.

DBH: The diameter of a tree measured at 4.5 feet above ground level.

Density: The number of stems of a particular species per unit area.

Distribution: The range of area occupied by a particular species.

Dominant: A plant species playing a major role in a community, determined by its relatively high cover or basal area.

Frequency: The number of plots or quadrats in which a species is found divided by the total number of plots or quadrats sampled. Percent frequency = frequency x 100. Thus frequency usually is relative only to the plots within a type; in the case of calculating the importance value index, however, frequency refers to all plots in all types.

Ground cover: All of the herbaceous plants and all woody plants less than 18 inches high within a given area.

Growing stock: The total volume per acre of all merchantable trees 5 inches DBH or larger.

Higher plants: Ferns, club mosses and flowering plants.

Merchantable timber: All sound, commercially valuable trees. In the study area this excludes blue beech and redbud.

Shrub stratum: The total of all woody vines and shrubs over 18 inches high and all trees over 18 inches high but less than one inch DBH within a given area.

Stand size: A classification system describing the volume of all timber in an acre area around the sampling site. There are four classes:

1. Large sawtimber - Stands of sawtimber trees containing a minimum of 1,500 board feet volume per acre in

living merchantable trees with more than 50 percent of the net board foot volume in trees 15 inches DBH or larger.

2. Small sawtimber - Stands of sawtimber trees containing a minimum of 1,500 net board feet per acre in living merchantable trees with 50 percent or less of the board foot volume in large trees 15 inches DBH and up.

3. Poletimber - Stands with less than 1,500 board feet per acre having at least 30 sound trees 5 inches DBH or larger per acre.

4. Seedlings and saplings - Stands with less than 1,500 board feet or 30 trees 5 inches DBH or larger per acre, but with at least 100 seedlings or saplings per acre.

Tree diameter class: A classification system used in measuring the wood volume in either cubic or board feet of a particular species. Each class represents a 2-inch range in DBH. Thus, for example, the 12-inch diameter class includes all trees from 11 to 12.99 inches DBH.

Tree size class: A classification system used in measuring the volume in cubic feet of wood of a particular species. There are two classes.

1. Pole - Applies to all hardwood species from 5 to 10.99 inches DBH and all softwoods from 5 to 8.99 inches DBH.

2. Sawtimber - Applies to all hardwood species 11 inches or over in DBH and all softwoods 9 inches or over in DBH.

Type: An association of dominant plant species normally occurring together.

Understory: All trees from 1 to 4.99 inches DBH.

Vegetation: The totality of all plants within a given area.

Volume: The total volume per acre of merchantable wood in all trees measured in cubic feet for trees 5 inches DBH and larger or in board feet for softwoods 9 inches DBH and larger and hardwoods 11 inches DBH and larger.

8. Nomenclature - Scientific nomenclature throughout this report for trees follows that of Little (1953)[11] and for other plants that of Radford, Ahles, and Bell (1969).[12]

REFERENCES

1. Hedlund, A. and J. M. Earles. 1972. Forest statistics for north Alabama counties. USDA Forest Service Resource Bull. SO-34. So. For. Exp. Sta., New Orleans, La.

2. Forest Inventory Statistics: 125 Tennessee Valley Counties. 1970. TVA, Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

3. Harper, R. M. 1942. Natural resources of the Tennessee Valley region in Alabama. Geol. Surv. Ala., Special Rpt.17.

4. Mohr, C. 1901. Plant Life of Alabama. USDA, Contrib. U.S. Nat. Herb., No. 6.

5. Soil Survey Staff. Established Series Descriptions. National Cooperative Soil Survey of the U.S. USDA Soil Conservation Service. (Pamphlets issued periodically.)

6. Baldwin, M., C. E. Kellogg, and J. Thorp. 1938. Soil Classification. In: Soils and Men. USDA Yearbook pp. 979-1001.

7. Soil Survey Staff. 1960. Soil Classification - A Comprehensive System (7th Approximation). USDA, Soil Conservation Service.

8. Forest Inventory Field Manual for County Unit and Watershed Surveys in the Tennessee Valley. 1970. TVA, Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

9. Swenson, G. A. et al. 1954. Soil Survey of Jackson County, Alabama. USDA, Soil Conservation Service, Soil Survey Rpt, Series 1941, No. 8.

10. Endangered, Rare and Uncommon Wildflowers. 1970. USDA, Forest Service, Southern Region.

11. Little, E. L. 1953. Checklist of Native and Naturalized Trees of the United States. USDA, Forest Service, Ag. Handbook, No. 41. Washington, DC.

12. Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. Univ. of N. C. Press, Chapel Hill.

Table B3-1

Volume of Merchantable Sawtimber by Species and Tree Diameter Expressed on a Board Feet Per Acre Basis

Species or Species Group	Tree Diameter Class in Inches 10	12	14	16-Larger	All Diameters
Loblolly Pine	54	52	60	147	313
Shortleaf Pine	21	23	-	-	44
Virginia Pine	81	101	47	35	264
Eastern Red Cedar	18	-	18	-	36
All Softwoods	174	176	125	182	657
Black Oak	-	23	10	-	33
Cherrybark Oak	-	13	24	16	53
Shumard Oak	-	9	13	-	22
Southern Red Oak	-	6	-	-	6
Scarlet Oak	-	12	-	-	12
Water Oak	-	7	22	30	59
Chestnut Oak	-	-	-	173	173
Chinquapin Oak	-	34	40	-	74
Post Oak	-	-	13	17	30
White Oak	-	-	-	102	102
Basswood	-	-	-	40	40
Black Gum	-	-	11	-	11
Sweetgum	-	41	22	128	191
Red Maple	-	23	44	-	67
Yellow Poplar	-	-	48	27	75
Box Elder	-	7	-	-	7
Black Willow	-	-	-	18	18
Ash	-	40	-	37	77
Elm	-	-	6	-	6
Hickory	-	35	42	-	77
Sugar Maple	-	-	-	135	135
Hackberry	-	-	7	14	21
Black Locust	-	36	8	21	65
Honey Locust	-	6	-	15	21
Sassafras	-	5	-	-	5
All Hardwoods	*	297	310	773	1,380
All Species	174	473	435	955	2,037
Percent	9	23	21	47	

*Hardwood trees in this class are pole timber.

Table B3-2

Volume of Merchantable Trees by Species and Diameter Expressed on a Cubic Feet Per Acre Basis

Species or Species Group	Tree Diameter Class in Inches 6	8	10	12	14	16-Larger	All Diameters
Loblolly Pine	-	7	17	12	12	25	73
Shortleaf Pine	5	10	6	6	-	-	27
Virginia Pine	4	10	24	25	10	7	80
Eastern Red Cedar	5	19	5	-	4	-	33
All Softwoods	14	46	52	43	26	32	213
Black Oak	1	-	-	8	3	-	12
Cherrybark Oak	3	-	9	4	6	4	26
Shumard Oak	2	9	4	3	3	-	21
Southern Red Oak	-	0	3	2	-	-	5
Scarlet Oak	1	2	4	4	-	-	11
Water Oak	3	-	-	2	5	7	17
Chestnut Oak	-	9	8	-	-	35	52
Chinquapin Oak	3	7	6	10	10	-	36
Post Oak	-	-	7	-	3	3	13
White Oak	-	-	-	-	-	17	17
Basswood	-	-	-	-	-	8	8
Black Gum	-	-	-	-	3	-	3
Sweetgum	14	4	9	12	5	23	67
Red Maple	3	4	18	7	13	-	45
Yellow Poplar	-	-	6	-	11	6	23
Box Elder	3	2	10	2	-	-	17
Black Willow	-	2	-	-	-	4	6
Ash	12	23	4	13	-	8	60
Black Cherry	5	3	-	-	-	-	8
Elm	12	11	6	-	2	-	31
Hickory	3	9	3	10	11	-	36
Sugar Maple	3	3	-	-	-	26	32
Persimmon	1	5	-	-	-	-	6
Black Walnut	1	-	7	-	-	-	8
Winged Elm	2	-	3	-	-	-	5
Hackberry	4	17	5	-	2	3	31
Black Locust	4	9	25	10	2	6	56
Honey Locust	-	-	-	2	-	4	6
Osage Orange	1	-	-	-	-	-	1

Table B3-2, Contd.

Species or Species Group	6	8	10	12	14	16-Larger	All Diameters
Sassafras	-	-	-	1	-	-	1
All Hardwoods	81	119	137	90	79	154	660
All Species	95	165	189	133	105	186	873
Percent	11	19	22	15	12	21	

Table B3-3

Volume of All Merchantable Trees by Species and Tree Size Class Expressed on a Cubic Feet Per Acre Basis

Species or Species Group	Tree Size Class: Pole	Tree Size Class: Sawtimber	All Classes
Loblolly Pine	7	66	73
Shortleaf Pine	15	12	27
Virginia Pine	14	66	80
Eastern Red Cedar	23	9	32
All Softwoods	59	153	212
Black Oak	1	11	12
Cherrybark Oak	13	13	26
Shumard Oak	16	5	21
Southern Red Oak	3	2	5
Scarlet Oak	8	4	12
Water Oak	3	13	16
Chestnut Oak	17	35	52
Chinquapin Oak	15	21	36
Post Oak	7	6	13
White Oak	-	17	17
Basswood	-	8	8
Black Gum	-	3	3
Sweetgum	27	40	67
Red Maple	25	20	45
Yellow Poplar	6	17	23
Box Elder	15	2	17
Black Willow	2	4	6
Ash	39	21	60
Black Cherry	8	-	8
Elm	29	2	31
Hickory	15	21	36
Sugar Maple	6	26	32
Persimmon	6	-	6
Black Walnut	8	-	8
Winged Elm	5	-	5
Hackberry	26	6	32
Black Locust	37	19	56
Honey Locust	-	6	6
Osage Orange	1	-	1
Sassafras	-	1	1
All Hardwoods	338	323	661
All Species	397	476	873
Percent	46	54	100

Table B3-4

Tree Species Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Liquidambar styraciflua	Sweetgum	9.74
Pinus virginiana	Virginia Pine	7.60
Fraxinus sp.	Ash	7.10
Robinia pseudoacacia	Black Locust	6.53
Pinus taeda	Loblolly Pine	5.82
Carya sp.	Hickory	4.61
Ulmus sp.	Elm	4.47
Quercus muehlenbergii	Chinquapin Oak	4.13
Acer rubrum	Red Maple	4.05
Juniperus virginiana	Eastern Red Cedar	3.79
Quercus prinus	Chestnut Oak	3.49
Q. Falcata var. pagodaefolia	Cherrybark Oak	3.02
Pinus echinata	Shortleaf Pine	2.81
Celtis sp.	Hackberry	2.79
Quercus nigra	Water Oak	2.73
Liriodendron tulipifera	Yellow Poplar	2.70
Acer saccharum	Sugar Maple	2.55
Quercus shumardii	Shumard Oak	2.20
Acer negundo	Box Elder	2.12
Quercus velutina	Black Oak	1.71
Cercis canadensis	Redbud	1.57
Tilia heterophylla	Basswood	1.40
Quercus coccinea	Scarlet Oak	1.36
Prunus serotina	Black Cherry	1.34
Quercus stellata	Post Oak	1.26
Q. alba	White Oak	1.19
Gleditsia tricanthos	Honey Locust	.99
Juglans nigra	Black Walnut	.95
Quercus falcata	Southern Red Oak	.83
Nyssa sylvatica	Black Gum	.81
Ulmus alata	Winged Elm	.75

Table B3-4, Contd.

Scientific Name	Common Name	Importance Value Index
Diospyros virginiana	Persimmon	.74
Salix nigra	Black Willow	.54
Sassafras albidum	Sassafras	.43
Quercus phellos	Willow Oak	.39
Carpinus carolinanan	Blue Beech	.36
Maclura pomifera	Osage Orange	.36

Table B3-5

Understory Species Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Ulmus sp.	Elm	12.68
Celtis sp.	Hackberry	7.88
Fraxinus sp.	Ash	7.48
Juniperus virginiana	Eastern Red Cedar	7.48
Carya sp.	Hickory	6.50
Ulmus alata	Winged Elm	6.44
Cornus florida	Flowering Dogwood	4.82
Cercis canadensis	Redbud	4.50
Liquidambar styraciflua	Sweetgum	3.52
Quercus prinus	Chestnut Oak	3.40
Acer rubrum	Red Maple	3.05
Quercus coccinea	Scarlet Oak	2.81
Carpinus caroliniana	Blue Beech	2.46
Nyssa sylvatica	Black Gum	2.34
Kalmia latifolia	Mountain Laurel	2.15
Acer saccharum	Sugar Maple	1.93
Viburnum prunifolium	Black Haw	1.76
Quercus muehlenbergii	Chinquapin Oak	1.60
Fagus grandifolia	American Beech	1.42
Morus rubra	Mulberry	1.27
Quercus alba	White Oak	1.22
Prunus serotina	Black Cherry	1.20
Quercus falcata	Southern Red Oak	1.07
Q. nigra	Water Oak	1.00
Acer negundo	Box Elder	1.00
Robinia pseudoacacia	Black Locust	.94
Diospyros virginiana	Persimmon	.94
Pinus echinata	Shortleaf Pine	.94
Quercus velutina	Black Oak	.87
Liriodendron tulipifera	Yellow Poplar	.75
Rhamnus caroliniana	Carolina Buckthorn	.67
Gleditsia triacanthos	Honey Locust	.60

Table B3-5, Contd.

Scientific Name	Common Name	Importance Value Index
Quercus falcata var. *pagodaefolia*	Cherrybark Oak	.60
Oxydendrum arboreum	Sourwood	.47
Quercus phellos	Willow Oak	.40
Q. stellata	Post Oak	.40
Sassafras albidum	Sassafras	.40
Tilia heterophylla	Basswood	.27
Ilex decidua	Possum Haw	.20
Lindera benzoin	Spicebush	.20
Pinus taeda	Loblolly Pine	.20
P. virginiana	Virginia Pine	.20

Table B3-6

Shrub Stratum Vegetation Found in the **Bellefonte** Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance Value Index
Ulmus alata	Winged Elm	6.74
Cercis canadensis	Redbud	6.10
Lonicera japonica	Japanese Honeysuckle	5.78
Carya sp.	Hickory	5.18
Rubus sp.	Blackberry	5.04
Diospyros virginiana	Persimmon	4.97
Robinia pseudoacacia	Black Locust	4.12
Fraxinus sp.	Ash	3.96
Cornus sp.	Dogwood	3.81
Berchemia scandens	Supplejack	3.34
Vitis rotundifolia	Muscadine	3.32
Juniperus virginiana	Eastern Red Cedar	2.86
Celtis sp.	Hackberry	2.65
Sassafras albidum	Sassafras	2.21
Carpinus caroliniana	Blue Beech	2.07
Ulmus sp.	Elm	1.81
Quercus velutina	Black Oak	1.77
Liriodendron tulipifera	Yellow Poplar	1.75
Quercus coccinea	Scarlet Oak	1.74
Acer rubrum	Red Maple	1.73
Smilax rotundifolia	Catbrier	1.60
Quercus prinus	Chestnut Oak	1.59
Lindera benzoin	Spicebush	1.53
Kalmia latifolia	Mountain Laurel	1.51
Vaccinium corymbosum	Highbush Blueberry	1.24
Ampleopsis cordata	Heartleaf Ampleopsis	1.18
Campsis radicans	Trumpet Creeper	1.18
Liquidambar styraciflua	Sweetgum	1.18
Rhamnus caroliniana	Carolina Buckthorn	1.18
Acer saccharum	Sugar Maple	1.17
Prunus serotina	Black Cherry	1.12

Table B3-6, Contd.

Scientific Name	Common Name	Importance Value Index
Quercus muehlenbergii	Chinquapin Oak	1.12
Callicarpa americana	French Mulberry	1.04
Smilax bona-nox	Bullbrier	.99
Ilex decidua	Possum Haw	.98
Hydrangea quercifolia	Oakleaf Hydrangea	.97
Vitis palmata	Red Grape	.96
Quercus stellata	Post Oak	.90
Acer negundo	Box Elder	.90
Hydrangea arborescens	Wild Hydrangea	.70
Oxydendrum arboreum	Sourwood	.62
Rhus copallina	Winged Sumac	.56
Fagus grandifolia	American Beech	.48
Morus rubra	Mulberry	.42
Rhus radicans	Poison Ivy	.34
Bumelia lycioides	Southern Buckthorn	.34
Cocculus carolinus	Coralbeads	.28
Nyssa sylvatica	Black Gum	.28
Quercus falcata	Southern Red Oak	.28
Aesculus octandra	Buckeye	.14
Alnus serrulata	Common Alder	.14
Euonymous americanus	Strawberry Bush	.14
Ostrya virginiana	Ironwood	.14
Parthenocissus quinquefolia	Virginia Creeper	.14
Pinus taeda	Loblolly Pine	.14
Quercus alba	White Oak	.14
Q. shumardii	Shumard Oak	.14
Rhododendon nudiflorum	Pinxter-flower	.14
Salix nigra	Black Willow	.14
Sambucus canadensis	Elder	.14
Smilax glauca	Sawbrier	.14
Vaccinium arboreum	Sparkleberry	.14
Viburnum prunifolium	Black Haw	.14
Quercus phellos	Willow Oak	.14

Table B3-7

Ground Cover Vegetation Found in the Bellefonte Nuclear Plant Site Vegetation Survey, Arranged According to Importance Value Index.

Scientific Name	Common Name	Importance
Poaceae	Grass	32.50
Lespedeza sp.	Lespedeza	7.60
Andropogon virginicus	Broom Sedge	6.27
Parthenocissus quinquefolia	Virginia Creeper	4.52
Lonicera japonica	Japanese Honeysuckle	3.53
Ambrosia artemisiifolia	Ragweed	3.25
Vitis rotundifolia	Muscadine	2.32
Celtis sp.	Hackberry	2.32
Phytolacca americana	Poke	1.56
Coreopsis tripteris	Coreopsis	1.54
Berchemia scandens	Supplejack	1.50
Campsis radicans	Trumpet Creeper	1.42
Helenium amarum	Bitterweed	1.34
Rubus sp.	Blackberry	1.24
Vernonia altissima	Ironweed	1.24
Festuca sp.	Fescue	1.22
Cercis canadensis	Redbud	1.08
Rhus radicans	Poison Ivy	1.03
Anisostichus capreolata	Cross Vine	1.02
Polyganum sp.	Smartweed	.92
Ulmus alata	Winged Elm	.85
Smilax rotundifolia	Catbrier	.82
S. glauca	Sawbrier	.78
Solanum carolinense	Horse-nettle	.72
Impatiens capensis	Jewel-weed	.72
Robinia pseudoacacia	Black Locust	.69
Desmodium sp.	Beggar's Lice	.69
Prunus serotina	Black Cherry	.65
Eupatorum serotinum	Thoroughwort	.64
E. coelestinum	Mistflower	.62
Smilax bona-nox	Bullbrier	.58

Table B3-7, Contd.

Scientific Name	Common Name	Importance Value Index
Fraxinus sp.	Ash	.58
Acer negundo	Box Elder	.58
Cornus sp.	Dogwood	.56
Sassafras albidum	Sassafras	.52
Acer rubrum	Red Maple	.52
Diospyros virginiana	Persimmon	.50
Carya sp.	Hickory	.47
Asplenium platyneuron	Black Spleenwort	.46
Houstonia sp.	Bluets	.41
Quercus stellata	Post Oak	.40
Liquidambar styraciflua	Sweetgum	.36
Boehmeria cylindrica	False Nettle	.36
Sedum sp.	Stone Crop	.34
Cassia fasciculata	Partridge Pea	.34
Dioscorea villosa	Wild Yam	.30
Solanum americanum	Deadly Nightshade	.28
Erechtites hieracifolia	Fireweed	.28
Solidago sp.	Goldenrod	.26
Chimaphila maculata	Pipsissewa	.26
Cocculus carolinus	Coralbeads	.26
Polystichum acrostichoides	Christmas Fern	.26
Quercus muehlenbergii	Chinquapin Oak	.26
Q. phellos	Willow Oak	.26
Ampleopsis cordata	Heartleaf Ampleopsis	.24
Galium sp.	Bedstraw	.24
Iva annua	Marsh Elder	.24
Hibiscus sp.	Hibiscus	.24
Carpinus caroliniana	Blue Beech	.21
Euonymus americanus	Strawberry Bush	.20
Liriodendron tulipifera	Yellow Poplar	.20
Philadelphis inodorus	Mock-orange	.20
Quercus alba	White Oak	.20
Q. prinus	Chestnut Oak	.20

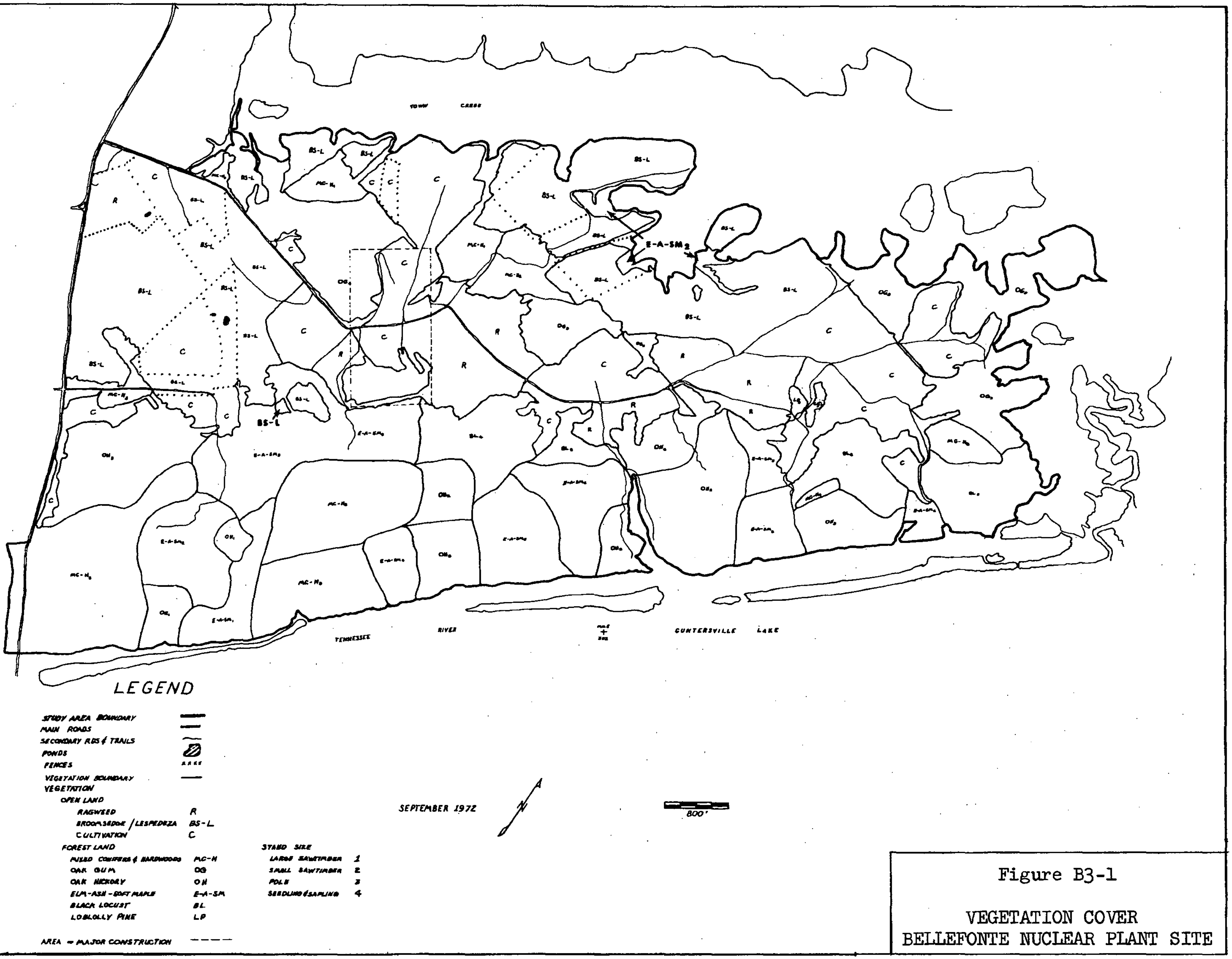


Figure B3-1

VEGETATION COVER
BELLEFONTE NUCLEAR PLANT SITE

Appendix B4

OTHER AQUATIC LIFE SURVEYS

1. Introduction - Surveys to assess the limnological characteristics of the proposed site area near Bellefonte, Alabama, were conducted in April, September, and November 1971 and in July, August, September, and October 1972. Shorelines, embayments, tributary areas, and the Tennessee River were examined and sampled. Ten stations, located between TRM 390.8 and TRM 392.3 along the right bank and in the middle of the navigation channel and alternate channel (figure B4-1), were selected for detailed investigation in 1972.

2. Methods and sample locations - A rough approximation of bottom topography was established by means of a series of sonar profiles determined along selected transects near the proposed site. The line transects for the Bellefonte site are shown in the offset in figure B4-2. Five such profiles were made between TRM 391.2 and TRM 392.8 (figure B4-2). The recordings were used to graph the general topographic features of the reservoir bottom and, when possible, to indicate large differences in sediment composition; thus the illustrations are not to scale. Areas for sampling benthic sediment and macroinvertebrates were tentatively designated from this knowledge. The final sampling stations were then determined from the results of trial sampling.

The detailed sampling in 1972 included three bottom samples at each sampling point shown in figure B4-1. The samples were separated for analysis of sediment and benthic macroinvertebrates.

Organic and volatile solids content along with particle size composition were determined from the sediment portion of these samples. The percentages of volatile solids were determined by ashing subsamples at 600°C in a muffle furnace for 6 hours. Samples were cooled and weighed repeatedly until a constant weight was determined. Particle size was determined by using Krumbein and Pettijohn's standard pipette analysis techniques[1] (Table B4-1). Replicate samples for analyses of benthic macroinvertebrates were washed free of sediment on graded screens in the field, and the material collected from the screens was preserved with ethanol and returned to the laboratory for processing. All macroinvertebrates were identified, counted, and weighed. Neither age nor length was determined, but a general impression of population structure was obtained by observation of the specimens. Preliminary identifications reported here were to genera for all organisms except Amniocolidae snails. The total wet weight obtained in replicate samples was used to calculate biomass in terms of grams per square meter (Table B4-2).

Duplicate samples of phytoplankton were taken in warm weather at the surface and 1 and 3 meters below the surface in July. The samples were poured into 100-ml Nalgene bottles and preserved by adding 2 ml of formalin. Phytoplankton were identified to genera and counted by using an inverted microscope at 312.5X. The raw enumerations and identifications were coded and processed by TVA computer programs. The percentage composition of the phytoplankton and the predominant genera that occurred at the site are shown in Tables B4-3 and B4-4, respectively.

Also in July, vertical qualitative zooplankton samples were collected by lowering a plankton net, 1/2 meter in diameter and equipped with a No. 20 net (173 mesh per inch), to the bottom and raising it to the surface in a single haul. All samples were taken from midchannel. In the embayments horizontal tows were made adjacent to watermilfoil beds.

In October preliminary quantitative zooplankton samples were collected with a Van Dorn water sampler at the same stations used in July. Duplicate samples composed of 7 liters of water were collected at the surface, middle, and near the bottom of the vertical water column. The zooplankters were concentrated by pouring the water through a Wisconsin plankton net bucket, preserved with ethanol, and returned to the laboratory for identification and enumeration with the aid of a compound microscope at 100X. Genera and species found are reported in Table B4-5. Those occurring most frequently are indicated with asterisks.

Concentrations of chlorophyll _a_ pigment were determined by filtering collected water through 1.2mu Millipore membrane filters; extracting the pigment in a dark refrigerator for 24 hours with a solution of 90 percent acetone, which dissolves the filter and its collected residue; and reading individual stock of pigment reported as chlorophyll _a_ per unit of volume was estimated (Table B4-6). A mean concentration was determined for each depth.

3. General observations - The bottom of the reservoir at Bellefonte near areas of proposed construction impact has a smooth gradient and the channel banks slope gradually to a depth of 25 to 30 feet at midchannel. The sediment is basically fine, dominated by very fine sand. Little volatile material is present--only 0.1 to 0.6 percent of the weight was lost by ashing the samples at 600°C. The results of trace metal analysis of bottom sediments in the vicinity of the Bellefonte site are shown in Table B4-7.

The macroinvertebrate fauna of the channel bottom and slopes is limited in diversity, but that of the shoreline, island slopes, overbank macrophyte beds, and embayments was diverse. Additional careful shoreline work will be necessary to document the fauna more fully. The rooted macrophyte flora was surveyed to determine species and to map the distribution of watermilfoil. The partial list of flora is shown in Table 1.2-17, in section 1.2, and a map illustrating distribution of watermilfoil is shown in figure B4-3. The macrophyte fauna in a downstream watermilfoil bed surveyed in 1969-70 is presented in Table B4-8.

Chrysophyta and Chlorophyta (diatoms and green algae) are the dominant phytoplankters. The actual abundance of various forms is very unevenly distributed within and between given water masses. These phytoplankters are preyed on by a diverse zooplankton assemblage. In turn, many of the zooplankters are preyed on by other more active zooplankters such as Chaoborus and Leptodora. Each step in the trophic network increases the diversity of pathways. Additionally, many zooplankters and macroinvertebrates are associated with the macrophyte beds.

Present sample data would suggest that a limited topographic diversity and restricting sediment composition are reducing the diversity of macroinvertebrates in the Tennessee River near the proposed Bellefonte site. Macrophyte beds and shoreline development provide multilevel stratification and diverse habitats for shoreline organisms, and samples reflect this diversity of physical habitat.

REFERENCES FOR APPENDIX B4

1. Krumbein, W. C., and F. J. Pettijohn. 1938. Manual of Sedimentary Petrography. Appleton-Century-Crofts, Inc., New York. 549 pp.

Table B4-1

SIEVE ANALYSIS AND PERCENTAGE OF VOLATILE SOLIDS IN THE BENTHIC SEDIMENTS

COLLECTED AT BELLEFONTE - AUGUST 1972

Station		Particulate Sizes (percent)							
TRM	Bank	Very Fine Sand (1/8-1/16 mm)	Coarse Silt (1/32 mm)	Medium Silt (1/64 mm)	Fine Silt (1/128 mm)	Very Fine Silt (1/256 mm)	Coarse Clay (1/512 mm)	Medium Clay (1/1024 mm)	Organic Content
390.8,	right	60.55	5.51	3.61	0.36	8.13	0.70	5.56	0.6
391.3,	right	52.54	11.71	6.87	3.45	7.79	3.46	2.47	0.3
391.6,	right	51.07	0.48	7.87	13.18	7.37	3.47	2.45	0.1
392.0,	right	62.85	6.18	6.32	7.90	4.08	1.24	2.62	0.2
392.3,	right	54.04	5.54	10.75	7.20	4.59	2.00	2.98	0.3

Table B4-2

NUMBER AND WET WEIGHTS OF BENTHIC FAUNA TAKEN IN EACH PONAR DREDGE AT THE BELLEFONTE STATIONS - JULY 1972

	Sampling Location (TRM, right bank)														
Sample	390.8			391.3			391.6			392.0			392.3		
Organism	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Amphipoda															
Gammarus sp.					1	1									
Diptera															
Chaoborus sp.	1	1				2									
Chironomus sp.	1	2		3	22	29					1	3	1		
Chrysops sp.					1										
Coelotanypus sp.						1		3					1	1	1
Pentaneura sp.			No organisms	3	1	3	1	1		2	5	6	1	2	2
Ephemeroptera															
Caenis sp.					1	1									
Hexagenia sp.		1		6			10	10			9	10	3	4	4
Pelecypoda															
Corbicula sp.	4	2		3	2	1	6	3	10	6	4	8	6	12	20
Oligochaeta															
Branchiura sp.		1		2											
Total wet weight per dredge sample (g)	16.567	16.901	-	112.612	00.062	00.071	01.145	01.180	57.590	00.150	00.853	00.792	00.318	00.670	01.446
Avg. weight g/m^2		287.3			645.4			342.9			10.27			13.92	

Table B4-3

PERCENT COMPOSITION OF SUMMER PHYTOPLANKTON SAMPLES - BELLEFONTE SITE

PHYTOPLANKTON COMPOSITION (PERCENT) AT INDICATED DEPTH (M)

	TRM 391.3			TRM 392.3		
	Surf.	1	3	Surf.	1	3
Chrysophyta	68.85	64.30	71.85	65.10	81.15	68.50
Chlorophyta	23.80	30.40	21.50	31.00	14.45	21.60
Cyanophyta	4.70	3.70	5.30	1.40	4.40	8.75
Euglenophyta	0.45	0.60	0.45	1.40		1.15
Pyrrophyta		0.60	0.90	1.10		

Table B4-4

PREDOMINANT GENERA OF PHYTOPLANKTON THAT OCCURRED IN THE EPILIMNION AT BELLEFONTE SITE (JULY 6, 1972)

Chrysophyta (Diatoms)

Asterionella sp.
Cocconeis sp.
Cyclotella sp.
Cymbella sp.
Diatoma sp.
Dinobryon sp.
Eunotia sp.
Fragilaria sp.
Gyrosigma sp.
Melosira sp.
Navicula sp.
Nitzschia sp.
Rhizosolenia sp.
Stephanodiscus sp.
Synedra sp.
Tabellaria sp.

Chlorophyta (Greens)

Ankistrodesmis sp.
Carteria sp.
Chlamydomonas sp.
Chlorella sp.
Cosmarium sp.
Dictyosphaerium sp.
Eudorina sp.
Kirchneriella sp.
Pandorina sp.
Pediastrum sp.
Protococcus sp.
Scenedesmus sp.
Staurastrum sp.
Tetraedron sp.
Tetraspora sp.

Cyanophyta (Bluegreens)

Anabaena sp.
Aphanizomenon sp.
Arthrospira sp.
Coelosphaerium sp.
Merismopedia sp.
Oscillatoria sp.

Euglenophyta (Euglenoids)

Euglena sp.
Phacus sp.

Pyrrophyta (Browns)

Ceratium sp.
Cryptomonas sp.
Glenodinium sp.
Gymnodinium sp.
Peridinium sp.

Table B4-5

ZOOPLANKTON AT THE BELLEFONTE STATIONS - JULY 6 AND OCTOBER 3, 1972

Organisms	TRM 391.3 July	TRM 391.3 October	TRM 392.3 July	TRM 392.3 October
Argulus japonicus	X			
Asplanchna sp.	X	X	X	X
*Bosmina longirostris**	X	X	X	X
*Brachionus angularis**	X	X	X	X
Brachionus bennini	X			
Brachionus bidentata	X		X	
Brachionus budapestinensis	X	X	X	
Brachionus caudatus	X	X	X	X
*Brachionus calyciflorus**	X	X	X	X
Brachionus nilsoni	X			
Brachionus quadridentatus	X		X	
Ceriodaphnia lacustris	X			X
Cyclops vernalis	X	X	X	X
Daphnia parvula			X	
Daphnia retrocurva	X	X	X	X
Diaphanosoma leuchtenbergianum	X	X	X	X
Diaptomus pallidus	X	X	X	
Diaptomus reighardi	X		X	
Ergasilus sp.	X			X
Euchlanis sp.	X			
Ilyocryptus spinifer	X	X	X	
Keratella sp.*	X	X	X	X
Keratella cochlearis	X	X	X	X
Keratella earlinae			X	
Leptodora kindtii	X		X	
Mesocyclops edax	X	X	X	X
Moina micrura		X		
Monostyla sp.	X			
Nitocra lacustris	X		X	
Platyias patulus	X		X	X
Platyias quadricornis	X			
Ploesoma sp.			X	
Polyarthra crystallina				X
Scapholeberis kingi			X	
Sida crystallina	X		X	
Simocephalus serrulatus		X		
Synchaeta sp.	X		X	X
Trichocera sp.			X	
Total	30	16	27	16

*Zooplankters that occurred most frequently in the quantitative samples collected on October 3, 1972

Table B4-6

VERTICAL CHLOROPHYLL "a" ESTIMATES FROM SUMMER SHADES

Bellefonte, July 6, 1972

mg/m^3

Depth (m)	TRM 391.3 Sample 1	TRM 391.3 Sample 2	TRM 391.3 Avg.	TRM 392.3 Sample 1	TRM 392.3 Sample 2	TRM 392.3 Avg.
0.0	2.28	2.17	2.23	3.15	4.02	3.59
1.0	2.50	2.50	2.50	2.50	4.02	3.26
3.0	2.28	3.15	2.72	3.38	4.02	3.70

Table B4-7

Trace Metal Analyses of Bottom Sediments

In Vicinity of the Bellefonte Nuclear Plant Site

Stream*	Metals Content of Sediment (µg/g) (dry weight)												
	Iron	Manganese	Copper	Zinc	Chromium	Aluminum	Nickel	Silver	Lead	Mercury	Barium	Cadmium	Beryllium
TRM													
366.0 RB	32,000	4,600	16	170	32	29,000	27	2	9	0.11	<5	1	2
366.0 MC	38,000	4,500	41	450	58	40,000	55	2	20	1.5	<8	2	2
366.0 LB	37,000	3,600	36	35	52	36,000	39	.7	28	1.1	<8	1	2
368.9 MC	45,000	1,400	23	160	52	45,000	26	2	18	0.42	<7	1	3
368.9 LB	30,000	2,200	31	340	35	25,000	48	2	20	1.0	<7	1	2
390.8 RB	18,000	1,500	23	240	26	17,000	54	2	15	0.46	<4	1	0.8
392.3 RB	19,000	1,100	16	120	21	16,000	19	1	11	0.29	<4	0.8	0.8

Samples collected August 31, 1972

*RB - right bank
MC - mid-channel
LB - left bank

<u>BENTHIC POPULATION MEANS AND STANDARD DEVIATIONS CALCULATED FOR A 9- BY 9-INCH EKMAN DREDGE SAMPLE - GUNTERSVILLE RESERVOIR,</u>
<u>JAGGER BRANCH (HONEYCOMB CREEK) - MARCH 25, 1969 - APRIL 14, 1969</u>

	March 25, 1969 24-Hour Prebenthic Subplots						April 2, 1969 24-Hour Postbenthic Subplots						April 14, 1969 2-Week Postbenthic Subplots					
	A		B		C		A		B		C		A		B		C	
	X̄[a]	s[b]	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s
Gastropoda																		
Basommatophora																		
Physidae																		
<u>Physa</u>	4.11	4.29	4.00	5.76	6.00	7.00	6.20	3.70	5.50	4.51	0.60	0.89	2.00	2.00	2.60	2.51	0.75	0.96
Planorbidae																		
<u>Gyraulus</u>	77.33	117.49	22.17	31.16	44.33	51.25	112.60	106.02	70.00	17.09	21.20	8.64	79.00	67.16	38.20	25.12	32.25	28.27
Mesogastropoda																		
Hydrobiidae																		
<u>Marstonia</u>	4.78	6.06	2.00	2.76	2.33	4.04	2.80	3.83	0.33	0.58			11.20	13.26	0.20	0.45	1.75	0.50
Pleuroceridae																		
<u>Pleurocera</u>	0.22	0.44	1.00	1.27	0.33	0.58			0.75	1.50					0.20	0.45		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
<u>Corbicula</u>	0.44	0.88	6.17	6.11	0.67	0.58	0.60	0.89	1.25	0.96	0.80	0.84	0.20	0.45	3.20	1.79		
Crustacea																		
Amphipoda							0.20	0.45										
Oligochaeta	0.11	0.33									0.40	0.55	1.00	1.41	1.20	0.84	1.25	0.50
Hirudinea											0.20	0.45						
Insecta																		
Ephemeroptera																		
Ephemeridae																		
<u>Hexagenia</u>	0.11	0.33									0.20	0.45	0.20	0.45	0.80	1.30		
Baetidae																		
<u>Caenis</u>	1.89	2.26	0.17	0.41			0.80	0.84	0.50	1.00			0.60	1.34	0.40	0.55		
Heptageniidae																		
<u>Stenonema</u>							0.20	0.45										
Lepidoptera																		
Pyralididae																		
<u>Nymphula</u>	0.11	0.33	0.33	0.52	1.00	1.00	0.60	0.89	1.25	1.50	0.20	0.45			0.40	0.55		
Odonata																		
Coenagrionidae																		
<u>Enallagma</u>	3.11	1.90	0.50	1.23	1.67	2.89	6.80	6.22	2.00	1.41	0.60	0.89	4.60	6.07	4.80	1.92	1.00	1.41
Libellulidae	0.11	0.33			0.33	0.58					0.20	0.45						
Diptera[c]	9.22	9.16	5.33	5.12	4.67	3.06	2.20	3.49	4.00	2.16	2.20	2.39	3.20	3.12	7.80	5.17	8.50	2.89

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	April 28, 1969 1-Month Postbenthic Subplots						May 26, 1969 2-Month Postbenthic Subplots						June 30, 1969 3-Month Postbenthic Subplots					
	A		B		C		A		B		C		A		B		C	
	$\bar{X}$[a]	s[b]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Gastropoda																		
Basommatophora																		
Physidae																		
Physa			0.20	0.45			0.25	0.50	0.20	0.45								
Planorbidae																		
Gyraulus	8.00	8.37	13.40	17.39	18.80	17.48	0.50	1.00										
Mesogastropoda																		
Hydrobiidae																		
Marstonia			0.40	0.89	1.00	2.24					0.20	0.45	0.50	0.84				
Pleuroceridae																		
Pleurocera			0.40	0.89					0.60	1.34					0.40	0.89		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
Corbicula	1.00	0.82	3.60	2.07	0.60	0.89			1.80	1.64	0.60	0.89	0.17	0.41	2.00	1.87	1.20	1.30
Crustacea																		
Amphipoda			0.20	0.45	0.60	1.34	0.25	0.50										
Oligochaeta	1.75	1.26	1.00	1.23	0.20	0.45	1.75	1.50	2.80	2.59	1.00	0.71	2.00	1.27	9.40	4.39	6.80	3.42
Hirudinea	0.25	0.50																
Insecta																		
Ephemeroptera																		
Ephemeridae																		
Hexagenia									0.40	0.55					1.20	0.84		
Baetidae																		
Caenis	18.75	14.59	6.00	6.12	27.60	24.79					0.20	0.45			0.40	0.55		
Heptageniidae																		
Stenonema													0.33	0.87				
Lepidoptera																		
Pyralididae																		
Nymphula	0.25	0.50																
Odonata																		
Coenagrionidae																		
Enallagma	7.75	12.87	8.60	10.07	9.60	8.79												
Libellulidae	0.25	0.50	0.20	0.45	0.20	0.45												
Diptera[c]	4.25	3.69	3.20	1.92	10.40	4.78	106.50	43.78	53.60	19.42	52.00	7.52	18.50	6.80	28.20	9.58	25.00	9.49

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	October 8, 1969 6-Month Postbenthic Subplots						March 31, 1970 1-Year Postbenthic Subplots					
	A		B		C		A		B		C	
	$\bar{X}$[a]	s[b]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Gastropoda												
Basommatophora												
Physidae												
Physa												
Planorbidae												
Gyraulus												
Mesogastropoda												
Hydrobiidae												
Marstonia												
Pleuroceridae												
Pleurocera									0.20	0.45		
Pelecypoda												
Heterodonta												
Corbiculidae												
Corbicula	1.40	0.55	1.80	1.10	0.25	0.50	72.40	148.00	6.00	6.89	2.40	2.30
Crustacea												
Amphipoda			0.40	0.55								
Oligochaeta	0.20	0.45	0.40	0.55			2.80	1.92	0.40	0.55	10.60	9.86
Hirudinea					0.25	0.50			0.20	0.45	0.20	0.45
Insecta												
Ephemeroptera												
Ephemeridae												
Hexagenia			0.40	0.89	4.75	5.74	0.20	0.45	8.40	6.19	0.20	0.45
Baetidae												
Caenis			0.20	0.45								
Heptageniidae												
Stenonema	0.40	0.55										
Lepidoptera												
Pyralididae												
Nymphula					0.25	0.50						
Odonata												
Coenagrionidae												
Enallagma												
Libellulidae												
Diptera[c]	56.00	27.48	25.00	7.65	20.50	2.52	3.20	4.44	43.80	11.93	6.40	4.83

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

Table B4-8
(continued)

	March 25, 1969 24-Hour Presurface Subplots						April 2, 1969 24-Hour Postsurface Subplots						April 14, 1969 2-Week Postsurface Subplots					
	A		B		C		A		B		C		A		B		C	
	X̄[a]	s[b]	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s	X̄	s
Gastropoda																		
Basommatophora																		
Physidae																		
Physa	4.88	5.08	11.00	6.25	13.33	7.23	7.33	6.43	5.67	7.23	20.00	14.41	3.60	6.95	1.25	0.96	1.00	0.82
Planorbidae																		
Gyraulus	60.75	76.22	350.67	72.76	238.67	72.59	352.33	275.96	186.67	87.50	273.40	124.43	69.00	60.19	85.75	31.02	126.75	82.15
Mesogastropoda																		
Hydrobiidae																		
Marstonia	0.13	0.35																
Pleuroceridae																	0.50	0.58
Pleurocera																		
Pelecypoda																		
Heterodonta																		
Corbiculidae																		
Corbicula																		
Crustacea																		
Amphipoda									0.33	0.58					0.50	0.58		
Oligochaeta																		
Hirudinea																		
Insecta																		
Ephemeroptera																		
Ephemeridae																		
Hexagenia							1.00	1.73										
Baetidae																		
Caenis	2.88	4.61					0.33	0.58	0.33	0.58	0.20	0.45	2.80	1.10	1.25	1.50	2.25	1.89
Heptageniidae																		
Stenonema																		
Lepidoptera																		
Pyralididae																		
Nymphula	0.38	0.52	3.33	1.53	3.00				0.67	0.58	3.20	3.27						
Odonata																		
Coenagrionidae																		
Enallagma	9.25	7.70	2.67	1.53	2.33	2.08	19.33	10.97	19.33	13.65	12.00	5.20	11.40	5.60	11.50	5.00	15.00	4.32
Libellulidae			0.67	1.16													0.25	0.50
Diptera[c]	7.88	19.90	0.33	0.58	1.00	1.00	0.33	0.58	13.00	19.05	1.20	1.64			1.00	1.00	0.75	0.96

a. Population Mean
b. Population Standard Deviation
c. Family Chironomidae makes up 90 percent of the order Diptera

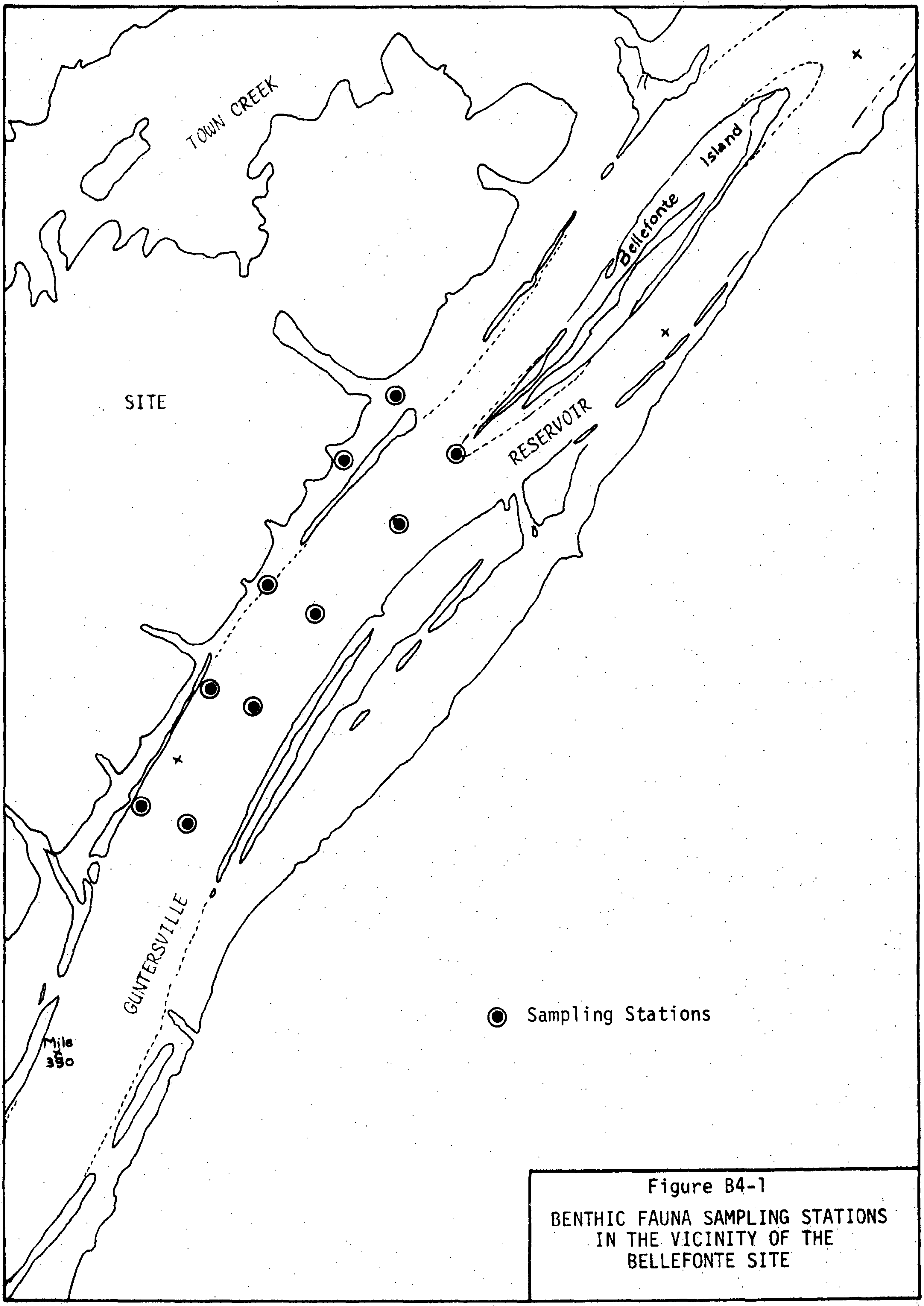
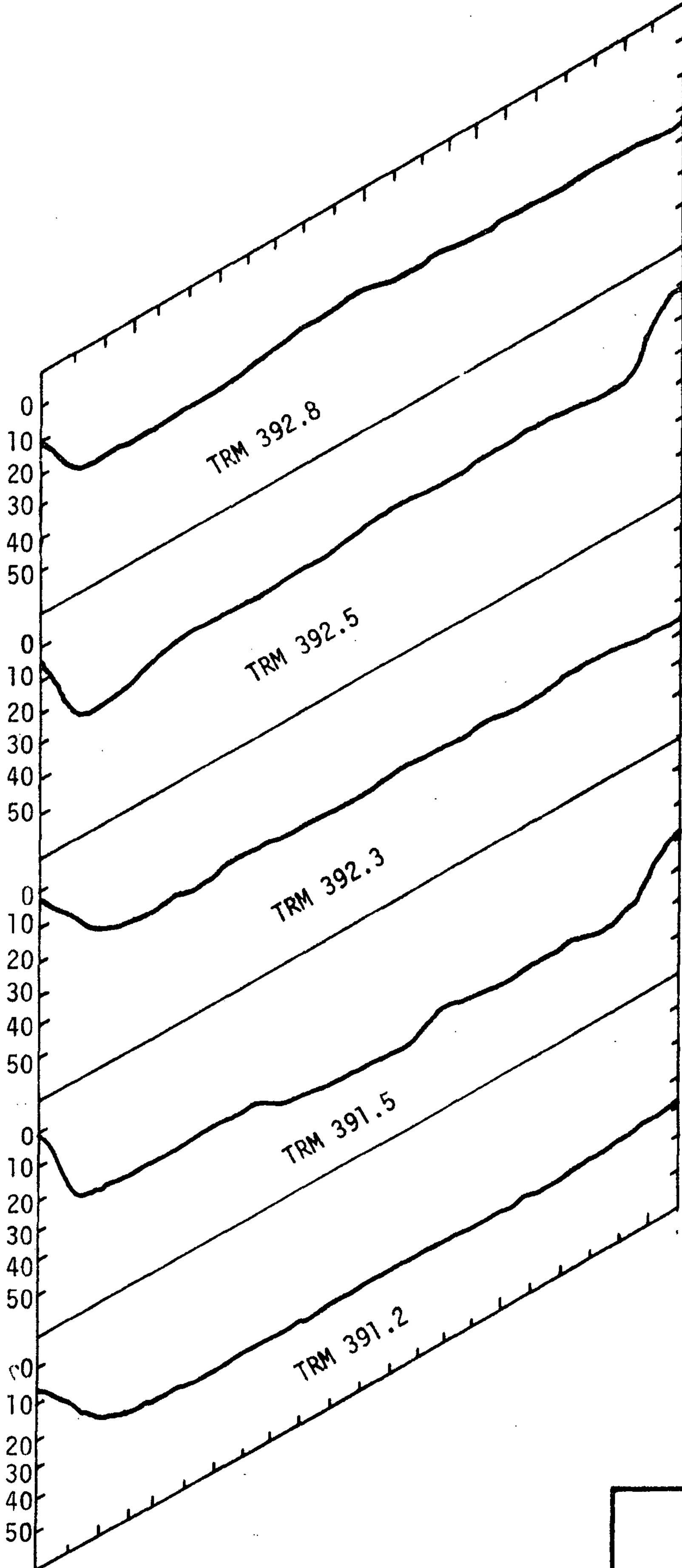


Figure B4-1

BENTHIC FAUNA SAMPLING STATIONS IN THE VICINITY OF THE BELLEFONTE SITE



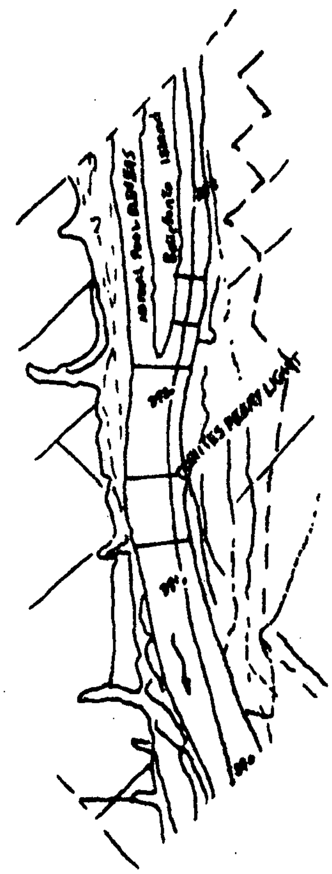
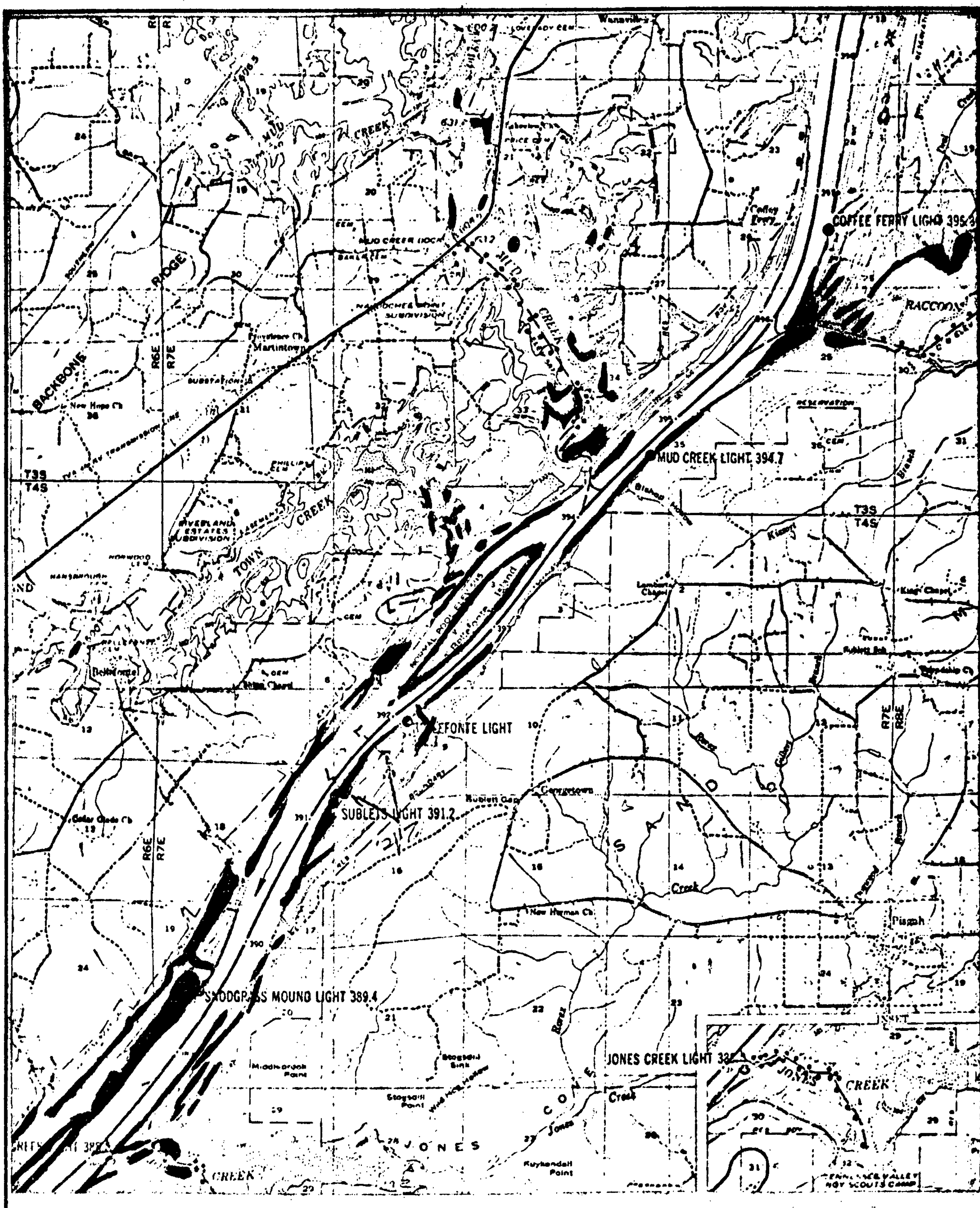


Figure B4-2

TOPOGRAPHIC FEATURES OF GUNTERSVILLE RESERVOIR IN THE VICINITY OF THE BELLEFONTE SITE



Shaded Area is Eurasian Watermilfoil Colonies.

Figure B4-3

WATERMILFOIL INVASION NEAR BELLEFONTE PLANT SITE

Samples and Observations were Done on July 18, 1972

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-2

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-3

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-5

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-6

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-9

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-10

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-11

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

C-12

Exempted from Disclosure by Statute – Withhold under 10 CFR 2.390(a)(3)

Appendix D

RADIOLOGICAL ANALYSIS FOR TRANSPORTATION OF SPENT FUEL AND RADIOACTIVE WASTE

1. Normal shipment - The direct external radiation dose from the normal shipment of irradiated fuel elements and radioactive waste has been estimated.

Three cases are considered. These cases are: (1) the dose rate versus distance from a stationary shipping container under normal conditions; (2) the dose to an individual from the passing shipping container; and (3) the population dose due to the passage of the shipping container (see figure D-1).

The dose rates and doses are estimated by considering the source to be an isotropic point source located at the centerline of the shipping container. Under normal conditions the dose rate shall not exceed 10 mrem/h at 6 feet from the container surface. The source strength, I, produces 10 mrem/h at 6 feet + R_c, where R_c is the container half thickness. The average gamma-ray energy is calculated to be about 1 MeV.

The dose rate as a function of distance from the shipping container is calculated by

$$DR = \frac{I\ e^{-\mu r}\ B(E,\ Z,\ \mu r)}{r^2}\ , \qquad (1)$$

where

I = source output, $\left(\frac{\text{mrem-ft}^2}{\text{h}}\right)$,

r = source to receptor distance, (ft),

μ = linear attenuation coefficient, (ft^{-1}), = 2.5×10^{-3} ft^{-1},

$B(E, Z, \mu r)$ = linear buildup factor for air and is given by

$$1 + K\mu r \quad , \qquad (2)$$

where

$$K = \frac{\mu - \mu_{en}}{\mu_{en}}$$

and μ_{en} is the linear energy-absorption coefficient.

The results of the dose rate calculations for a stationary shipping container are shown in figure D-2.

The total dose delivered to an individual at a given distance from the centerline of the right of way by a passing shipping container passing with a constant speed of 20 mi/h is calculated by

$$D(d) = \int_{-\infty}^{\infty} DR \, dt \quad , \qquad (3)$$

where

$$dt = \frac{dx}{v} \quad ,$$

and

x = the distance along the shipping route, (ft),

v = the velocity, $\frac{ft}{h}$,

therefore,

$$D(d) = \frac{2I}{v} \int_{0}^{\infty} \frac{e^{-\mu r}}{r^2} B(E, Z, \mu r) dx \quad , \qquad (4)$$

where

I = source output, $\left(\frac{mrem\text{-}ft^2}{h}\right)$,

$r = (x^2 + d^2)^{1/2}$, (ft),

d = the distance normal to the centerline of the container's line of travel at which a person is located, (ft),

B(E, Z, μr) and μ are as defined for equation 1.

The dose to an individual at varying distances, d, from a passing shipping container is given below.

d (ft)	Dose (mrem)
100	2.9×10^{-4}
200	1.0×10^{-4}
350	5.9×10^{-5}
600	9.7×10^{-6}
1,000	1.5×10^{-6}
1,500	2.6×10^{-7}
2,200	5.4×10^{-8}

The population dose within 1/2 mile of the route of travel is calculated by considering the integrated dose at 6 intervals between 100 and 2,640 feet from the right of way centerline. The computation is based on the assumption that 100 people per square mile are uniformly distributed along the route of travel. An actual population dose may be computed by multiplying the population dose based on 100 persons per square mile by the ratio of the actual population density to the assumed population density. Using these assumptions a population dose of 1.59×10^{-6} man-rem/mi per shipment is calculated.

In these calculational estimates, the attenuation due to manmade structures, trees, and other scatterers and/or absorbers is not considered.

2. Transportation accident - The principal potential environmental effects from an accident involving irradiated fuel are those from direct radiation resulting from increased radiation levels and from gaseous release of noble gases and iodine.

The direct external radiation dose rate from a transportation accident has been evaluated. Under accident conditions the dose rate shall not exceed 1,000 mrem/h at 3 feet from the container surface. The dose rate is estimated using equation 1 and a source strength which produces 1,000 mrem/h at 3 feet + R_c. The results are shown in figure D-3.

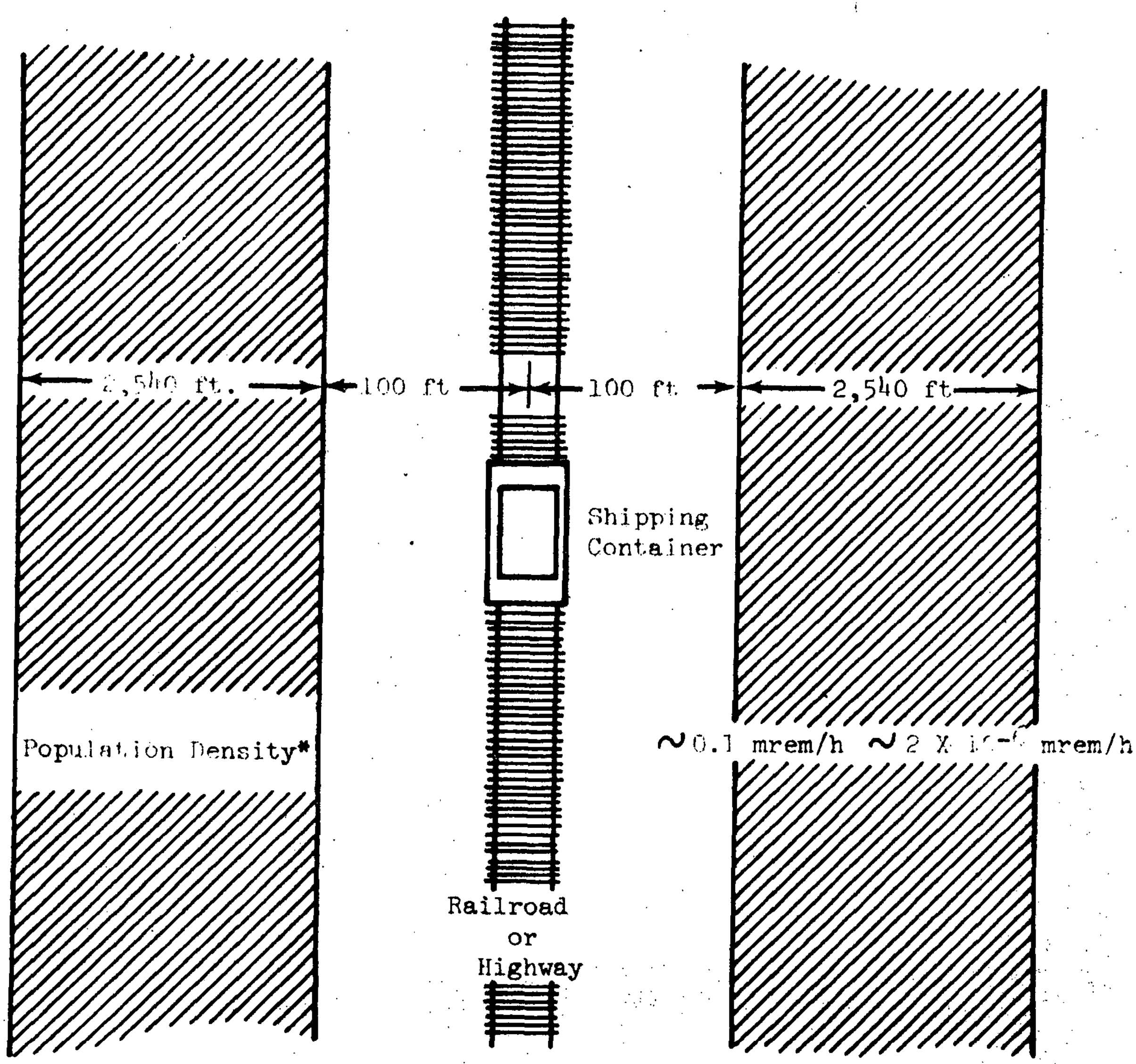
It is assumed that there would be no gaseous releases without a substantial quantity of decay heat in the shipping container plus the addition of external heat such as from a fire. Thus, it is assumed that the thermal currents surrounding the container carry any released fission gases to a height of 10 meters before they are dispersed in the environment. Doses to the whole body, skin, and thyroid have been calculated and are plotted vs. distance in figure D-4. These dose curves represent the envelope of the doses for Pasquill stability conditions A through F with a wind speed of 1 m/s. For a specific accident (with a wind speed of 1 m/s and for one particular Pasquill stability condition) the maximum doses would be equal to the "plateau" doses shown in figure D-4, but the "plateau" doses would not prevail over the entire range of distance between 50 and 1,300 feet. For wind speeds in excess of 1 m/s the doses would be lower than shown in figure D-4 by a factor equal to the reciprocal of the wind speed. Assuming a person stands 50 feet from the cask during the entire accident, the resulting whole-body dose is about 2 mrem, the skin dose is about 86 mrem, and the thyroid dose is about 5 rem. Assuming an average population density of 100 persons per square mile, the whole body dose due to gaseous releases is 0.07 man-rem, the population skin dose is 2.5

man-rem, and the iodine inhalation population dose is 150 man-rem. TVA considers the average population to be the most realistic number to use in analyzing transportation accidents because of the small fraction of the total distance traveled in high population density areas and because accidents in such areas generally occur at lower speeds and therefore would be less severe.

Doses to a truck driver who remains near the truck during a transportation accident are about 2 mrem to the whole body, about 86 mrem to the skin, and about 5 rem to the thyroid. The whole-body dose to the driver due to direct radiation from the shipping cask can be estimated from figure D-3.

Consideration has been given to the radiological impact of the shipment of tritiated water. The low-energy direct radiation from tritium will be shielded by the shipping container and will not be a source of radiation exposure during normal transportation. Calculations have been performed for an accidental release of the entire contents of a 3,700-gallon container of tritiated water with a tritium concentration of 2.5 μCi/cc. A conservative upper limit for the resulting radiation dose is computed by assuming that all of the tritium evaporates into the atmosphere and is blown directly to an individual who remains at the maximum dose point for the entire period of release to the atmosphere. With these assumptions the maximum whole-body dose is computed to be 440 mrem, which is less than the annual dose limit to an individual in the general public specified in 10 CFR Part 20. This dose decreases rapidly with distance, as shown in figure D-5, and at 600 feet is 17 mrem. Figure D-5 has been prepared assuming Pasquill stability condition

F and a wind speed of 1 m/s. For Pasquill stability condition A through E and wind speeds of 1 m/s, the dose at 50 feet from the cask will be about the same as shown in figure D-5 (440 mrem), but the doses at downwind distances beyond 50 feet would be lower than shown in the figure. For wind speeds above 1 m/s, doses may be predicted by multiplying the doses calculated for a wind speed of 1 m/s by a factor equal to the reciprocal of the wind speed. If a uniform average population density of 100 persons per square mile is assumed, the population dose within 50 miles is less than 0.08 man-rem.



When Container is moving at 20 mph:

Maximum Individual Exposure = 0.00029 mrem/trip
Average Individual Exposure = 0.000016 mrem/trip

* Assume 100 persons/mi^2 for spent fuel shipments and for radioactive waste shipments.

Figure D-1
Spent Fuel and Radioactive Waste Shipments Population Exposure Distribution

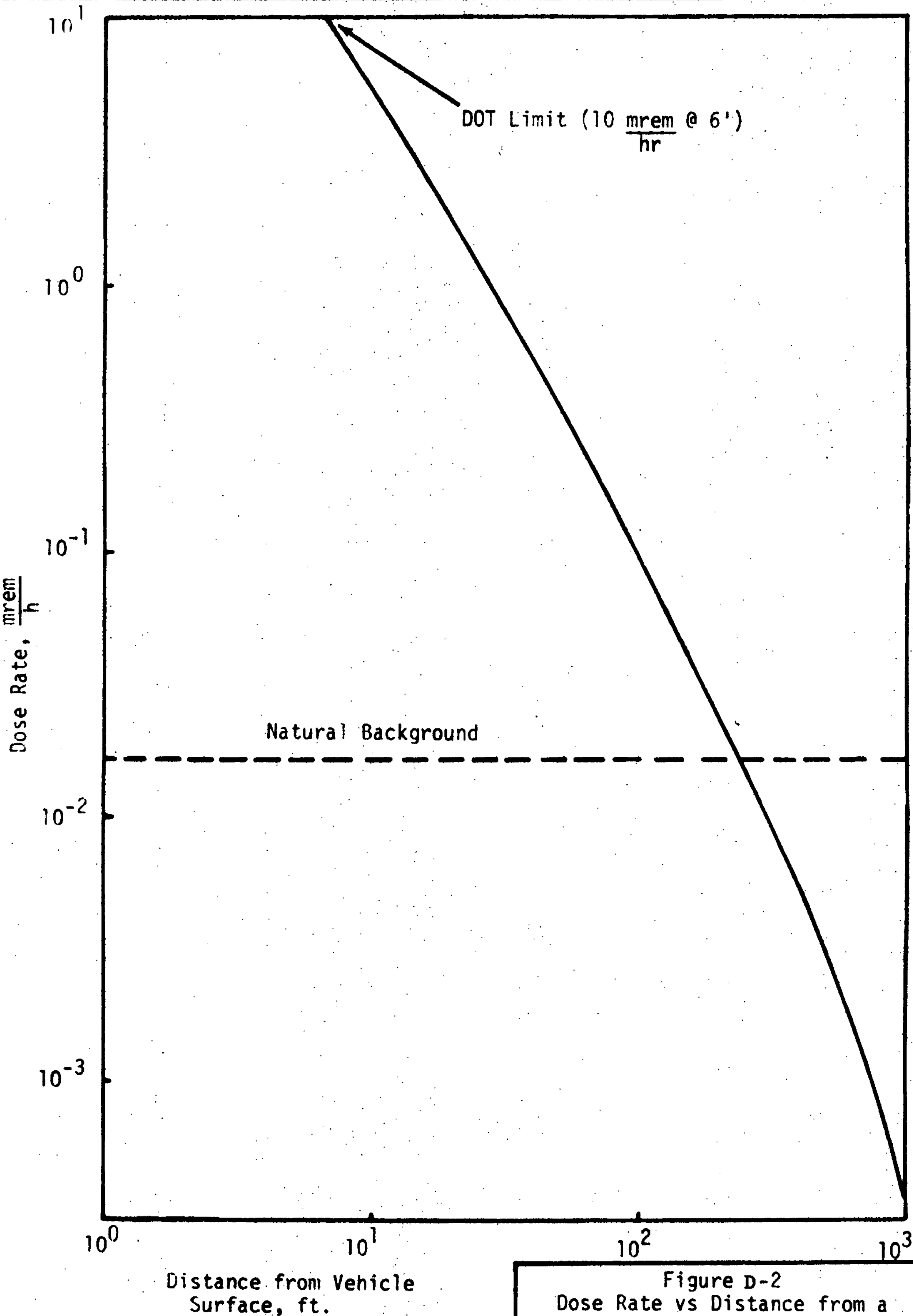


Figure D-2
Dose Rate vs Distance from a Stationary Shipping Container, Normal Conditions

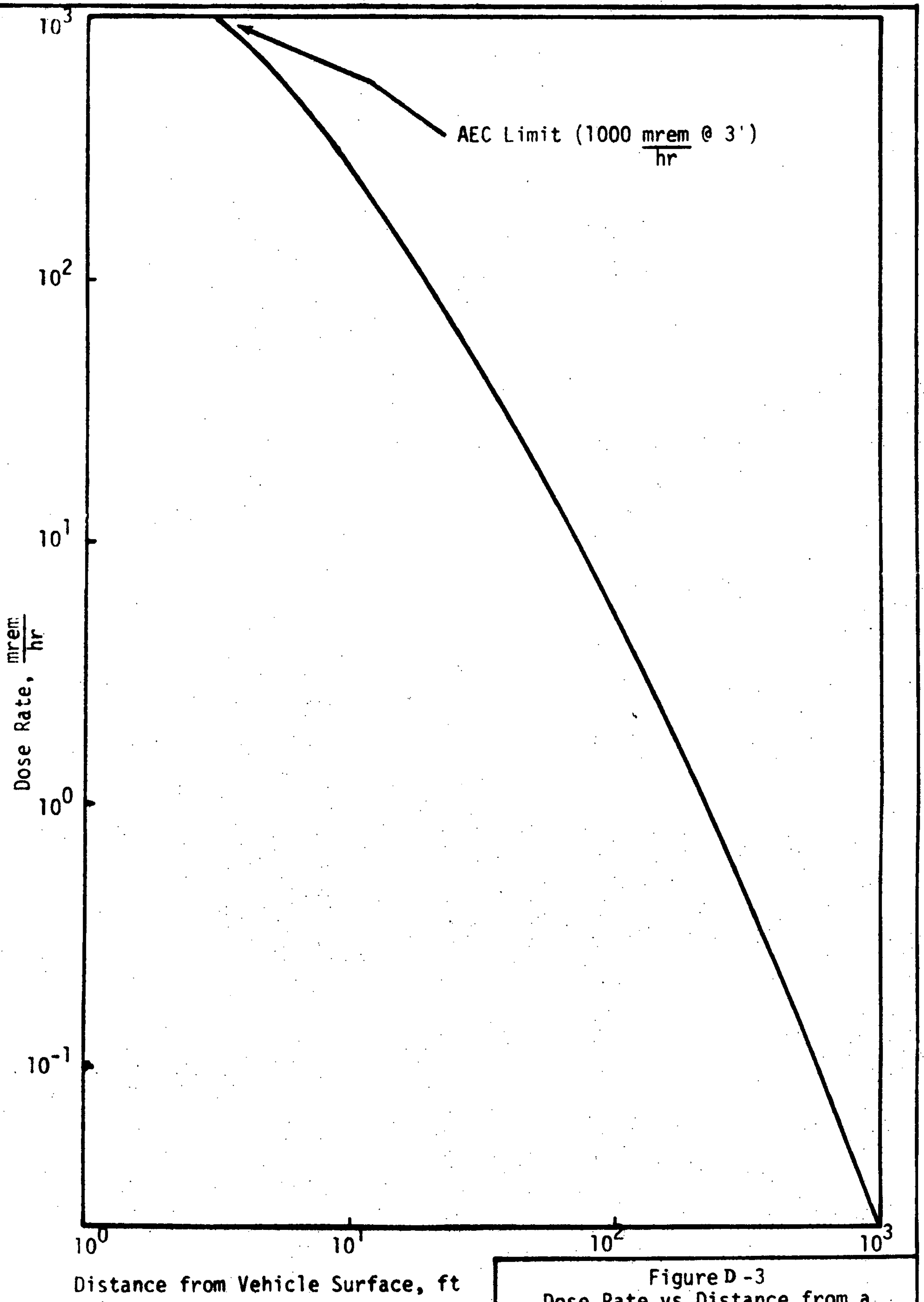


Figure D-3
Dose Rate vs Distance from a Stationary Shipping Container, Accident Conditions

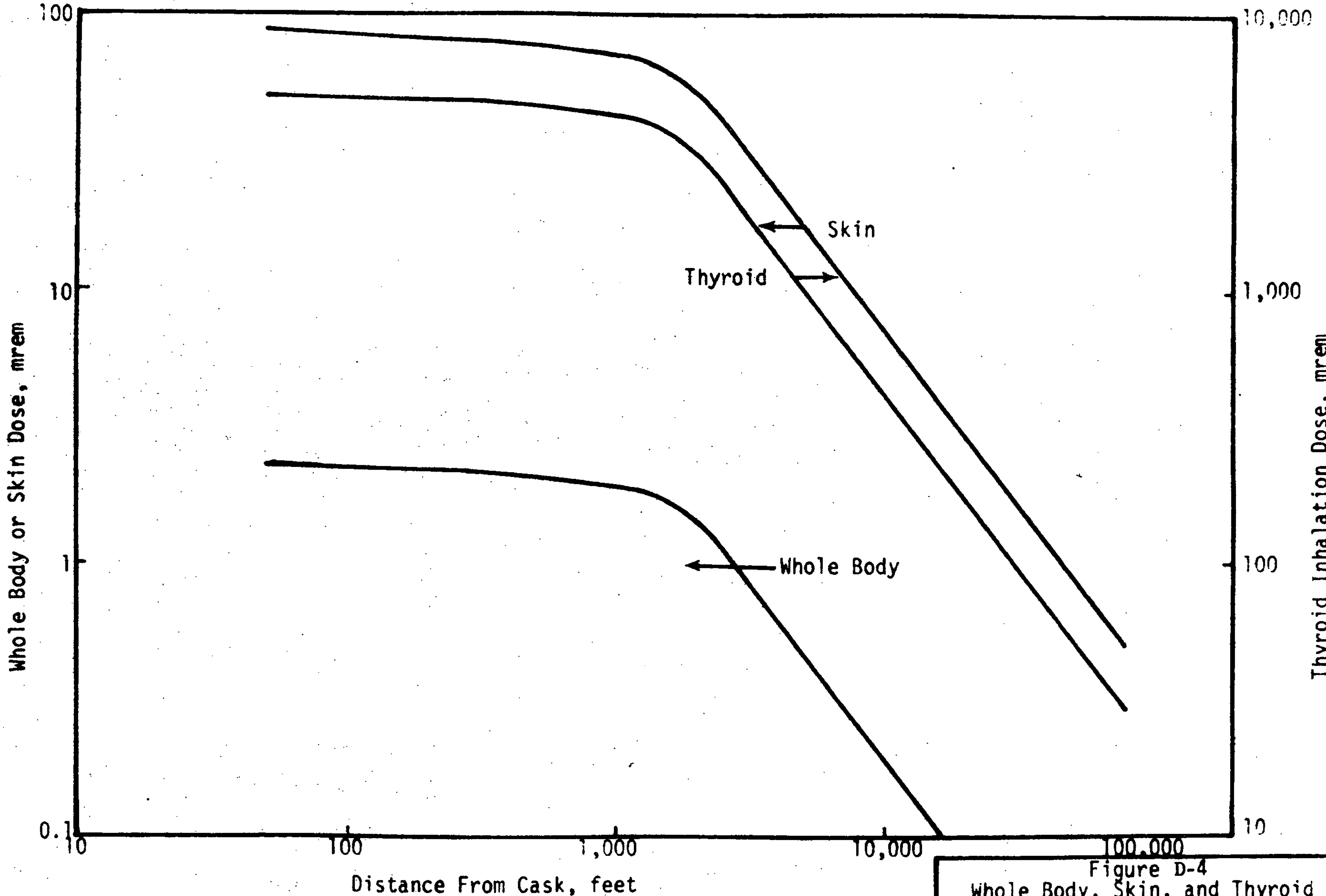


Figure D-4
Whole Body, Skin, and Thyroid Inhalation Doses vs Distance for Release of 1000 Ci of Noble Gases and 10 Ci of I-131 During a Spent Fuel Transportation Accident

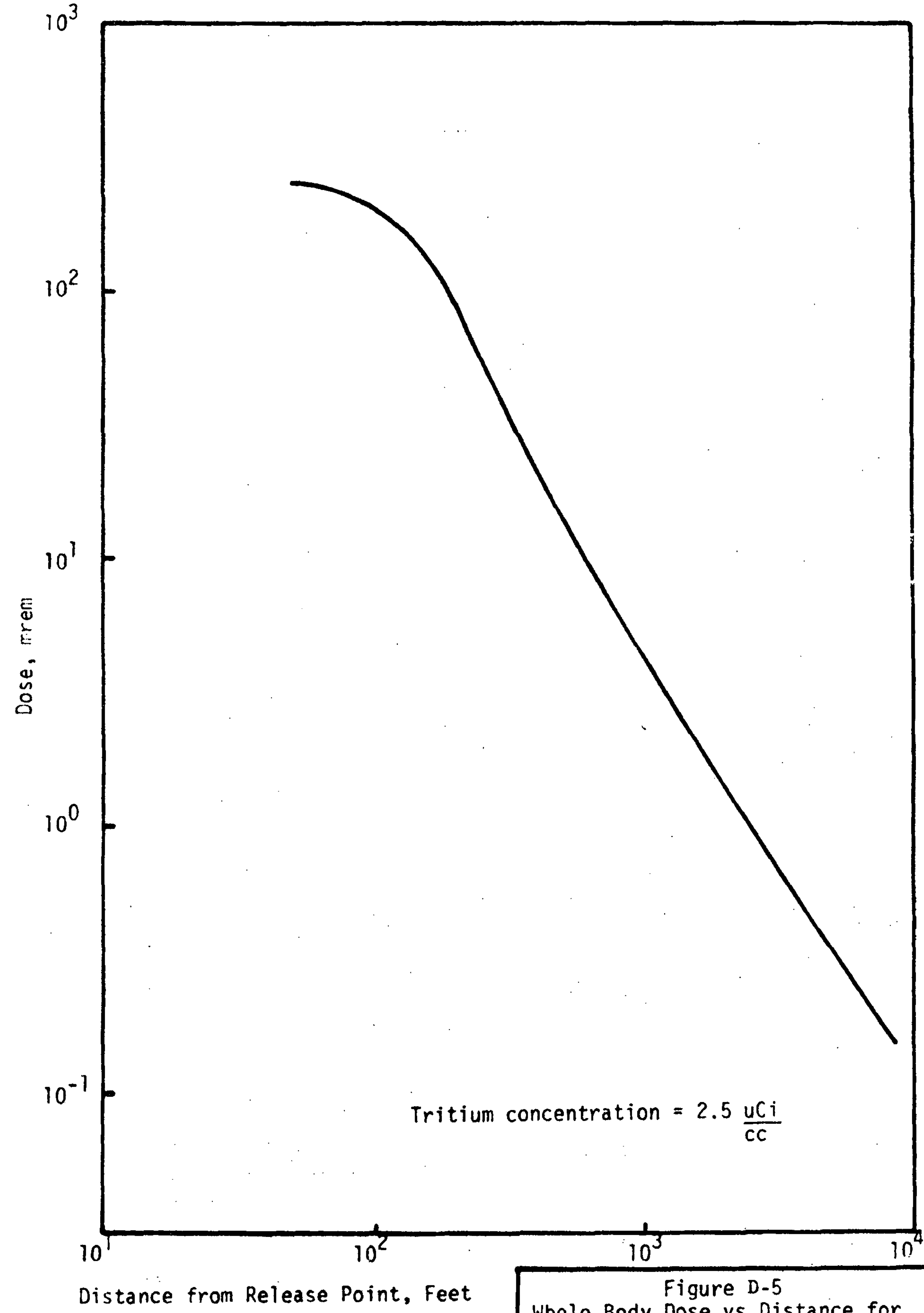


Figure D-5
Whole Body Dose vs Distance for Release of 3,700 Gallons of Tritiated Water During Transportation Accident

Appendix E

RELATION OF 10 CFR PART 71 ACCIDENT REQUIREMENTS TO ACTUAL SHIPPING ENVIRONMENT

1. Performance requirements of 10 CFR Section 71.36 - The domestic transportation of radioactive materials is regulated at the Federal level by both the Atomic Energy Commission and the Department of Transportation. The primary aim of the regulations is, of course, to protect the public by rigorously restricting the amount of radiation to which people are exposed. The regulations given in 10 CFR Section 71.36 are written in terms of performance specification requirements for hypothetical accident conditions.

The following discussion is directed toward relating the 10 CFR Part 71 accident conditions to similar conditions which might be experienced as a result of a transportation accident.[1]

It should be noted that there is a wide margin of safety in the container design itself. The container is required to withstand the accident conditions imposed pursuant to 10 CFR Part 71 with only relatively minor damage to the container and no release of the contents except for a small amount of coolant and a small quantity of noble gases. For example, the IF-300 shipping cask is designed to absorb the total effects of the impact with only minor deformation of the outer fins that have been provided for impact protection. No credit is taken for deformation of the outer steel shell. Thus, because of the relative strength of the shell as opposed to the impact energy-absorbing fins, there is a wide margin between the damage that would be experienced by the cask in absorbing the energy of the 30-foot free fall and that which would be required to breach the container such that there could be a release of the radioactive contents. It is estimated that the amount of energy involved to sustain a significant breach would be from five to ten times that which the cask experiences in a 30-foot free fall.

Thus, as pointed out below, it is unlikely that the casks will experience conditions as severe as those imposed by the 10 CFR Part 71 requirements, and in any event, conditions far more severe than those would be required to result in a substantial breach of a container. As shown in the analysis below, the proposed tests are representative of conditions at least as severe as those which would be experienced by containers in transport. Further, since the tests are required to be applied to the containers in sequence, the cumulative severity of conditions to which the containers are subjected in all probability far exceeds that to which the containers would ever be subjected as a result of an accident in the course of transportation. It is highly improbable that a container would be subjected to conditions as severe as even one of these conditions, let alone all three in the sequence provided for the test.

(1) 30-foot free fall - The shipping cask is required to withstand a 30-foot free fall onto an essentially unyielding surface. This requires that all the energy of the impact be absorbed by deformation of the container. In addition, the container impact must be considered from all possible orientations to assure that the impact protection provided is adequate regardless of the orientation of

the fall. Based on previous design experience, it is estimated that a shipping cask will decelerate (stop) on impact within a distance of 2 to 8 inches.[2] To provide a basis for this comparison it has been assumed that a shipping cask would decelerate completely within 6 inches after impact with the unyielding surface. Table E-1 shows a comparison of the various forces which would be generated by the stopping of the shipping cask, an overweight truck, or an automobile traveling at various speeds on striking an unyielding surface.

As indicated in the table, a 45,000-pound shipping cask traveling at 30 mi/h, which is the terminal velocity following a 30-foot free fall, would create 2,700,000 pounds of force if stopped within a distance of 6 inches. A 130,000-pound cask, which is equivalent to the IF-300, would generate about 7,800,000 pounds of force. A loaded truck, weighing 75,000 pounds and traveling at 60 mi/h, coming in contact with the unyielding surface is assumed to decelerate within 10 feet. Under these conditions, the truck would generate a maximum of 900,000 pounds of force, or about one-third of the force that would be generated by the 45,000-pound cask as a result of the 30-foot free fall. Likewise, a 5,000-pound automobile traveling at 80 mi/h hitting an unyielding surface is assumed to stop in only 5 feet, which would generate about 220,000 pounds of force. Thus, it is seen that typical objects which the cask might encounter would generated substantially less force than the shipping cask because of the relatively weaker sections of their structures and the greater distance required to decelerate those bodies.

A second area of concern is the shipping cask colliding with stationary objects such as bridge abutments, etc. In this regard, it should be noted that even heavily loaded trucks contacting such stationary objects generally severely damage the object and displace it by some measurable amount. Therefore, these stationary objects generally cannot be considered as unyielding surfaces for the purposes of assessing the effects of a shipping cask impact. As demonstrated in Table E-1, the force developed by the shipping cask would be far greater than that developed by even a loaded truck, and thus the displacement of the "stationary objects" would be even greater than that encountered in a truck-type accident. Additionally, these impacts with the shipping cask assume that the shipping cask contacts the surface with the center of gravity directly behind the point of impact and in the line of travel such that the maximum force is exerted on the cask. In all likelihood, a shipping cask contacting such surfaces would strike a glancing blow in which case the energy required to be absorbed by the shipping cask would be greatly diminished over that which would result from a direct impact.

The required analysis of a 30-foot drop onto an essentially unyielding surface adequately provides for force to which a cask might be subjected as a result of a transportation accident. Therefore, as a result of these conditions and the ruggedness of the cask, the possibility of encountering a transportation accident of sufficient severity to result in rupture of the container has an extremely low, if not incredible, probability.

(2) <u>40-inch drop test</u> - The 40-inch puncture test requires that the cask be dropped from a height of 40 inches,

with the center of gravity directly above the point of impact, onto a 6-inch diameter pin of sufficient length to puncture the container but without allowing the puncture of even the outer shell of the vessel. The formula for analysis of this condition was developed at Oak Ridge National Laboratories[2] and other places based on extensive testing of steel and lead shipping containers.

In regard to the relationship of this test to the transportation environment, it was originally intended that the 6-inch diameter pin would approximate that of the end of a rail for rail transportation accidents. It should be noted that the puncture so specified would require that the cask hit the pin exactly perpendicular to the cask surface. Any deviation from this would result in a substantially reduced loading on the side of the cask and enhance chances of deflection. Further, the pin must be long enough to penetrate through the walls of the container, which would require damage to the contents. In most cases this would require that the pin be approximately 12 to 18 inches in length. However, if the pin is much longer than this, it becomes doubtful that the column strength of the pin is sufficient to rupture the container without buckling of the proposed pin.

It should be noted that the containers are required to pass the puncture test without rupture of even the outer shell. As generally there is a heavy outer shell backed up by several inches of shielding material followed by an inner steel shell, there is a wide margin between the damage that the container would sustain as a result of the required puncture test and that which would be required to rupture the inner vessel such that there could be dispersal of the radioactive contents. This test provides conditions at least as severe as those to which a container would be subjected as a result of a transportation accident.

(3) 30-minute fire test - The 30-minute fire test was proposed as that to which a container would be subjected as a result of large open burning of petroleum such as diesel or jet fuel. In this regard it should be noted that the test conditions require that it be assumed that the cask is perfectly surrounded by a uniform heat flux corresponding to a thermal emissivity of 0.9 at a temperature of 1475°F. In actuality, the cask will most likely be lying on the ground near the cooler part of the flames such that it is not surrounded completely by the fire environment. Further, while there may be individual flame temperatures hotter than the proposed 1475°F, the average flame temperatures will not exceed these values. It is unlikely that a container the size of a large shipping cask would be completely engulfed in flames due to lack of the required quantities of combustible materials, winds which tend to blow the flames away from the container, and other factors which act to reduce the idealized conditions assumed for compliance with the 10 CFR Part 71 requirements. It is felt that the test conditions proposed in the regulations provide adequate, if not more severe, simulation of the fire conditions to which a container might be subjected during the course of transportation.

(4) Conclusion - In summary, the casks are designed to meet the requirements of applicable regulations, and it is unlikely that accident conditions more severe than those postulated in the regulations would be encountered.

REFERENCES FOR APPENDIX E

1. Excerpt from Applicant's Environmental Report, Supplement 1 - Midwest Fuel Recovery Plant, Morris, Illinois, General Electric Company.

2. Cask Designers Guide. Oak Ridge National Laboratory, ORNL-NSIC-68.

Table E-1

IMPACT ACCIDENT COMPARISON

Object	Weight (lb)	Initial Velocity (mi/h)	Stopping Distance (ft)	G's	Deceleration Force (lb)
Cask	45,000	30	0.5	60	2,700,000
Cask	130,000	30	0.5	60	7,800,000
Truck	75,000	60	10.0	12	900,000
Car	5,000	80	5.0	44	220,000

Appendix F

OZONE PRODUCTION AND ITS POTENTIAL EFFECTS

This appendix summarizes and references the literature on the characteristics of ozone and its potential effects on plants, animals, and man. Natural sources of ozone are compared with reference values of the quantities measured during tests on EHV transmission lines. Ozone quantities are also compared with the "Community Air Quality Guides"[1] and the "National Primary and Secondary Ambient Air Quality Standards"[2] for oxidants.

1. Ozone characteristics and potential effects on plants, animals, and man - The characteristic pungent odor of ozone can be detected at very low concentrations (0.02 to 0.05 ppm depending on individual acuity). At somewhat higher concentrations (0.05 to 0.10 ppm) the odor becomes more pronounced and disagreeable. Ozone is one of the most powerful oxidizing substances known and combines readily with many materials.

Ozone is not considered to be injurious to vegetation, animals, and humans unless concentrations exceed about 0.05 ppm over prolonged periods.[1] Extremely sensitive varieties of tobacco can be injured after about 8 hours of exposure to 0.05 ppm ozone or a 1-hour exposure of 0.07 ppm.[1,3] Most other vegetation, however, can withstand exposures exceeding 0.10 ppm for 8 hours without injury.[1,3] Mice exposed to ozone levels of 0.08 ppm in the laboratory for 3 hours which were then infected with streptococcus experienced a 23 percent increase in mortality rate.[4] TVA is not aware of any similar correlation studies of reduced tolerance to diseases versus ozone exposure which may have been made for humans. Most humans generally experience discomfort from ozone's unpleasant odor by the time concentrations approach 0.05 ppm.[4] Spectrograph operators who have experienced intermittent exposures of ozone concentrations in the range of 0.10 to 1.00 ppm over a 2-week period complained of shortness of breath and continuous headaches.[4] The visual acuity of humans can be reduced by prolonged exposures of 0.20 to 0.50 ppm.[3] Technical literature dealing with possible ozone-induced chromosome aberrations extrapolated from animal studies indicated that presently permitted ozone exposure would be expected to result in break frequencies that are orders of magnitude greater than those resulting from permitted radiation exposures.[5] The recent "Community Air Quality Guide,"[1] issued for ozone by the American Industrial Hygiene Association after consideration of the radiomimetic nature of ozone and the need for a realistic limit, recommended an upper concentration limit of 0.05 ppm for not more than 1 to 2 hours per day to protect very sensitive plants, and an exposure limit of 0.1 ppm/h/d on the average during any year if human health is not to be significantly impaired during a lifetime of exposure. By projecting observed impacts from experimental ozone exposures of Chinese hamsters, one observer estimates that even these levels could possibly produce about 1,270 times more lymphocyte chromosome breaks than the maximum permitted occupational radiation exposure.[5]

2. <u>Natural ozone sources</u> - Ozone is formed in nature by the dissociation action of solar ultraviolet radiation below 2,450A on the oxygen molecules present in the atmosphere. Peak

natural-formed concentrations of ozone as high as 11 ppm or more have been measured in the stratosphere; however, chemical, photochemical, and catalytic reactions tend to destroy the major portion of the ozone at ground levels where peak natural-formed concentrations would be expected to exceed 0.05 ppm only under rare circumstances, i.e., about 1 percent of the time.[1] Average ground-level concentrations of naturally formed ozone is estimated to be about 0.01 ppm in the United States.[4]

The actual instantaneous values for any specific location can vary from less than 0.01 ppm to over 0.05 ppm, depending on altitude, meteorological factors, geographical latitude, time of day, and time of year. Figure F-1 illustrates how ozone concentrations vary with altitude; however, vertical air currents constantly change the distribution, pattern, and magnitude of peak concentrations from those indicated. Similarly, figures F-2 and F-3 illustrate the magnitude of the diurnal variations which can occur between daytime ozone levels produced by the sun and nighttime levels when ozone tends to dissociate to its original oxygen form. The implications of figure F-2 will be discussed in greater detail later as it relates to the environmentally insignificant levels of ozone produced by transmission lines. Lightning is another natural phenomenon which produces large instantaneous quantities of extremely localized ozone; however, this accounts for very little of the total ozone existing in nature.

3. <u>Ozone generation by transmission facilities and other potential sources</u> - Ozone may be generated by any corona or electrical discharge in air or other oxygen medium. Quantities produced are dependent on the quantity of oxygen in the energy envelope. Ozone

may, therefore, be generated in undetermined quantities by motors, circuit breakers, electric welding torches, plasma sources, ultraviolet and fluorescent lamps, applicances, switches, transmission lines, or any other device which produces corona or electrical discharges.

Corona discharges can increase as a result of abrasions, foreign particles or sharp points on electrical conductors and electric equipment, or incorrect design which produces excessively high potential gradients. However, the design and construction of TVA transmission facilities minimize corona discharges and arcing. TVA specifications require that transmission line hardware and electrical equipment for operation at 500,000 volts be factory tested to assure as near corona-free performance as possible up to maximum operating voltage levels.

An extensive field-test program of detection of ozone in the vicinity of 765-kV lines has recently been completed, and full details and conclusions were incorporated in papers submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.[6,7] Tests were conducted by Battelle Memorial Institute at 20 locations and under a variety of meteorological conditions, including several tests in which the instruments were placed as close as 6 meters downwind from the energized 765-kV conductors, at the conductor height. Ozone, NO_x, and corona-loss measurements were simultaneously conducted, under contract to AEP, at the Westinghouse EHV Laboratory at Trafford to measure the rates of ozone and NO_x production from full-scale conductor bundles which could be operated at 765 kV.[8] Diffusion models developed from these tests agreed closely with the actual transmission line measurements. No ozone contribution to the natural ozone levels was detected which could be attributed to the transmission lines.

Under these tests sponsored by the Electric Research Council and jointly financed by the Edison Electric Institute and the Bonneville Power Administration, the General Electric Company[9,10,11,12] is conducting transmission research in the 1,000-kV to 1,500-kV range. As a result of questions posed about the possible levels of ozone generation from the UHV configurations, ozone was monitored at the project. Figure F-2 shows ozone concentrations during the time the UHV test line was energized and deenergized over a 2-week period and graphically illustrates the following conclusions:

> From the results, it was evident that sunlight on a clear day is a more efficient producer of ozone than UHV lines, and any amounts created by the lines were so small that they were lost in the background produced by the sun's radiation.[13]

4. Conclusion - No significant adverse effects on vegetation, animals, or humans are expected to result from possible levels of ozone production attributable to transmission facilities for transmission voltages up to 765 kV. It is concluded that any level of ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum voltage), either resulting from normal transmission operation or following breaker or switching operations for the periods and the levels that they could be expected to persist, are environmentally inconsequential to humans, animals, or vegetation.

REFERENCES FOR APPENDIX F

1. American Industrial Hygiene Association. "Community Air Quality Guides. Ozone." American Industrial Hygiene Association, J. 29, pp. 299-303. 1968.

2. "Environmental Protection Agency's National Primary and Secondary Ambient Air Quality Standards," Federal Register, Volume 36, No. 84 (April 30, 1971), pp. 8186-8201.

3. Heggested, H. E., "Consideration of Air Quality Standards for Vegetation with Respect to Ozone," Journal of the Air Pollution Control Association.

4. Jaffe, Louis S., "The Biological Effects of Ozone on Man and Animals," American Industrial Hygiene Association Journal, May-June 1967, pp. 267-277.

5. Zelac, R. E., H. L. Cromroy, W. C. Bloch, B. G. Danavant, and H. A. Bevis. "Inhaled Ozone as a Mutogen - Chromosome Abberrations Induced in Chinese Hamster Lymphocytes," Environmental Research 4, pp. 262-282, 1971.

6. Fryden, M., A. Levy. "Oxident Measurements in the Vicinity of Energized 765-kV lines," American Power and Battelle Memorial Institute submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.

7. Schere, H. N., B. J. Ware, and C. H. Shih. "Gaseous Effluents Due to EHV Transmission Line Corona," American Electric Power submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.

8. Roach, J. F., Chartier. "An Estimate of Ozone and NO_x Concentrations Near Extra High Voltage Transmission Lines Based on Laboratory Measurements of Ozone and NO_x Production Rates for Four Conductor Bundles," Westinghouse Research Laboratories Research Report 71-7E8-COZOM-R1, December 31, 1971.

9. Letter and attachments, J. M. Schanberger to Dr. G. W. Walkins, dated November 15, 1971. "Report to the Electrical Research Council RP-68 UHV Transmission Research Project."

10. Juette, G. W., "Corona-Caused Air Pollution - Preliminary Tests," Electrical Utility Engineering Technical Report T18-71-HY-13, March 18, 1971.

11. Anderson, J. G., "Project UHV Quantity Progress Report - January 1 to March 31, 1971, "Electrical Utility Engineering Technical Report T1S-71-EU-14, March 14, 1971.

12. Juette, G. W., and L. E. Zaffanella. "Test Results of the Energization of Project UHV Test Line-12 x 0.918-inch bundle, 36-inch diameter," Electrical Utility Engineering Technical Report T1S-71-EU-15, May 28, 1971.

13. "UHV Transmission Research Project Extended for Additional Two Years," Edison Electric Institute Bulletin, January-February 1972.

14. Ripperton, L. A., L. Kornreich, and J. Worth. "Nitrogen Dioxide and Nitric Oxide in Nonurban Air," <u>Air Pollution Control Association Journal</u>, Volume 20, No. 9 (September 1970), pp. 589-592.

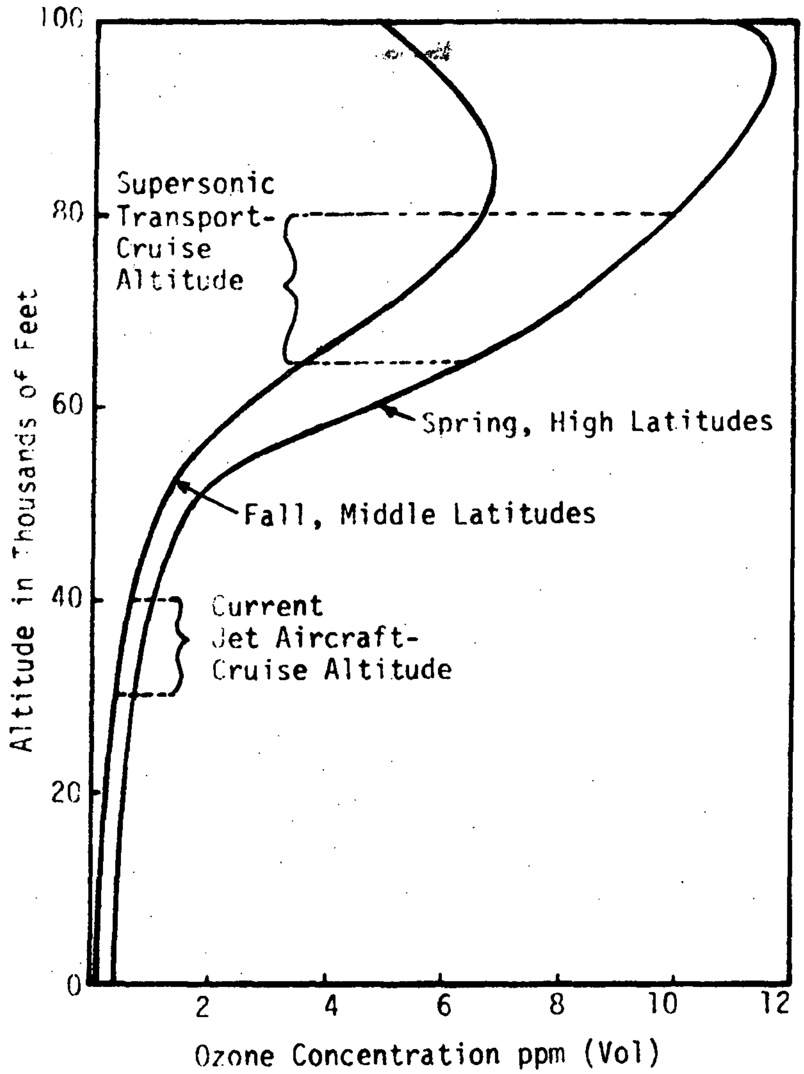


Figure F-1

Ozone Distribution
Northern Hemisphere

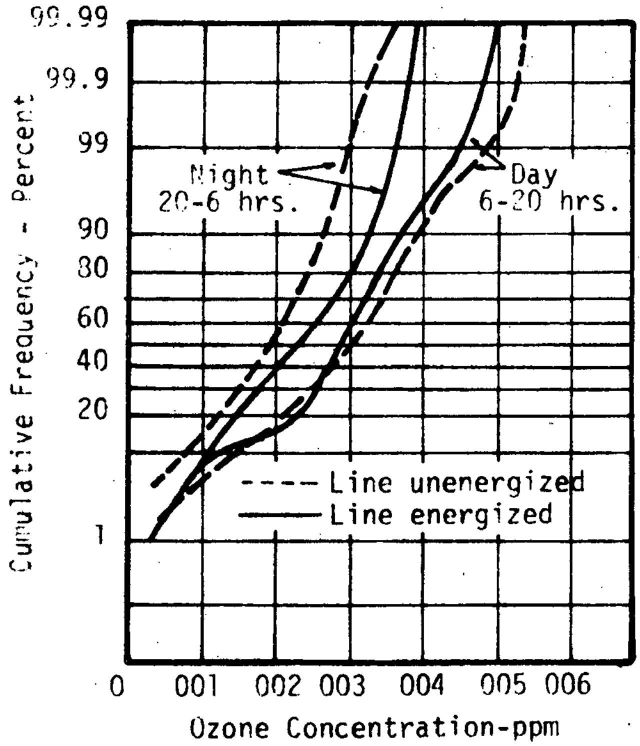


Figure F-2
Ozone Statistic obtained near UHV Test Line during 8 days of Energization and 10 days without Energization

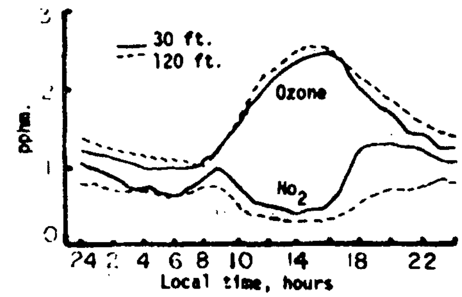
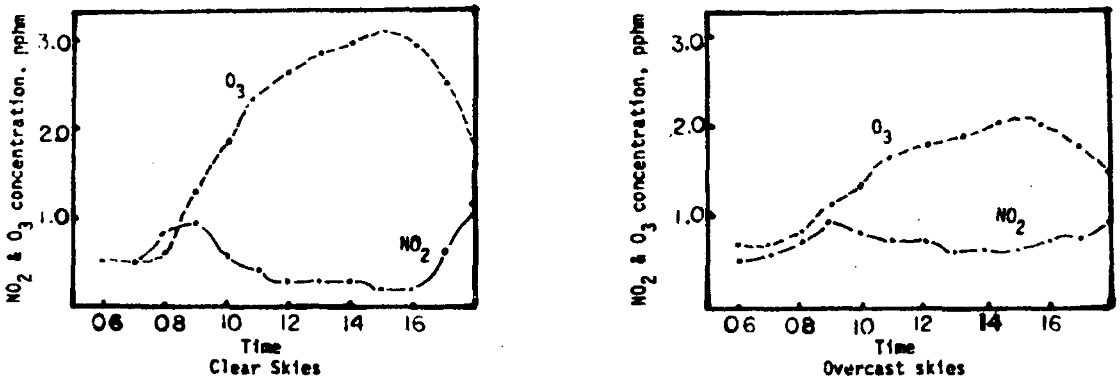


Figure 1. Averages of ozone and nitrogen dioxide for five months(Sept. 1966-Jan. 1967)



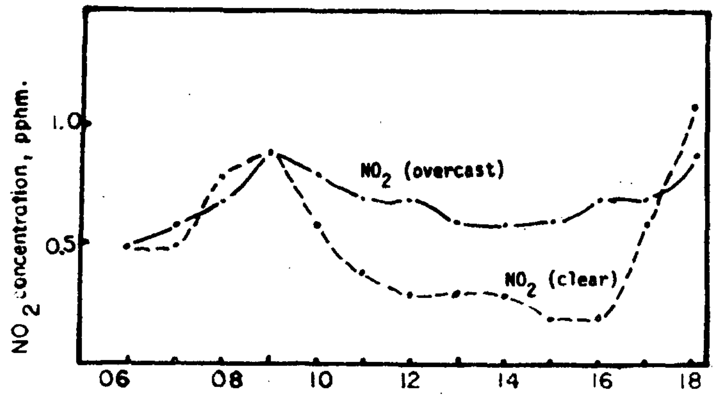


Figure 2. Nitrogen dioxide on clear and overcast days (Sept. 1966-Jan. 1967)

Figure F-3

Functional Relationships of Ozone and Nitrogen Dioxide[14]

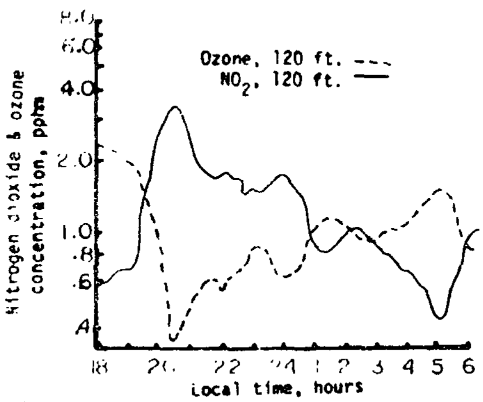


Figure 3. Nitrogen dioxide and ozone (1800-0600 hr on 11/24/66).

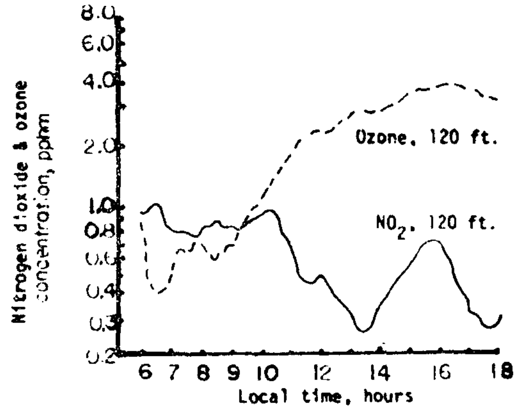


Figure 4. Nitrogen dioxide and ozone (0600 1800 hr on 11/25/66).

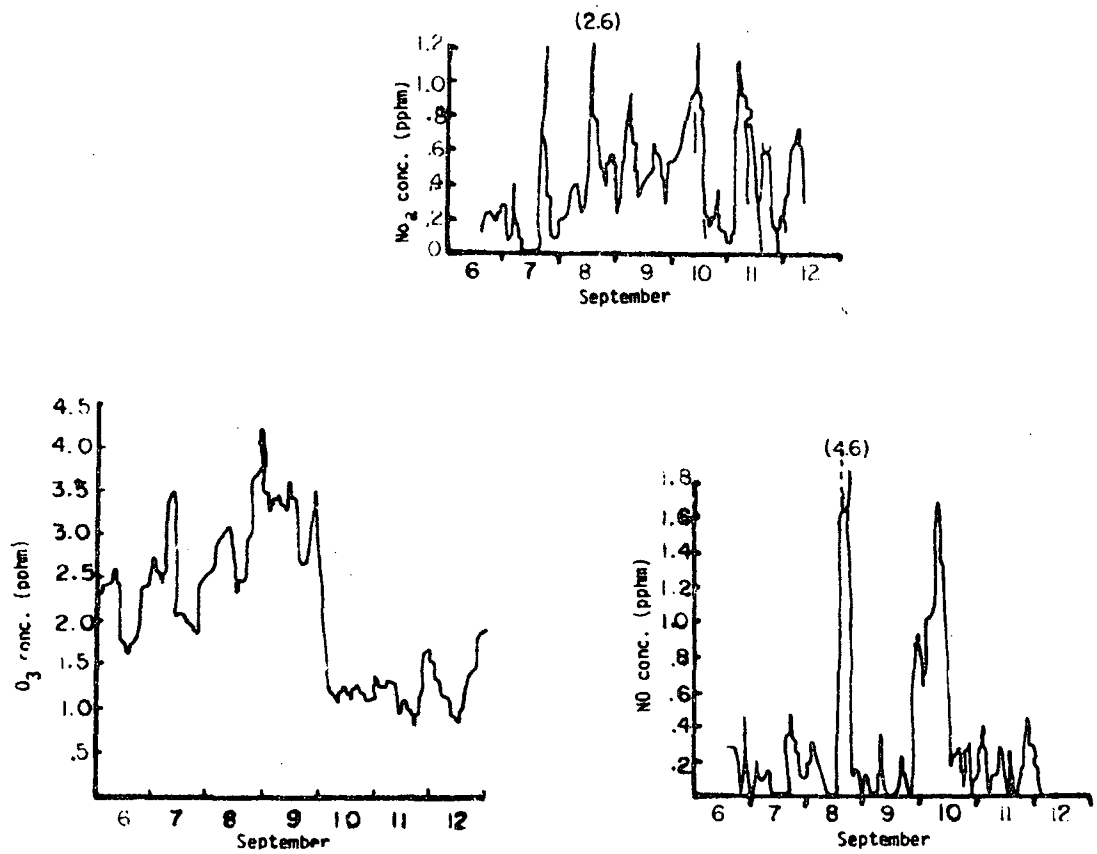


Figure 5. Diurnal averages for nitrogen dioxide and ozone at Green Knob. N. C. (Sept. 1965).

Figure F-3 (Cont'd)

Functional Relationships of Ozone and Nitrogen Dioxide[14]

Appendix G

OUTLINE OF ACCIDENT ANALYSES

1. Introduction - This appendix describes the evaluation of the environmental impact of postulated occurrences and accidents for the Bellefonte Nuclear Plant. This evaluation follows the guidelines given in the AEC document, "Scope of Applicants' Environmental Reports with Respect to Transportation, Transmission Lines, and Accidents," issued on September 1, 1971, and the guidance provided by AEC for the consideration of accidents in December 1971. As shown in Table G-1, the results of this evaluation demonstrate that the consequences of the postulated accidents and occurrences have no significant adverse environmental effects.

The postulated events are divided into the nine accident classes as shown in Table 2.3-1. The events analyzed in each class are those identified in Reference 1. Assumptions not specified in Reference 1 have been selected on the basis of using the most realistic values consistent with the present state of knowledge.

In the following pages, the individual events are described with emphasis on the routes of escape of activity to the environment, and the equipment and structures which contain the activity. Indications of the probable frequency or probability of occurrences of the postulated events are provided to the degree possible. Detailed descriptions of critical equipment and structures will be provided in the preliminary safety analysis report, which will also contain descriptions of very conservative analyses of many of these same events.

Table G-2 through G-8 give the fission product inventories in various plant components that were used in the analysis. Tables G-9a through G-9g tabulate the principal assumptions and parameters used in the analysis of each event. The dispersion of gaseous releases offsite was based on the assumptions discussed in section 10, below.

2. Evaluation of Class 1 and 2 events - Class 1 events are trivial incidents involving small releases due to normal operations. Class 2 events are small releases outside containment such as valve leakage, spills, etc. The releases from both Class 1 and Class 2 events are considered in the evaluation of routine releases.

3. Analysis of Class 3 events - Class 3 events include releases of radioactivity from the waste disposal systems as a result of equipment malfunction or a single operator error. The waste disposal system has been designed to collect, monitor, treat, and discharge or package for disposal liquid, solid, and gaseous wastes. Operations will be conducted in accordance with administrative procedures.

Waste releases and shipments are made on a batch basis which permits knowledge and control of anticipated releases before any action is undertaken to make the actual release. For the liquid and gaseous cases, the actual release is monitored by radiation detectors, and a permanent record of the activity release is recorded.

(1) Liquid radwaste - The bulk of the radioactive liquids discharged from the reactor coolant system are processed and retained inside the plant by the makeup and purification system recycle train. This minimizes liquid input to the waste disposal system which processes relatively small quantities of generally low

activity level wastes. The processed water from waste disposal, which contains relatively little radioactive material, is discharged through a monitored line into the waste discharge pipe.

At least two valves must be manually opened to permit discharge of liquid from the waste disposal system. One of these valves is normally locked closed and the other is interlocked with a flowmeter in the discharge pipe so that it can be opened only if the flow rate exceeds 15,000 gal/min. A control valve will trip closed on a high effluent radioactivity level signal.

The system is controlled from a central panel in the auxiliary building. Malfunction of the system actuates an alarm in the auxiliary building and annunciates in the control room. All system equipment is located in or near the auxiliary building except for the reactor coolant drain tank and drain tank pumps and flood and equipment drain sump and pumps which are located in the containment building.

Leakage of liquid radwaste from tanks is caught in sumps in the auxiliary building. Therefore, leakage or rupture of a radwaste tank does not lead to a significant release to the river. Gaseous activity from such a spill would be picked up by the auxiliary building ventilation system.

For illustrative purposes, an unplanned release of 0.93 curie of radioactive material (equal to the entire expected yearly liquid releases) was assumed to be released inadvertently to the river during conditions when the river dilution flow was 50 percent of the average flow.

(2) Solid radwaste - Because of the nature of solid radioactive wastes and specialized procedures and equipment provided for packaging and handling these wastes, significant accidental releases of radioactivity from solid wastes is considered extremely unlikely.

(3) Gaseous radwaste - Several postulated Class 3 accidents were analyzed, and a major leak in a gas waste holdup tank was found to yield the greatest potential for release to the environment. Operating experience indicates that the activity stored in the gas holdup tank consists of the noble gases released from the primary coolant and only negligible quantities of the less volatile isotopes. Any major leakage from these tanks would be processed through the filtration system in the auxiliary building ventilation systems to further reduce any potential release of particulates and iodines.

(4) Evaluation - The potential for environmental effects from Class 3 events is based on releases from a gaseous decay tank for gaseous releases and from a hypothetical liquid release. These releases are given in Tables G-10, G-11, and G-12.

The inventory in the gaseous radwaste tank is based on the accident occurring to the tank immediately after the coolant had been degassed during a reactor shutdown. The average inventory in each of the two gaseous decay tanks will be much less than this.

Leakage from the gaseous radwaste system might be expected to occur during the lifetime of the plant. Complete failure of a radwaste tank (gas or liquid) is not expected to occur during the lifetime of the plant.

4. <u>Analysis of Class 4 events</u> - Class 4 accidents are events that release radioactivity into the primary coolant, including anomalous fuel failures as well as fuel failures which might result in an increased primary coolant activity which increases the activity of the fluids processed by the waste disposal system.

The fuel rods consist of uranium dioxide ceramic pellets contained in slightly cold-worked Zircaloy-4 tubing which is plugged and seal-welded at the ends to encapsulate the fuel. The manufacturing process is subject to an extensive quality assurance program which provides assurance that the resulting fuel rods satisfy the manufacturing tolerances and design specifications. Excessive heating or pressurization of the fuel rods could possibly cause perforation of the fuel element cladding and subsequent fission product release. Consequently, very conservative design margins are used for the fuel to further reduce the possibility of fuel damage.

Operating experience with Zircaloy cladding has demonstrated that the extent of anomalous fuel rod failures during normal operation will be less than 0.5 percent failed fuel* with administrative controls. Therefore, 0.5 percent failed fuel is an upper bound basis for evaluation of accidental releases. A failed fuel level of 0.25 percent is used for routine releases since the releases occur over a long period of time.

Without protective systems, fuel failures are also possible as a result of certain abnormal operating transients. However, the plant design incorporates a reactor protection system which limits the postulated transients so that the design limits for the fuel will

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*0.5 percent failed fuel is defined as small clad defects (holes) in fuel pins which produce 0.5 percent of the total core power.

not be exceeded. As a result, the fuel will not be damaged, and no activity will be released to the primary coolant as a result of an abnormal operating transient.

5. Analysis of Class 5 accidents - Class 5 accidents are events which result in the release of radioactive material to the environment via any secondary plant system. Primary protection against Class 5 accidents is afforded by coolant chemistry control and good steam generator design. The plant fluid systems are designed with an intermediate water system between any radioactive fluid and any water that is continually discharged to the environment. For example, the component cooling water system cools all of the heat exchangers which contain primary coolant, and the component cooling water is in turn cooled by raw cooling water in a separate heat exchanger. Consequently, a highly unlikely simultaneous failure of two heat exchangers would be required in order for the primary coolant to reach the environment. As an added precaution, the component cooling water loop is continuously monitored for radioactivity, providing timely indication of a leak into the component cooling water system from the primary system.

The other source of possible radioactive release is a primary to secondary leak in a steam generator which transports the fission products, released by cladding failures, into the main steam system. Indication of the occurrence will be afforded by a radiation monitor in the effluent line of the vacuum pump which monitors the activity of the noncondensable gases leaving the main condenser. When a predetermined activity level is reached, the monitor actuates an alarm in the control room.

The most important environmental consequence of this event is the release of noble gases and iodines which are removed from the main condenser by the vacuum pump, and exhausted via a vent on the turbine building roof after passing through charcoal filters which remove most of the iodines. Releases due to steam generator tube leakage are included in the radioactive discharge section.

A hypothetical release due to an offdesign transient has been analyzed using the assumptions specified in Reference 1. The releases for this event are given in Table G-13.

The steam generator tube rupture accident is defined as a complete severence of one steam generator tube. The accident results in an increase in the contamination of the secondary (steam) system.

The plant design incorporates the following features to protect the reactor during and following the postulated accident:

1. The reactor will trip on a low pressurizer pressure signal,
2. The safety injection signal is actuated by coincident low pressurizer pressure and level signals, and
3. The safety injection signal actuates the emergency feedwater system.

Plant recovery can be achieved and normal shutdown initiated in 30 minutes.

The rupture of a steam generator tube would allow fission products that might be in the primary coolant to contaminate the secondary coolant, leading to releases of activity to the environment via the condenser offgas. The results of this postulated event are evaluated based on the release of 15 percent of the primary coolant to the secondary system. The secondary coolant activity before rupture of the tube is based on a primary to secondary leak rate of 20 gallons per day per unit.

All noble gases and 0.1 percent of the iodines in the secondary system are assumed to be released to the environment. The releases for this event are given in Table G-14.

The events analyzed in this class (offdesign transient and steam-generator tube rupture) are not expected to occur during the lifetime of the plant; however, steam-generator tube leakage may occur for short time periods during the plant lifetime, and therefore, it is included as part of the routine radioactive releases.

6. <u>Analysis of Class 6 events</u> - Included in this class of accidents are fuel failures (from any cause) that occur during refueling operations inside the primary containment.

The reactor is refueled with equipment specially designed to handle the spent fuel underwater from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site. Underwater transfer of spent fuel provides an effective radiation shield and provides adequate cooling for the removal of decay heat. Boron added to the water as a neutron absorber ensures subcritical neutron multiplication during refueling.

The various components of the fuel-handling equipment are designed for failsafe operation utilizing interlocks and limit switches designed to preclude any occurrences which might damage a fuel assembly. Administrative procedures will ensure that the integrity of the equipment is maintained.

Detailed refueling instructions will be used to ensure a safe and orderly refueling. When fuel is being inserted, removed, or rearranged in the reactor core, licensed operators will be in the control room and on the refueling floor supervising the operations.

Detailed descriptions of fuel-handling equipment will be given in the Bellefonte Nuclear Plant PSAR.

Accidents involving spent fuel after it has left the transfer tube are discussed in the following section as part of the Class 7 accidents.

In the event of an accident the containment ventilation systems will be isolated on high containment activity. This effectively precludes the release of significant amounts of fission products to the environment since:

1. This accident is not accompanied by any containment pressure increase which could serve as a driving force for leakage.
2. Any leakage that does occur can be treated by the emergency gas treatment system.

Two events in this class are described by Reference 1. TVA has analyzed these events using the assumptions of Reference 1. It is assumed, however, that all activity released from the pool is exhausted to the purge exhaust filters where 99 percent of the iodines is removed. The releases for these events are given in Table G-15 and G-16.

Fuel-handling accidents have occurred in the past with both new and irradiated fuel. However, none has resulted in a substantial release of radioactivity to the environment. Therefore, while fuel element drops or other minor events may occur during the life of the plant, a fuel-handling accident leading to a significant release of activity from the fuel is not expected to occur during the lifetime of the plant or, in fact, during several plant lifetimes.

7. Analysis of Class 7 accidents - Class 7 accidents are events initiated during refueling operations outside the primary containment or storage of spent fuel which result in a release of radioactivity to the environment.

The movement of the spent fuel is accomplished in accordance with strict administrative procedures to reduce the possibility of an accident to a minimal level. Precautions taken include:

1. The fuel pool is designed to ensure that the stored fuel is submerged in water and placed in a subcritical array at all times.
2. The spent fuel pool water is cooled to remove decay heat and purified to remove metallic ions which could cause corrosion of the fuel assemblies, and fission products which may leak into the water.
3. Safety features incorporated into the fuel-handling crane which preclude dropping of the fuel shipping cask.
4. The spent fuel pool is normally ventilated with outside air at the rate of five volume changes per hour and maintained at a slight negative pressure. The exhaust is routed via the auxiliary building exhaust vent system which contains radioactivity monitors and filter trains which are automatically aligned in the event of an accident. These filters remove essentially all particulates and at least 99 percent of the iodines.

The three events analyzed in this class are (1) fuel element drop, (2) heavy object dropped on fuel storage rack, and (3) fuel cask drop accidents. The releases from the fuel element drop accident are based on the release of 1 percent of the fission product activity in 15 fuel pins (one row) after 7 days' decay time. The releases from the heavy object drop accident are based on the release of fuel pins (one fuel assembly) after 30 days' decay time. For both these events, 99.8 percent of the iodines is assumed to remain in the spent fuel pool water.

The results of the fuel cask drop accident have been estimated assuming one fuel assembly is damaged releasing 1 percent of the contained noble gas activity inside the auxiliary building. In all three events, it is assumed that 99 percent of the iodines in the exhaust from the building is removed by charcoal filters. Because of the design of the fuel cask and cask-handling equipment, no significant releases of radioactivity to the environment are expected, and no fuel damage is likely from hypothetical cask drop. However, the results for damage to one assembly are presented for illustrative purposes. The number of assemblies carried in a cask depends on the specific cask design as well as the mode of transportation. The releases for these events are given in Tables G-17, G-18, and G-19.

With the exception discussed above, events in this class are expected to have the same probability as those discussed for Class 6.

8. Class 8 accidents - Those accidents chosen as design basis accidents are included in Class 8. The postulated accidents

considered in this class are:

1. Loss-of-coolant accidents
2. Control rod ejection accident
3. Steamline rupture accidents

These accidents have a very low probability of occurring; however, several engineered safety features are incorporated in the plant design to minimize any significant radioactivity release associated, should any of the accidents occur. Each of the design basis accidents is discussed below.

(1) Loss-of-coolant accident - A loss-of-coolant accident may result from a rupture of a reactor coolant system (RCS) component or of any line connected to that system up to the first closed valve which results in loss of coolant at a rate which exceeds the capability of the makeup system.

The severity of the accident is a function of the primary coolant leakage rate and consequently the size of the pipe rupture. The most severe postulated accident is a result of the hypothetical "double-ended" rupture of the largest RCS pipe.

The design of the plant will include several safety features designed to minimize the effects of a loss-of-coolant accident. These features include:

1. A prestressed concrete primary containment structure surrounded by a secondary containment structure to prevent the leakage of fission products (double containment).
2. The emergency core cooling system which provides core cooling following the accident to minimize fuel element failure.

3. The emergency gas treatment system which filters the leakage from the primary containment before releasing it to the plant vent.

If a postulated loss-of-coolant accident should occur, the RCS will rapidly depressurize. The reactor trip will actuate when the pressurizer low-pressure set point is reached. The emergency core cooling system is actuated by the pressurizer low-pressure or by the high-containment pressure signal. These counter-measures will limit the consequences of the accident in two ways:

1. Reactor trip and borated water injection by the emergency core cooling system supplement void formation in causing rapid reduction of the nuclear power to a residual level corresponding to the fission product decay heat.
2. Injection of borated water ensures sufficient flooding of the core to prevent excessive temperatures.

For short-term core cooling, passive protection is provided by two core flooding tanks pressurized with nitrogen which rapidly discharge their borated water to the RCS when the RCS pressure decreases below the tank pressure. In addition, borated cooling water is injected by high-head charging pumps and low-head safety injection pumps.

For long-term core cooling, water spilled from the ruptured reactor coolant system and containment spray drainage are collected, cooled, and recirculated through the core. This recirculated water is delivered by low-head pumps when the reactor system pressure is low.

The decay heat generated in the core is removed for an indefinite period of time by this recirculation flow which is cooled by two residual heat exchangers.

Fission products which are released from failed fuel as a result of a loss of coolant are released to the primary coolant where some of the iodines and most of the particulate fission products are trapped. Of the iodine released to the primary containment, most is removed from the containment atmosphere by the containment sprays.

Fission products leaking from the primary containment to the annulus (region between primary containment and shield building) are held up for a long period of time. The release from this volume is through the charcoal filters of the emergency gas treatment system to atmosphere. The assumptions specified in Reference 1 were used to estimate releases. Fission products which leak to the auxiliary building are exhausted to atmosphere through charcoal filters. For this analysis, 10 percent of the primary containment leakage is assumed to bypass the annulus and go to the auxiliary building. It is expected that the final containment design will include provisions to preclude any such bypass leakage.

The releases estimated for the loss-of-coolant events specified in Reference 1 are given in Table G-20 and G-21.

(2) Control rod ejection accident - The design basis reactivity transient is the postulated ejection of a control rod. Such an ejection could result from a complete rupture of a control rod mechanism housing.

If the postulated accident should occur, a power transient would result, causing a reactor scram; fuel failures may occur as a result of this transient. The fission products in the coolant as a result of 0.5 percent failed fuel are assumed expelled from the reactor vessel through the broken control rod housing into the primary containment. The airborne and gaseous fission products may leak into the secondary containment (shield building) after which they are exhausted via the secondary containment cleanup system where filtration reduces the iodine concentration. As far as activity releases are concerned, this event is a small loss-of-coolant accident and is analyzed according to the guidance in Reference 1. The releases for this event are given in Table G-22.

(3) Main steamline rupture accident - A rupture of a steamline would result in an uncontrolled steam release from a steam generator. However, this only results in a significant radioactive material release when the reactor is being operated with primary to secondary leak in a steam generator in conjunction with fuel failures (cladding perforations).

The accident is initiated by a postulated failure in the main steamline system outside the containment which could cause depressurization of the steam generator in that loop. The following plant systems mitigate the consequences of a steam pipe rupture:

1. Emergency core cooling activation from one of several signals
2. The overpower reactor trips
3. Redundant isolation of the main feedwater lines
4. Trip of the fast-acting main steamline stop valves

The analysis of a steamline rupture does not yield any core damage so that the radioactivity release will be a function of the secondary system activity at the time of the accident.

The initial secondary system activity is based on a primary to secondary leak rate of 20 gallons per day per unit. The guidance given in Reference 1 is followed in the analysis. However, the halogen reduction factor for releases from the primary system is taken to be 0.1 for small breaks and 0.5 for large breaks. The releases for these events are given in Tables G-23 and G-24.

9. Evaluation of Class 9 accidents - Class 9 accidents are described as hypothetical sequences of successive failures which are more severe than those postulated as design-basis accidents whose results are summarized in safety analysis reports by applicants requesting construction permits and operating licenses from AEC for nuclear power plants. Although the consequences of Class 9 accidents could be severe, the probability of their occurrence is so small that their environmental risk is extremely low.

These accidents would require the occurrence of multiple failures of the plant's engineered safety features with each failure even more severe than the postulated design-basis accidents, which have extremely low probabilities of occurrence.

Conservative design; diverse and redundant physical barriers, protection systems, and engineered safety features; extensive quality assurance; and control of operations dictate such a probability of occurrence that the environmental risk associated with Class 9 accidents is negligible as compared to that of the other classes of accidents.

10. Atmospheric dispersion conditions - TVA has a site meteorological investigations program under way at the Bellefonte

site. However, only a few months' data has been collected at this time. Therefore, the evaluation of the site atmospheric conditions has been based on data collected at the Widows Creek Steam Plant (about 20 miles north-northeast of the site), the Sequoyah Nuclear Plant (60 miles northeast of the site), and Watts Bar Nuclear Plant (85 miles northeast of the site). The evaluation predicts that the atmospheric dispersion conditions are similar to those at Sequoyah where there is a small but significant percentage of occurrence of low wind speeds concurrent with very stable atmospheric conditions. Although the small amount of onsite data indicates that the actual conditions may be more favorable than predicted, TVA has used accident relative dispersion factors which are 10 times higher than the values suggested by Appendix D, 10 CFR Part 50.[2]

Figure G-1 gives the dispersion values used as a function of distance for the time periods used in the analyses. For an explanation of these values see reference 3. Wind direction frequencies used in the analysis are given as baseline data in section 1.2.

11. Population densities - The population exposures from each postulated event have been estimated using projected population information for the year 2020. The population distribution used is shown in section 1.2. Population doses are based on doses to persons residing within 50 miles of the plant site.

12. Evaluation of environmental impact of postulated accidents - The principal effect of accidents on the environment is the increased exposure to man which might result from the release of radioactive material. This exposure is summarized in Table G-1 for the principal accidents analyzed. This analysis of this information shows that no accident or class of accidents is environmentally significant.

REFERENCES FOR APPENDIX G

1. "Safety Guide 4 - Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors," Safety Guides for Water-Cooled Nuclear Power Plants, November 2, 1970, United States Atomic Energy Commission.

2. Title 10, Code of Federal Regulations, Part 50, "Appendix I - Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," June 9, 1971.

3. DiNunno, J. J., et al., Calculation of Distance Factors for Power and Test Reactor Sites, United States Atomic Energy Commission, Division of Technical Information, TID-14844, March 23, 1962.

Table G-1

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses at the Site Boundary (rem)				Fraction of Limit[b]	Dose Commitment to Population[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation		Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
1.0	Trivial incidents	*	*	*	*	*	*	*	*	*
2.0	Small releases outside containment	*	*	*	*	*	*	*	*	*
3.0	Radwaste system failures									
3.1	Equipment leakage or malfunction	8.5×10^{-2}	1.2×10^{-1}	2.1×10^{-1}	4.6×10^{-3}	4.2×10^{-1}	$1.7 \times 10^{+1}$	$2.3 \times 10^{+1}$	9.3×10^{-1}	$4.1 \times 10^{+1}$
3.2	Release of waste gas storage tank contents	3.4×10^{-1}	4.4×10^{-1}	7.8×10^{-1}	1.9×10^{-2}	1.6	$6.8 \times 10^{+1}$	$9.0 \times 10^{+1}$	3.8	1.6×10^{2}
3.3	Release of liquid waste storage tank contents	--	--	6.5×10^{-3}	4.2×10^{-2}**	4.1×10^{-2}	$\gamma + \beta$ =	1.2	6.1**	7.3
4.0	Fission products to primary system (BWR)	NA	NA	NA	NA	NA	NA	NA	NA	NA
5.0	Fission products to primary and secondary systems (PWR)									
5.1	Fuel cladding defects and system generator leaks	*	*	*	*	*	*	*	*	*
5.2	Offdesign transient that induce fuel failure above the expected and steam generator leak	6.3×10^{-4}	4.5×10^{-4}	1.1×10^{-3}	9.7×10^{-5}	2.3×10^{-3}	1.5×10^{-1}	1.2×10^{-1}	2.6×10^{-2}	3.0×10^{-1}
5.3	Steam generator tube rupture	4.1×10^{-2}	6.6×10^{-2}	1.1×10^{-1}	2.0×10^{-2}	2.3×10^{-1}	8.5	$1.3 \times 10^{+1}$	4.1	2.6×10^{1}
6.0	Refueling accidents									
6.1	Fuel bundle drop	1.3×10^{-3}	2.9×10^{-3}	4.2×10^{-3}	6.5×10^{-4}	8.8×10^{-3}	2.6×10^{-1}	5.9×10^{-1}	1.3×10^{-1}	9.8×10^{-1}
6.2	Heavy object drop onto fuel in core	2.6×10^{-2}	5.8×10^{-2}	8.4×10^{-2}	1.2×10^{-2}	1.8×10^{-1}	5.3	$1.2 \times 10^{+1}$	2.4	$2.0 \times 10^{+1}$

Table G-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Individual Doses at the Site Boundary (rem): Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	Dose Commitment to Population[a] (man-rem): Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
7.0	Spent fuel handling accident									
7.1	Fuel assembly drop in fuel storage pool	$1.3x10^{-3}$	$2.9x10^{-3}$	$4.2x10^{-3}$	$6.5x10^{-4}$	$8.8x10^{-3}$	$2.6x10^{-1}$	$5.9x10^{-1}$	$1.3x10^{-1}$	$9.8x10^{-1}$
7.2	Heavy object drop onto fuel rack	$8.9x10^{-4}$	$2.6x10^{-3}$	$3.5x10^{-3}$	$1.2x10^{-3}$	$7.8x10^{-3}$	$1.8x10^{-1}$	$5.3x10^{-1}$	$2.5x10^{-1}$	$9.6x10^{-1}$
7.3	Fuel cask drop[d]	$5.7x10^{-6}$	$6.0x10^{-4}$	$6.1x10^{-4}$	0.0	$1.2x10^{-3}$	$1.2x10^{-3}$	$1.2x10^{-1}$	0.0	$1.2x10^{-1}$
8.0	Accident initiation events considered in design basis evaluation in safety analysis report									
8.1	Small loss-of-coolant	$1.2x10^{-5}$	$2.5x10^{-5}$	$3.7x10^{-5}$	$1.9x10^{-6}$	$7.5x10^{-5}$	$3.5x10^{-3}$	$1.0x10^{-2}$	$7.5x10^{-4}$	$1.4x10^{-2}$
8.1	Large loss-of-coolant	$8.0x10^{-2}$	$8.1x10^{-2}$	$1.6x10^{-1}$	$7.7x10^{-3}$	$3.2x10^{-1}$	$2.3x10^{+1}$	$2.8x10^{+1}$	3.0	$5.4x10^{1}$
8.1 (a)	Instrument line break	NA	NA	NA	NA	NA	NA	NA	NA	NA
8.2 (a)	Rod ejection accident	$7.8x10^{-3}$	$7.9x10^{-3}$	$1.6x10^{-2}$	$1.4x10^{-3}$	$3.3x10^{-2}$	2.3	2.8	$5.8x10^{-1}$	5.7
8.3 (a)	Small MSLR	NIL	NIL	NIL	$9.8x10^{-7}$	$6.5x10^{-7}$	NIL	NIL	$2.0x10^{-4}$	$2.0x10^{-4}$
8.3 (a)	Large MSLR[c]	NIL	NIL	NIL	$5.1x10^{-6}$	$3.4x10^{-6}$	NIL	NIL	$1.0x10^{-3}$	$1.0x10^{-3}$

* Evaluated as routine releases in Section 2.4, Radioactive Discharges.

** Iodine ingestion.

NA Not applicable.

NIL Results in doses less than 10^{-4} rem and population doses less than 10^{-3} man-rem.

a. Based on estimated population within 50 miles of plant.

b. Estimated fraction of 10 CFR Part 20 limit at site boundary.

c. Main steamline rupture.

d. Represents the release from a single fuel element, since the number of elements in a cask varies with shipping method.

TABLE G-2

Primary Coolant Activity (Based on 0.50 Percent Failed Fuel, ρ = 42 lbm/ft3)

Isotope	Primary Coolant Activity (μCi/cc)
Kr-85m	0.664(+0)
Kr-85	0.620(+0)
Kr-87	0.364(+0)
Kr-88	0.117(+1)
Xe-131m	0.856(+0)
Xe-133m	0.192(+1)
Xe-133	0.109(+3)
Xe-135m	0.310(+0)
Xe-135	0.177(+1)
I-129	*NEG
I-131	0.143(+1)
I-132	0.998(+0)
I-133	0.174(+1)
I-134	0.199(+0)
I-135	0.848(+0)

*NEG = Negligible

TABLE G-3

Secondary Coolant Inventory (Based on 0.50 Percent Failed Fuel and 20 gpd/unit Hot Primary-to-Secondary Steam Generator Leak Rate)

Isotope	Primary Equilibrium Coolant Inventory (Ci)
Kr-85m	0.427(-9)
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Xe-131m	0.315(-9)
Xe-133m	0.521(-8)
Xe-133	0.923(-7)
Xe-135m	0.712(-5)
Xe-135	0.502(-6)
I-131	0.791(-3)
I-132	0.377(-3)
I-133	0.104(-2)
I-134	0.967(-4)
I-135	0.562(-3)

*NEG = Negligible

TABLE G-4

0.02 Percent* of Core Fission Product Inventory of Halogens and Noble Gases

Isotope	0.02 Percent Core Inventory (Ci)
Kr-83m	0.312(+4)
Kr-85m	0.976(+4)
Kr-85	0.259(+3)
Kr-87	0.176(+5)
Kr-88	0.241(+5)
Kr-89	0.299(+5)
Xe-131m	0.195(+3)
Xe-133	0.423(+5)
Xe-133m	0.104(+4)
Xe-135m	0.117(+5)
Xe-135	0.403(+5)
Xe-137	0.384(+5)
Xe-138	0.358(+5)
I-131	0.188(+5)
I-132	0.285(+5)
I-133	0.422(+5)
I-134	0.495(+5)
I-135	0.383(+5)

*0.02 percent of core inventory is utilized in off-design transient accident analysis.

2 percent of core inventory is utilized in large loss-of-coolant accident analysis.

TABLE G-5

Fission Product Gap Inventory of Halogens and Noble Gases Contained in One Fuel Assembly

Isotope	1 Fuel Assy (Ci) (100 Hrs Decay)	1 Fuel Assy (Ci) (30 Days Decay)
Kr-83m	*NEG	*NEG
Kr-85m	0.302(-3)	*NEG
Kr-85	0.327(+2)	0.325(+2)
Kr-87	*NEG	*NEG
Kr-88	0.833(-7)	*NEG
Kr-89	*NEG	*NEG
Ke-131m	0.382(+2)	0.857(+1)
Xe-133	0.609(+4)	0.205(+3)
Xe-133m	0.735(=2)	0.298(-1)
Xe-135m	*NEG	*NEG
Xe-135	0.503(+1)	*NEG
Xe-137	*NEG	*NEG
Xe-138	*NEG	*NEG
I-131	0.328(+4)	0.356(+3)
I-132	0.900(-9)	*NEG
I-133	0.385(+3)	0.470(-6)
I-134	*NEG	*NEG
I-135	0.322(+0)	*NEG

Gap activity is defined for environmental statement accident analysis as 1 percent of total pin activity.

*NEG = Negligible

TABLE G-6

Noble Gas Gap Inventory of One Assembly

Isotope	Noble Gas Inventory - 1 Assy (Ci) (120 Days Decay)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	0.319(+2)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Ke-131m	0.471(-1)
Xe-133	0.152(-2)
Xe-133m	*NEG
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG - Negligible

TABLE G-7

Fission Product Gap Inventory of Halogens and Noble Gases Contained In One Row of Fuel Pins

Isotope	Inventory of One Row of Pins (Ci) (1 Week Decay)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	0.234(+1)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	0.233(+1)
Xe-133	0.302(+3)
Xe-133m	0.224(+1)
Xe-135m	*NEG
Xe-135	0.206(-2)
Xe-137	*NEG
Xe-138	*NEG
I-131	0.185(+3)
I-132	*NEG
I-133	0.291(+1)
I-134	*NEG
I-135	0.210(-4)

*NEG = Negligible

TABLE G-8

Gas Decay Tank Inventory (Based on 0.50 Percent Failed Fuel)

Isotope	Gas Decay Tank Inventory (Ci)
Kr-83m	0.847(+2)
Kr-85m	0.413(+3)
Kr-85	0.777(+2)
Kr-87	0.234(+3)
Kr-88	0.743(+3)
Kr-89	*NEG
Xe-131m	0.212(+3)
Xe-133	0.377(+5)
Xe-133m	0.560(+3)
Xe-135m	0.222(+3)
Xe-135	0.111(+3)
Xe-137	*NEG
Xe-138	*NEG
I-131	0.747(-1)
I-132	0.115(+0)
I-133	0.966(-1)
I-134	0.124(-1)
I-135	0.298(-1)

*NEG = Negligible

*TABLE G-9a

Accident Assumptions Used in Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 1.0 Trivial Incidents

These incidents are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

ACCIDENT 2.0 Small Release Outside Containment

These releases include such things as releases through steamline relief valves and small spills and leaks of radioactive materials outside containment. These releases are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

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*The classification of accidents in this and the following tables of assumptions is that of 10 CFR 50, Appendix D Annex. Note, however, that classifications 4.0, 8.2(b), and 8.3(b) were not considered as they pertain only to boiling water reactors. Classification 5.1 is also considered under routine release calculations. Meteorology assumptions common to all accidents are discussed in section 10 of this appendix.

TABLE G-9b

Accident Assumptions Used In
Bellefonte Environmental Statement Accident Analysis

ACCIDENT 3.0 Radwaste System Failure

3.1 Equipment leakage or malfunction
(Includes operator error)

(a) Release of 25 percent of the average inventory of gases in a waste gas decay tank assuming operation with 0.5 percent failed fuel.

(b) The waste gas decay tank inventory given in Table G-8.

3.2 Release of waste gas storage tank contents

(a) 100 percent of the average waste gas decay tank inventory (Table G-8) is assumed to be released.

3.3 Release of liquid waste storage tank contents

(a) Hypothetical instantaneous release to the river of the expected routine liquid radwaste releases for an entire year.

(b) Low river flow.

TABLE G-9c

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 5.0 Fission Products to Primary and Secondary Systems (Pressurized Water Reactor)

5.1 Fuel cladding defects and steam generator leaks

Releases from these events are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR Part 50.

5.2 Off-design transients that induce fuel failure above those expected and steam generator leak (such as flow blockage and flux maldistributions)

(a) 0.02 percent of the core inventory of noble gases and 0.02 percent of the core inventory of halogens is assumed to be released into the reactor coolant (see Table G-4).

(b) Average inventory in the primary system before the transient is based on operation with 0.5 percent failed fuel (see Table G-2).

(c) Secondary system equilibrium radioactivity before the transient is based on a 20 gal/day steam generator leak (see Table G-3).

(d) All noble gases and 0.01 percent of the halogens in the steam reaching the condenser are assumed to be released by the condenser air ejector. (Assumes air ejector charcoal filters remove 90 percent of the iodines.)

(e) The release is terminated after one day.

5.3 Steam generator tube rupture

(a) 15 percent of the average inventory of noble gases and halogens in the primary coolant is assumed to be released into the secondary coolant. The average primary coolant activity is based on 0.5 percent failed fuel (see Table G-2).

(b) Equilibrium radioactivity before rupture is based on a 20 gallon per day steam generator leak (see Table G-3).

(c) All noble gases and 0.1 percent of the halogens in the steam reaching the condenser is assumed to be released by the condenser air ejector.

TABLE G-9d

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 6.0 Refueling Accidents

6.1 Fuel bundle drop

(a) The gap activity (noble gases and halogens) in one row of fuel pins is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin--see Table G-7).

(b) One week decay time before the accident occurs is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines shall be 99 percent.

(e) 100 percent of the containment volume is assumed to leak to the atmosphere.

6.2 Heavy object drop onto fuel in core

(a) The gap activity (noble gases and halogens) in one average fuel assembly is assumed to be released into the water. (Gap activity shall be 1 percent of total activity in a pin).

(b) 100 hours of decay time before object is dropped is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines is 99 percent.

TABLE G-9e

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 7.0 <u>Spent Fuel Handling Accident</u>

7.1 Fuel assembly drop in fuel storage pool

(a) The gap activity (noble gases and halogens) in one row of fuel pins is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin).

(b) One week decay time before accident occurs is assumed.

(c) Iodine decontamination factor in water is assumed to be 500.

(d) Charcoal filter efficiency for iodines is assumed to be 99 percent.

7.2 Heavy object drop onto fuel rack

(a) The gap activity (noble gases and halogens) in one average fuel assembly is assumed to be released into the water. (Gap activity is 1 percent of total activity in a pin.)

(b) 30 days decay time before the accident occurs is assumed.

(c) Iodine decontamination factor in water is 500.

(d) Charcoal filter efficiency for iodines is 99 percent.

7.3 Fuel cask drop

(a) Noble gas gap activity from one fuel assembly (120 day cooling) is assumed to be released. (Gap activity is 1 percent of total activity in the pins.)

TABLE G-9f

Accident Assumptions Used In Bellefonte
Environmental Statement Accident Analysis

ACCIDENT 8.0 Accident Initiation Events Considered in Design Basis Evaluation in the Safety Analysis Report

8.1 Loss-of-coolant accidents
Small Pipe Break (6-in. or less)

(a) Source term: the average radioactivity inventory in the primary coolant is used. (This inventory is based on operation with 0.5 percent failed fuel.)

(b) Charcoal filter efficiency is assumed to be 99 percent.

(c) For the effects of plateout, sprays, decontamination factor in pool, and core sprays a 0.2 reduction factor is assumed.

(d) The primary containment leak rate is assumed to be 0.2 percent/day for the first day and 0.1 percent thereafter.

(e) The exhaust rate from the secondary containment is assumed to be 50 percent/day.

Large Pipe Break

(a) Source term: The average radioactivity inventory in the primary coolant is used. (This inventory is based on operation with 0.5 percent failed fuel.) In addition a release into the coolant of 2 percent of the core inventory of halogens and noble gases is assumed.

(b) Charcoal filter efficiencies (two filters in series) is assumed to be 99 percent for elemental iodine and 95 percent for organic iodines.

(c) For the effects of plateout, containment spray, core sprays a 0.2 reduction factor is assumed.

(d) Consequences are calculated by weighting the effects in different directions by the frequency the wind blows in each direction.

8.1(a) Break in instrument line from primary system that penetrates the containment.

Not applicable to Bellefonte.

8.2(a) Rod ejection accident (pressurized water reactor)

TABLE G-9g

Accident Assumptions Used In Bellefonte Environmental Statement Accident Analysis

(a) 0.2 percent of the core inventory of noble gases and halogens are assumed to be released into the primary coolant plus the average inventory in the primary coolant based on operation with 0.5 percent failed fuel.

(b) The containment assumptions are the same as those used in Class 8.1.

8.3(a) Steamline breaks (pressurized water reactors - outside containment)

Small break

(a) Primary coolant activity is based on operation with 0.5 percent failed fuel. The primary system contribution during the course of the accident is based on a 20 gal/day tube leak.

(b) During the course of the accident, a halogen reduction factor of 0.1 is used.

(c) Secondary coolant system radioactivity before the accident is based on 20 gallons per day primary-to-secondary leak.

(d) Volume of one steam generator is released to the atmosphere with an iodine partition factor of 10.

Large break

(a) Primary coolant activity is based on operation with 0.5 percent failed fuel. The primary system contribution during the course of the accident is based on a 20 gal/day tube leak.

(b) A halogen reduction factor of 0.5 is applied to the primary coolant source during the course of the accident.

(c) Secondary coolant system radioactivity before the accident is based on 20 gallons per day primary-to-secondary leak.

(d) Volume of one steam generator is assumed to be released to the atmosphere with an iodine partition factor of 10.

TABLE G-10

ACCIDENT 3.1
Radwaste System Equipment Leakage

Isotope	0-8 Hr. Release (Curies)
I-131	1.87(-2)
I-132	2.88(-2)
I-133	2.41(-2)
I-134	3.09(-3)
I-135	7.46(-3)
Kr-83m	2.12(+1)
Kr-85m	1.03(+2)
Kr-85	1.94(+1)
Kr-87	5.80(+1)
Kr-88	1.86(+2)
Kr-89	*NEG
Xe-131m	5.30(+1)
Xe-133m	1.40(+2)
Xe-133	9.42(+3)
Xe-135m	5.56(+1)
Xe-135	2.79(+2)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-11

ACCIDENT 3.2

RELEASE OF WASTE GAS STORAGE TANK CONTENTS

Isotope	0-8 Hr. Release (Curies)
I-131	7.47(-2)
I-132	1.15(-1)
I-133	9.66(-2)
I-134	1.24(-2)
I-135	2.98(-2)
Kr-83m	8.47(+1)
Kr-85m	4.13(+2)
Kr-85	7.77(+1)
Kr-87	2.34(+2)
Kr-88	7.43(+2)
Kr-89	*NEG
Xe-131m	2.12(+2)
Xe-133m	5.60(+2)
Xe-133	3.77(+4)
Xe-135m	2.22(+2)
Xe-135	1.11(+3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-12

ACCIDENT 3.3

RELEASE OF LIQUID WASTE STORAGE TANK CONTENTS

Isotope	Release (Curies)
I-129	3.1(-8)
I-131	1.1(-1)
I-132	6.8(-7)
I-133	3.0(-2)
I-134	1.9(-7)
I-135	3.2(-5)
H-3	2.8(+2)
Cr-51	5.8(-4)
Mn-54	9.7(-5)
Fe-59	7.8(-5)
Co-58	4.5(-3)
Co-60	2.9(-3)
Br-84	1.2(-8)
Rb-88	7.9(-7)
Sr-89	8.8(-4)
Sr-90	9.2(-5)
Sr-91	2.7(-7)
Sr-92	4.6(-9)
Y-90	8.2(-6)
Y-91	5.8(-4)
Zr-95	5.9(-3)
Mo-99	3.1(-2)
Ru-106	1.0(-1)
Cs-134	1.1(-1)
Cs-136	4.9(-3)
Cs-137	2.8(-1)
Cs-138	2.3(-7)
Ba-140	9.1(-5)
La-140	2.0(-4)
Cs-144	2.5(-4)

TABLE G-13

ACCIDENT 5.2

OFF-DESIGN TRANSIENTS THAT INDUCE FUEL FAILURE ABOVE EXPECTED AND STEAM GENERATOR LEAKS

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.
I-131	2.72(-4)	3.26(-4)
I-132	1.66(-4)	1.18(-5)
I-133	5.41(-4)	4.67(-4)
I-134	1.24(-4)	1.56(-7)
I-135	3.83(-4)	1.59(-4)
Kr-83m	1.61(-1)	7.61(-3)
Kr-85m	9.15(-1)	2.95(-1)
Kr-85	7.85(-2)	1.39(-1)
Kr-87	6.70(-1)	8.62(-3)
Kr-88	1.72(+0)	0.24(+0)
Kr-89	3.17(-2)	*NEG
Xe-131m	3.60(-2)	6.20(-2)
Xe-133m	2.26(-1)	3.45(-1)
Xe-133	6.70(+0)	1.11(+1)
Xe-135m	9.00(-2)	*NEG
Xe-135	4.92(+0)	3.69(+0)
Xe-137	7.45(-2)	NEG
Xe-138	3.03(-1)	*NEG

*NEG = Negligible

TABLE G-14

ACCIDENT 5.3
STEAM GENERATOR TUBE RUPTURE

Isotope	0-8 Hrs. Release (Curies)
I-131	8.05(-2)
I-132	5.63(-2)
I-133	9.76(-2)
I-134	1.12(-1)
I-135	4.70(-2)
Kr-83m	*NEG
Kr-85m	3.72(+1)
Kr-85	3.48(+1)
Kr-87	2.05(+1)
Kr-88	6.58(+1)
Kr-89	*NEG
Xe-131m	4.82(+0)
Xe-133m	6.70(+1)
Xe-133	6.13(+3)
Xe-135m	1.74(+1)
Xe-135	9.98(+1)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-15

ACCIDENT 6.1
REFUELING ACCIDENT - FUEL BUNDLE DROP

Isotope	0-8 Hrs. Release (Curies)
I-131	3.70(-3)
I-132	*NEG
I-133	5.82(-5)
I-134	*NEG
I-135	4.20(-10)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	2.34(+0)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	2.33(+0)
Xe-133m	2.24(+0)
Xe-133	3.02(+2)
Xe-135m	*NEG
Xe-135	2.06(-3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-16

ACCIDENT 6.2
HEAVY OBJECT DROP ONTO FUEL IN CORE

Isotope	0-8 Hrs. Release (Curies)
I-131	6.56(-2)
I-132	*NEG
I-133	7.69(-3)
I-134	*NEG
I-135	6.43(-6)
Kr-83m	*NEG
Kr-85m	3.02(-4)
Kr-85	3.27(+1)
Kr-87	*NEG
Kr-88	8.33(-8)
Kr-89	*NEG
Xe-131m	3.82(+1)
Xe-133m	7.36(+1)
Xe-133	6.10(+3)
Xe-135m	*NEG
Xe-135	5.03(+0)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-17

ACCIDENT 7.1
FUEL ASSEMBLY DROP IN FUEL STORAGE POOL

Isotope	0-8 Hrs. Release (Curies)
I-131	3.70(-3)
I-132	*NEG
I-133	5.82(-5)
I-134	*NEG
I-135	4.20(-10)
Kr-83m	*NEG
Kr-85m	4.38(-10)
Kr-85	2.35(+0)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	2.33(+0)
Xe-133m	2.24(+0)
Xe-133	3.02(+2)
Xe-135m	*NEG
Xe-135	2.06(-3)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-18

ACCIDENT 7.2
HEAVY OBJECT DROP ONTO FUEL RACK

Isotope	0-8 Hrs. Release (Curies)
I-131	7.12(-3)
I-132	*NEG
I-133	9.41(-9)
I-134	*NEG
I-135	*NEG
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	3.25(+1)
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	8.58(+0)
Xe-133m	2.98(-2)
Xe-133	2.05(+2)
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-19

ACCIDENT 7.3
Fuel Cask Drop

Isotope	0-8 Hrs. Release (Curies)
I-131	*NEG
I-132	*NEG
I-133	*NEG
I-134	*NEG
I-135	*NEG
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	3.20(+1)
Kr-87	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	4.70(-2)
Xe-133m	*NEG
Xe-133	1.52(-3)
Xe-135m	*NEG
Xe-135	*NEG
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLE G-20

ACCIDENT 8.1 Small LOCA
Loss of Coolant Accident

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.	1-30 Days
I-131	2.45(-6)	1.23(-5)	7.29(-5)
I-132	4.04(-6)	2.00(-7)	6.32(-10)
I-133	2.96(-6)	9.23(-6)	5.24(-6)
I-134	5.18(-7)	3.07(-10)	*NEG
I-135	1.43(-6)	1.73(-6)	1.55(-7)
Kr-83m	*NEG	*NEG	*NEG
Kr-85m	2.37(-2)	1.31(-2)	1.20(-6)
Kr-85	4.11(-2)	1.31(-1)	6.50(+0)
Kr-87	4.85(-3)	1.04(-4)	1.70(-8)
Kr-88	3.12(-2)	7.24(-3)	1.51(-4)
Kr-89	*NEG	*NEG	*NEG
Xe-131m	5.62(-3)	1.75(-2)	4.14(-1)
Xe-133m	7.51(-2)	2.06(-1)	1.01(+0)
Xe-133	7.06(-2)	2.11(-1)	2.54(+0)
Xe-135m	7.42(-4)	*NEG	*NEG
Xe-135	8.43(-2)	1.14(-1)	5.03(-2)
Xe-137	*NEG	*NEG	*NEG
Xe-138	*NEG	*NEG	*NEG

*NEG = Negligible

TABLE G-21

ACCIDENT 8.1 Large LOCA
Loss of Coolant Accident

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.	1-30 Days
I-131	8.61(-3)	4.30(-2)	2.55(-1)
I-132	3.07(-2)	1.53(-3)	4.82(-6)
I-133	1.92(-2)	5.99(-2)	3.40(-2)
I-134	3.43(-2)	2.03(-5)	*NEG
I-135	1.74(-2)	1.10(-2)	1.90(-3)
Kr-83m	1.57(+1)	1.23(-1)	3.59(-3)
Kr-85m	9.31(+1)	5.12(+1)	4.70(+0)
Kr-85	4.58(+0)	1.47(+1)	7.25(+2)
Kr-87	6.28(+1)	1.34(+0)	2.20(-4)
Kr-88	1.71(+2)	3.98(+1)	8.31(-1)
Kr-89	3.92(+0)	*NEG	*NEG
Xe-131m	3.41(+0)	1.06(+1)	2.52(+2)
Xe-133m	1.74(+1)	4.78(+1)	2.36(+2)
Xe-133	8.16(+2)	2.19(+3)	2.64(+4)
Xe-135m	7.49(+0)	*NEG	*NEG
Xe-135	5.97(+2)	7.92(+2)	3.51(+2)
Xe-137	6.11(+0)	*NEG	*NEG
Xe-138	2.55(+1)	*NEG	*NEG

*NEG = Negligible

TABLE G-22

ACCIDENT 8.2a
Rod Ejection Accident

Isotope	Release (Curies) 0-8 Hrs.	8-24 Hrs.	1-30 Days
I-131	8.66(-4)	4.33(-3)	8.39(-2)
I-132	3.09(-3)	1.53(-4)	4.82(-7)
I-133	1.93(-3)	6.01(-3)	3.41(-3)
I-134	3.43(-3)	2.03(-6)	*NEG
I-135	1.74(-3)	2.11(-3)	1.90(-4)
Kr-83m	1.57(-1)	1.23(-1)	3.59(-4)
Kr-85m	9.50(+0)	5.23(+0)	4.81(-1)
Kr-85	4.94(-1)	1.58(+0)	7.81(+1)
Kr-87	6.28(+0)	1.34(-1)	2.20(-5)
Kr-88	1.71(+1)	3.98(+0)	8.31(-2)
Kr-89	3.92(-1)	*NEG	*NEG
Xe-131m	3.94(-1)	1.22(+0)	2.90(+1)
Xe-133m	1.08(+0)	4.97(+0)	2.45(+1)
Xe-133	8.03(+1)	2.40(+2)	2.66(+3)
Xe-135m	7.49(-1)	*NEG	*NEG
Xe-135	5.20(+1)	7.35(+1)	3.05(+1)
Xe-137	6.11(-1)	*NEG	*NEG
Xe-138	2.55(+0)	*NEG	*NEG

*NEG = Negligible

TABLE G-23

ACCIDENT 8.3a
Steamline Break - Small Break

Isotope	0-8 Hrs. Release (Curies)
I-131	3.92(-6)
I-132	1.86(-6)
I-133	5.16(-6)
I-134	4.78(-7)
I-135	2.77(-6)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	*NEG
Xe-133m	1.94(-9)
Xe-133	3.44(-8)
Xe-135m	2.65(-6)
Xe-135	1.88(-7)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

TABLEG-24

ACCIDENT 8.3a
Large Steamline Break

Isotope	0-8 Hrs. Release (Curies)
I-131	1.96(-5)
I-132	9.30(-6)
I-133	2.58(-5)
I-134	2.39(-6)
I-135	2.77(-5)
Kr-83m	*NEG
Kr-85m	*NEG
Kr-85	*NEG
Kr-87	*NEG
Kr-88	*NEG
Kr-89	*NEG
Xe-131m	*NEG
Xe-133m	1.94(-9)
Xe-133	3.44(-8)
Xe-135m	2.65(-6)
Xe-135	1.88(-7)
Xe-137	*NEG
Xe-138	*NEG

*NEG = Negligible

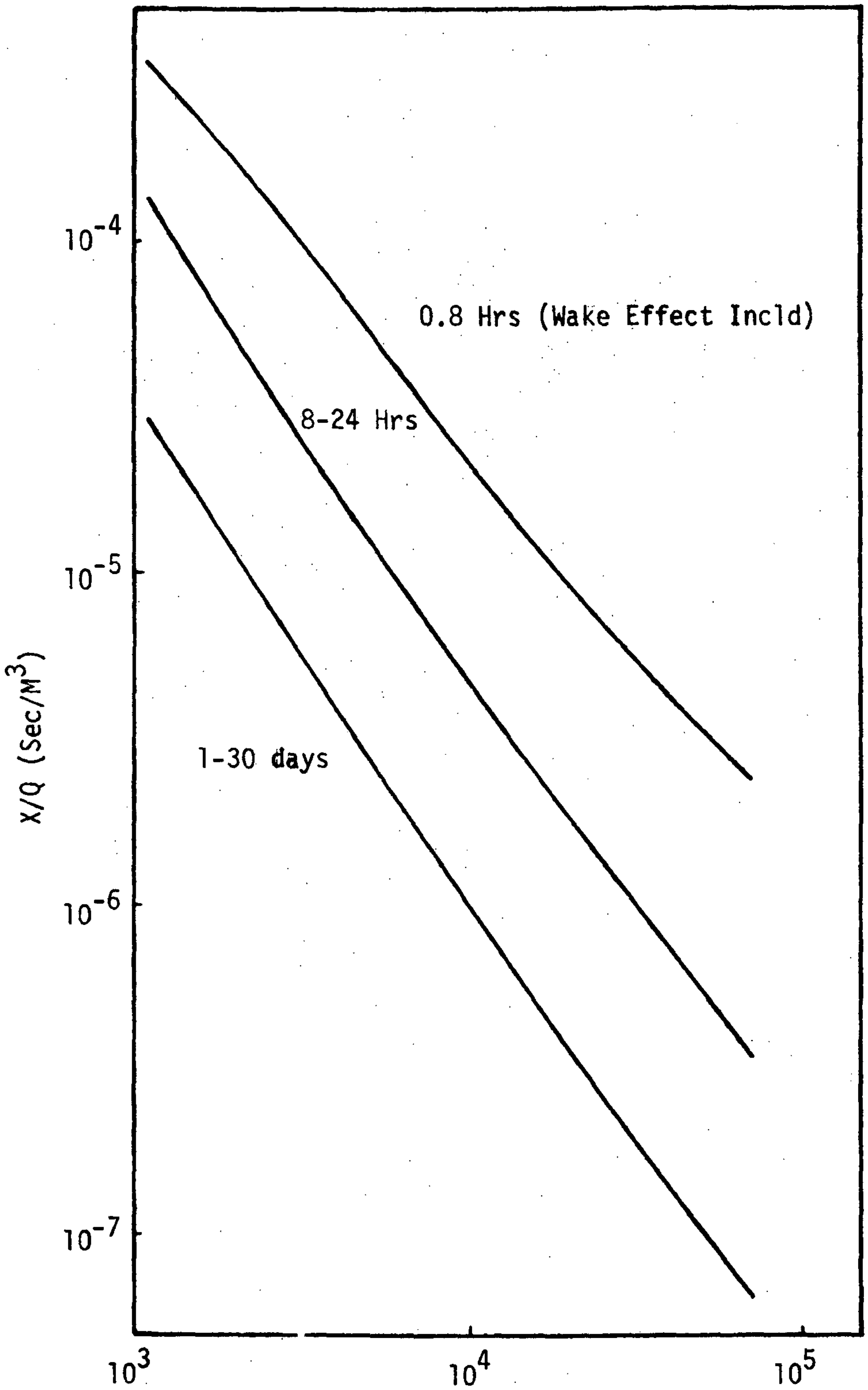

Figure G-1

X/Q VERSUS DISTANCE

Appendix H

RADIOLOGICAL IMPACT OF LIQUID EFFLUENTS

The calculation of radiation doses to organisms that are exposed in their normal environment is a difficult task. Because of the complexity of biological functions and the interrelationship between organisms and their environment, it is necessary to develop simplified dose models that can predict doses resulting from the more significant exposure pathways. While these models cannot predict the detailed variances of a system and while the results of an analysis cannot be applied equally to all members of a population, assumptions are chosen so that the radiation doses are conservative, i.e., overestimated. Only the basic assumptions are given in this appendix along with a brief outline of the models and methods of calculation. Doses listed in Table H-2 are calculated for the radionuclides which are expected to be released during normal operation of the Bellefonte Nuclear Plant.

Tritium doses are considered separately and are based on a normalized release of 1 Ci per year. The tritium dose can be computed by multiplying this normalized value by the annual tritium release in curies.

Calculations of doses to humans include doses to bone, G.I. tract, thyroid, skin tissues, and the total body. Total body doses are calculated for organisms other than man. Population doses are estimated for the year 2020 based on the current populations multiplied by 1.95. The factor 1.95 is the increase projected for a 125-county area in the Tennessee River basin.

1. Doses to man from the ingestion of water - Data listed on Table H-1 for public and industrial water systems is used to calculate dose commitments from the consumption of Tennessee River water. It is assumed that the plant effluent is mixed with one-half of the river flow in the 6-mile reach between the nuclear plant site and the first water supply intake. Although natural water turbulence will continue to increase the dispersion downstream, it is assumed that half-dilution is maintained as far as Guntersville Dam past which full-dilution is assumed.

Dilution is calculated using average annual flow data for the Tennessee River as measured during 1899-1968. The average flow ranges from approximately 39,000 ft^3/s at the nuclear plant site to 65,000 ft^3/s at the mouth of the river near Paducah, Kentucky.

Radioactive decay and the buildup of daughter activity are based on estimates of the transport time using data for water velocities which vary between 0.1 and 3.5 ft/s. No radioactive decay is considered between the time of intake in a water system and the time of consumption. It is assumed that each individual consumes 2,200 ml of water per day (the average daily adult ingestion from all sources including drinking water, food, bottled drinks, etc.).

Due to a lack of definitive data, no credit is taken for removal of activity from the water through absorption on solids and sedimentation, by deposition in the biomass, or by processing within water treatment systems.

Internal doses, D_{ij}, for the j^{th} organ from the i^{th} radionuclide are calculated using the relation

$$D_{ij} = (DCF)_{ij} \times I_i, \tag{1}$$

where

$(DCF)_{ij}$ = the dose commitment factor for the j^{th} organ from the i^{th} radionuclides for an average adult assuming that the dose can be accumulated over a 50-year interval, (mrem/μCi),

I_i = the activity of the i^{th} radionuclide taken into the body annually via ingestion, (μCi).

The dose commitment factors are derived from data given in the references listed[1,2,3,4] and are defined in units of (mrem/μCi) by the equation:

$$(DCF)_{ij} = \frac{51.2 \times 10^3 \, f_{wij} \, \varepsilon_{ij} \left(1 - \exp(-\lambda_{ij} T)\right)}{m_j \, \lambda_{ij}}, \tag{2}$$

where

$$51.2 \times 10^3 = \left(1.60 \times 10^{-8} \ \frac{\text{g-rad}}{\text{MeV}}\right) \left(3.20 \times 10^9 \ \frac{\text{dis}}{\mu\text{Ci-day}}\right) \left(10^3 \ \frac{\text{mrem}}{\text{rem}}\right)$$

f_{wij} = fraction of the i^{th} radionuclide taken into the body by ingestion that is retained in the j^{th} organ, (dimensionless),

ε_{ij} = effective energy absorbed in the j^{th} organ per disintegration of the i^{th} radionuclide including daughter products, (MeV-rem/dis-rad),

λ_{ij} = the effective decay constant of the i^{th} radionuclide in the j^{th} organ, (day^{-1}),

T = integration time, (18,250 days),

m_j = mass of the j^{th} organ, (g).

In the absence of a detailed knowledge regarding solubility characteristics of the radionuclides, the dose for the G.I. tract is overestimated using the assumption that none of the radionuclides is removed from the G.I. tract by absorption. Estimates of the doses to bone, thyroid, and total body are based on fractional uptakes given by the International Commission on Radiological Protection.[2] A detailed breakdown of the dose commitments at each public water supply intake is shown in Tables H-2 and H-3.

For comparison, dose commitments are also calculated for a hypothetical individual whose entire yearly water supply is obtained from the plant discharge conduit prior to dilution in the Tennessee River. These estimates are upper limits based on a continuous discharge flow rate of 30,000 GPM which corresponds to the minimum effluent flow rate. Average-annual concentrations of radionuclides in the liquid effluent can be estimated by dividing the releases by the annual discharge flow.

Dose commitments for the annual intake of ground water are derived from the estimates of the doses at Tennessee River water supplies. It is assumed that the radioactivity concentration in ground water within 0.5 mile of the Tennessee River is 100 percent of that present in the river. A conservative estimate of the human population drinking ground water within 0.5 mile of the river is 22,000 persons between Bellefonte and Paducah, Kentucky. The maximum population dose commitment (thyroid) for an annual release of 0.93 Ci in the liquid effluent is 0.11 man-rem. This dose commitment, DC_p, is obtained as follows:

$$DC_p = \sum_{i=1}^{24} \frac{P_i}{A_i} \times A_i^* \times DC_i$$

where

P_i = population of county i,

A_i = county area, (sq.mi.),

A_i^* = county area within 0.5 mile of the Tennessee River, (sq.mi.),

DC_i = individual thyroid dose commitment calculated for a public water supply in or near county i, (rem).

Doses to humans from ingestion of Tennessee River water affected by slug releases can be estimated using the data in section A of Tables H-2 and H-3 provided: (1) the distribution of activity is essentially the same as that given in Table G-2 of Appendix G, (2) the total activity of the slug release is known, and (3) the river velocities and dilution factors are not grossly different from the average values on which the routine dose estimates are based. A conservative estimate of the doses to humans from a slug of radioactivity released during low-flow conditions can be obtained by multiplying the doses in Table H-2 by: (1) the ratio of activity released to 0.93 Ci, and (2) by the ratio of the average flow rate to the acutal flow rate. For example, a slug of 1.0 Ci activity released during a 5 percent* flow condition could result in doses that are higher than those in Table H-2 by the factor

$$F = \frac{1.0 \text{ Ci}}{0.93 \text{ Ci}} \times \frac{(\text{Average Flow Rate})}{0.37 \times (\text{Average Flow Rate})} = 2.9$$

2. Doses to man from the consumption of fish - Current estimates of Tennessee River annual fish harvests are 15.2 lb/acre sport fish[5] and 13.7 lb/acre edible commercial fish.[6] It is assumed that these rates will increase with the population expansion, so that the dose calculations are based on harvests of 30-lb/acre sport fish and 27-lb/acre commercial fish in the year 2020. The Tennessee River is segmented into 10 reaches in order to facilitate the calculations of fish harvests and radioactivity concentrations. For convenience, the limits defining the reaches correspond to the locations of Guntersville, Wheeler, Wilson, Pickwick Landing, and Kentucky Dams, and the Browns Ferry Nuclear Plant site. Additional points were selected to subdivide Guntersville and Kentucky reservoirs into shorter reaches. The radioactivity levels in the fish from each reach are estimated by the product of an average activity concentration in the reach and a concentration factor for each radionuclide.[7,8] Concentration factors derived from references 7 and 8 are listed in Table H-4. It is assumed that the maximum annual consumption of fish by an individual is 45 lbs. The population dose is calculated using the assumption that all of the edible

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*A 5 percent flow rate is that which is equaled or exceeded 95 percent of the time. This flow rate is approximately 37 percent of the annual-average flow rate based on daily discharge data during 1960-1970 for Nickajack, Guntersville, Wheeler, Pickwick Landing, and Kentucky Dams.

fish harvested are consumed by humans. Radioactive decay is not considered between the time the fish is removed from the water and the time of consumption, and the entire mass of the fish is assumed to be eaten.

Dose commitments are calculated with equations 1 and 2 which are discussed for water ingestion in the previous section, and the results are shown in Tables H-2 and H-3.

Calculations indicate that there would be no significant radiological impact from human utilization of shellfish. Shellfish are not currently being harvested commercially in the Tennessee River, and consumption of shellfish by humans is assumed to be negligible.

3. Doses to man due to water sports - Estimates of the doses from immersion in the Tennessee River are calculated for each radionuclide using the following relations. For the dose rate to the skin,

$$R_i = 51.2 \times 10^3 \, C_{wi} \left(\bar{E}_\beta/2 + E_\gamma\right)_i \ \frac{\text{mrem}}{\text{day}} \qquad (3)$$

For the dose rate to the total body,

$$R_i = 51.2 \times 10^3 \, C_{wi} \, E_{\gamma i} \ \frac{\text{mrem}}{\text{day}} \qquad (4)$$

where 51.2×10^3 = (see equation 1),

C_{wi} = water concentration for the i^{th} radionuclide, (μCi/g),

$E_{\gamma i} = (\bar{E}_\beta/2 + E_\gamma)i$ = average effective energy emitted by the i^{th} radionuclide per disintegration (MeV-rem/dis-rad).

Dose rates for above-water activities such as boating are assumed to be given by equations 3 and 4 divided by 2. In order to estimate the doses from shoreline activities the simplifying assumption is made that all persons along the shoreline receive the same dose rate as a person boating or skiing. Water concentrations are calculated for 10 reaches between the nuclear plant site and Kentucky Dam (TRM 22.4). Doses to the population are calculated using estimates for above-water visits, in-water, and shoreline visits for the respective reaches based on current information given in reference 9 multiplied by the predicted population growth factor of 1.95.

The maximum individual doses for above-water use of the river are estimated for a commercial fisherman who is not a water sport enthusiast but who might be exposed for 300 days per year at 5 hours per day. The maximum individual doses for in-water activities are estimated for a person who swims 918 hours per year (6 hours per day for the 5 warm months) at a location just below the Bellefonte site. In order to estimate the maximum possible tritium dose to a swimmer, continuous immersion for 5 months in the Tennessee River just below the Bellefonte site is assumed.

4. Doses to organisms other than man - A comprehensive analysis of the radiation doses to species other than humans would require many man-years of effort that could be justified only if a significant radiological impact on a particular species were anticipated. After consultation with professionals in the health physics and radio-ecology fields, a decision was made by TVA to restrict the analyses to those organisms living on or near the Bellefonte site that would most likely receive the greatest doses. These include terrestrial vertebrates, aquatic plants, aquatic invertebrates, and fish.

(1) Terrestrial vertebrates - Radioactivity contained in nuclear plant liquid effluents is concentrated in fish, invertebrates, and plants by factors that range from less than 1 to greater than 10^5 depending on interrelated physical, chemical, and biological factors. Terrestrial vertebrates will receive a radiation dose from liquid effluents if their food chain includes aquatic organisms that have concentrated radionuclides. In general, aquatic plants such as green algae concentrate trace elements to a greater extent that do fish and invertebrates.[7] Therefore, internal dose estimates have been made for ducks and muskrats with the conservative assumption that their diet consists entirely of green algae from algal masses growing near the Bellefonte discharge. Equations 1 and 2 from section 1 are used for estimating the annual internal total body dose. It is assumed that the duck or muskrat has a mass m of 1,000 g, and effective radius of 10 cm, and consumes 33 g of green algae per day. Long-lived radionuclides such as Sr-90 can deliver significant portions of the total dose commitment long after the time of ingestion. Therefore, a period of 5 years was chosen for the integration interval T. In the absence of data specifically applicable to ducks or muskrats, ICRP data[2] are used for the fractional uptake in the total body and for the biological half-life of parent radionuclides. The use of human data for the biological half-lives is considered to be conservative because, in general, warm-blooded vertebrates that are smaller than man exhibit more rapid elimination rates.[8] Equation 5 is a combination of the above assumptions with equations 1 and 2.

$$D_i = 51.2 \times 10^3\ I_i\ f_{wi}\ \varepsilon_i\ (1-\exp(-\lambda_i T))/\lambda_i m \text{ mrad} \qquad (5)$$

where

$I_i = 333 \frac{g}{d} \times C_{wi} \times 365 \frac{d}{y}$, (μCi/y),

C_{wi} = water concentration, (μCi/g),

F_{pi} = concentration factor[7,8] for aquatic plants, (dimensionless).

T = 1,825 days

m = 1,000 g

External doses are estimated with equation 4 using the conservative assumption that the duck and muskrat are exposed continuously by full immersion in the water.

Estimates of the doses to ducks and muskrats living near the Bellefonte Nuclear Plant are shown in Table H-5.

(2) Aquatic plants, invertebrates, and fish - Radionuclide activity internally deposited in these organisms is estimated from the concentration in the water in the Tennessee River just below the liquid effluent discharge, assuming mixing with one-half the average river flow, multiplied by the applicable concentration factors.[7,8] Doses are estimated for organisms having effective radii of 3 cm and 30 cm. Although estimates for both geometries are reported, an effective radius of 30 cm could represent organisms weighing up to 250 pounds. This geometry probably results in overestimates of the doses. In the absence of a detailed knowledge of the dynamic behavior of daughter products that are produced from internally-deposited parents, the conservative assumption is made that all daughter products are permanently

bound in the organisms and every daughter in a decay chain contributes energy at an equilibrium disintegration rate for each disintegration of the parent. The annual doses from the i^{th} radionuclide are calculated using the relation:

$$D_i = 51.2 \times 10^3 \, C_{fi} \, \varepsilon_i \times 365 \text{ mrad} \qquad (6)$$

where

C_{fi} = radioactivity concentration in the organism

= $C_{wi} \times F_i$, (µCi/g),

C_{wi} = water concentration, (µCi/g),

F_i = concentration factor, (dimensionless)

External doses for organisms surrounded by water are calculated using equation 4. Benthic organisms such as mussels, worms, and fish eggs may receive higher external doses if significant radioactivity is associated with bottom sediments. Accurate prediction of the accumulation of activity in sediment requires a detailed knowledge of a number of physicochemical factors including mineralogy, particle size, exchangeable calcium in the sediment, channel geometry, water-flow patterns, and the chemical forms of the radio-compounds. Many of these factors must be obtained from extensive field experiments. In the absence of detailed knowledge, the doses are calculated using the following assumptions:

a. Two-tenths of the activity in the liquid effluent is deposited uniformly in a sediment bed having dimensions of 10 cm x 10 m x 10 km.

b. The radioactivity concentration in the sediment is calculated assuming a buildup over the plant life of 35 years at a constant rate of deposition.

c. Beta doses are based on a 4-π geometry and gamma doses assuming a 2-π geometry.

The doses calculated using these assumptions are probably overestimated. Periodic surveillance of the sediment downstream from the nuclear plant will detect a buildup of radionuclides in the sediment, should it occur. If a gradual buildup of radionuclides in the sediment does occur, corrective action will be taken prior to its becoming a significant environmental hazard.

Estimates of the doses to aquatic plants, invertebrates, and fish living near the Bellefonte Nuclear Plant are shown in Table H-6.

REFERENCES FOR APPENDIX H

1. Lederer, C. M., et al., Table of Isotopes, New York, John Wiley & Sons, 1968.

2. ICRP Publication 2, New York, Pergamon Press, 1959.

3. Cowser, K. E., et al, "Dose-Estimation Studies Related to Proposed Construction of an Atlantic-Pacific Interoceanic Canal with Nuclear Explosives: Phase I," Oak Ridge National Laboratory Report, ORNL-4101, 1967.

4. Eve, I. S., "A Review of the Physiology of the Gastrointestinal Tract in Relation to Radiation Doses from Radioactive Materials," Health Physics 12, p. 131 (1966).

5. Tennessee Game and Fish Commission, Tennessee Valley Authority, and Kentucky Department of Fish and Wildlife Resources, "Kentucky Lake Fishing."

6. U.S. Department of the Interior, "Estimated Commercial Fish Harvest, Tennessee Valley, 1969," Bureau of Commercial Fisheries.

7. Chapman, W. H., et al, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Lawrence Radiation Laboratory Report, UCRL-50564, 1968.

8. Reichle, D. E., et al, "Turnover and Concentration of Radionuclides in Food Chains," Nuclear Safety, 11, No. 1 (January-February 1970).

9. Tennessee Department of Conservation, "Statistical Summary--State Demand, Supply, and Comparisons," Tennessee Statewide Comprehensive Outdoor Recreation Plan - 1969, Final Report, Appendix IV, Table 27, 1969, p. 31.

Table H-1

TENNESSEE RIVER DRINKING WATER SUPPLY INTAKES

DOWNSTREAM FROM THE BELLEFONTE NUCLEAR PLANT

System	Location (TRM)	Distance (Miles)	Populations Served 1970	2020
Bellefonte Nuclear Plant	392.0	0.0	0	0
Scottsboro	385.8	6.5	11,000	21,000
Sand Mountain Water Authority	382.1	9.9	8,200	16,000
Christian Youth Camp	368.2	23.8	130	240
Guntersville	358.0	34.0	6,600	13,000
N. E. Morgan Co. Water and Fire	334.4	57.6	3,600	7,000
Huntsville	334.2	57.8	150,000	290,000
Decatur	306.0	86.0	41,000	80,000
U.S. Plywood - Champion Papers	283.0	109.0	500	1,000
Wheeler Dam	274.9	117.1	50	100
Reynolds Metals	260.0	132.0	5,000	10,000
Muscle Shoals	259.6	132.4	7,500	15,000
Wilson Dam	259.5	132.5	2,500	4,900
Sheffield	254.3	137.7	14,000	27,000
Colbert Steam Plant	245.0	147.0	350	680
Cherokee	239.3	152.7	2,700	5,300
Tri-County Utility District	193.5	198.5	1,700	3,200
Clifton	158.0	234.0	1,000	2,000
New Johnsonville	100.5	291.5	950	1,900
Camden	100.4	291.6	3,100	6,000
Foote Mineral	100.0	292.0	170	320
Johnsonville Steam Plant	100.0	292.0	380	730
Bass Bay Resort	79.5	312.5	120	230
Paris Landing State Park	66.3	325.7	100	200
Grand Rivers	24.0	368.0	640	1,200
Paducah	0.1	391.9	63,000	120,000

Table H-2

DOSES[a] TO HUMANS FROM WATER CONTAINING A MIXTURE[b] OF RADIONUCLIDES

A. Ingestion of Tennessee River Water[c]

Location	Bone	G.I. Tract	Thyroid	Total Body	
Bellefonte Site (for comparison)	1.7 (-3)[d]	2.1 (-3)	1.5 (-2)	9.8 (-4)	mrem
Scottsboro	1.7 (-3)	2.1 (-3)	1.4 (-2)	9.8 (-4)	mrem
	3.6 (-2)	4.4 (-2)	3.0 (-1)	2.1 (-2)	man-rem
Sand Mountain Water Authority	1.7 (-3)	2.0 (-3)	1.3 (-2)	9.7 (-4)	mrem
	2.7 (-2)	3.3 (-2)	2.1 (-1)	1.6 (-2)	man-rem
Christian Youth Camp	1.6 (-3)	2.0 (-3)	1.2 (-2)	9.6 (-4)	mrem
	4.0 (-4)	4.8 (-4)	2.8 (-3)	2.3 (-4)	man-rem
Guntersville	1.6 (-3)	1.9 (-3)	1.1 (-2)	9.3 (-4)	mrem
	2.1 (-2)	2.4 (-2)	1.4 (-1)	1.2 (-2)	man-rem
N. E. Morgan Co., Water and Fire	7.6 (-4)	8.8 (-4)	4.5 (-3)	4.4 (-4)	mrem
	5.3 (-3)	6.2 (-3)	3.2 (-2)	3.1 (-3)	man-rem
Huntsville	7.6 (-4)	8.8 (-4)	4.5 (-3)	4.4 (-4)	mrem
	2.2 (-1)	2.5 (-1)	1.3 (0)	1.3 (-1)	man-rem
Decatur	7.3 (-4)	8.5 (-4)	4.0 (-3)	4.3 (-4)	mrem
	5.9 (-2)	6.8 (-2)	3.2 (-1)	3.4 (-2)	man-rem
U.S. Plywood - Champion Papers	6.6 (-4)	7.5 (-4)	3.0 (-3)	3.8 (-4)	mrem
	6.4 (-4)	7.3 (-4)	2.9 (-3)	3.7 (-4)	man-rem
Wheeler Dam	6.5 (-4)	7.3 (-4)	2.5 (-3)	3.8 (-4)	mrem
	6.3 (-5)	7.1 (-5)	2.4 (-4)	3.7 (-5)	man-rem
Reynolds Metals	6.3 (-4)	7.0 (-4)	1.9 (-3)	3.7 (-4)	mrem
	6.1 (-3)	6.8 (-3)	1.8 (-2)	3.6 (-3)	man-rem
Muscle Shoals	6.3 (-4)	7.0 (-4)	1.8 (-3)	3.7 (-4)	mrem
	9.2 (-3)	1.0 (-2)	2.7 (-2)	5.3 (-3)	man-rem
Wilson Dam	6.3 (-4)	7.0 (-4)	1.8 (-3)	3.7 (-4)	mrem
	3.1 (-3)	3.4 (-3)	9.0 (-3)	1.8 (-3)	mrem
Sheffield	6.3 (-4)	6.9 (-4)	1.8 (-3)	3.6 (-4)	mrem
	1.7 (-2)	1.9 (-2)	4.9 (-2)	9.9 (-3)	man-rem
Colbert Steam Plant	6.2 (-4)	6.9 (-4)	1.8 (-3)	3.6 (-4)	mrem
	4.3 (-4)	4.7 (-4)	1.2 (-3)	2.5 (-4)	man-rem
Cherokee	6.2 (-4)	6.9 (-4)	1.7 (-3)	3.6 (-4)	mrem
	3.3 (-3)	3.6 (-3)	9.1 (-3)	1.9 (-3)	man-rem
Tri-County Utility District	5.9 (-4)	6.5 (-4)	1.3 (-3)	3.4 (-4)	mrem
	1.9 (-3)	2.1 (-3)	4.2 (-3)	1.1 (-3)	man-rem
Clifton	5.8 (-4)	6.4 (-4)	1.2 (-3)	3.4 (-4)	mrem
	1.1 (-3)	1.2 (-3)	2.4 (-3)	6.6 (-4)	man-rem

a. Estimates for parts A, B, and C are internal dose commitments for each annual intake of radioactivity. Estimates for part D are external doses for each annual exposure.
b. Excluding tritium.
c. Based on the estimated population in the year 2020.
d. 1.7×10^{-3}.

Table H-2 (Continued)

	Bone	G.I. Tract	Thyroid	Total Body	
New Johnsonville	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	9.6 (-4)	1.0 (-3)	1.8 (-3)	5.5 (-4)	man-rem
Camden	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	3.1 (-3)	3.3 (-3)	5.7 (-3)	1.8 (-3)	man-rem
Foote Mineral	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	1.7 (-4)	1.8 (-4)	3.1 (-4)	9.6 (-5)	man-rem
Johnsonville Steam Plant	5.2 (-4)	5.6 (-4)	9.5 (-4)	3.0 (-4)	mrem
	3.8 (-4)	4.1 (-4)	7.0 (-4)	2.2 (-4)	man-rem
Bass Bay Resort	5.1 (-4)	5.5 (-4)	8.6 (-4)	3.0 (-4)	mrem
	1.2 (-4)	1.3 (-4)	2.0 (-4)	6.9 (-5)	man-rem
Paris Landing State Park	5.0 (-4)	5.4 (-4)	7.9 (-4)	2.9 (-4)	mrem
	9.8 (-5)	1.1 (-4)	1.5 (-4)	5.7 (-5)	man-rem
Grand Rivers	5.0 (-4)	5.3 (-4)	5.4 (-4)	2.9 (-4)	mrem
	6.2 (-4)	6.6 (-4)	6.8 (-4)	3.6 (-4)	man-rem
Paduacah	4.9 (-4)	5.2 (-4)	5.1 (-4)	2.8 (-4)	mrem
	6.0 (-2)	6.4 (-2)	6.2 (-2)	3.5 (-2)	man-rem
Total Population Dose Commitments	4.7 (-1)	5.5 (-1)	2.5	2.8 (-1)	man-rem

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body	
Individual Dose Commitments	4.9 (-1)	6.2 (-1)	4.2	2.9 (-1)	mrem

C. Eating Fish Taken from the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body	
Maximum Individual Dose Commitment	1.9 (-2)	1.2 (-2)	1.9 (-2)	1.2 (-2)	mrem
Population Dose Commitment	6.1	4.1	4.9	3.9	man-rem

D. Use of the Tennessee River for Water Sports

	Above Water[f]		In Water[g]		Shoreline[h]		
	Skin	Total Body	Skin	Total Body	Skin	Total Body	
Maximum Individual Dose	2.6 (-5)	2.0 (-5)	6.6 (-5)	5.0 (-5)	2.6 (-5)	2.0 (-5)	mre
Population Dose	1.5 (-3)	1.1 (-3)	5.6 (-4)	4.3 (-4)	1.5 (-3)	1.1 (-3)	man rem

e. Assuming a continuous discharge of 30,000 GPM.
f. Boating and fishing, for example.
g. Swimming and water skiing, for example.
h. Picnicking and bank fishing, for example.

Table H-3

DOSES[a] TO HUMANS FROM WATER CONTAINING TRITIUM[b]

A. Ingestion of Tennessee River Water[c]

	Individual (mrem)	Population (man-rem)
Bellefonte Nuclear Plant (for comparison)	5.2 (-6)[d]	-
Scottsboro	5.2 (-6)	1.1 (-4)
Sand Mountain Water Authority	5.2 (-6)	8.3 (-5)
Christian Youth Camp	5.1 (-6)	1.2 (-6)
Guntersville	5.0 (-6)	6.4 (-5)
N. E. Morgan Co. Water and Fire	2.4 (-6)	1.7 (-5)
Huntsville	2.4 (-6)	6.8 (-4)
Decatur	2.3 (-6)	1.8 (-4)
U.S. Plywood - Champion Papers	2.1 (-6)	2.0 (-6)
Wheeler Dam	2.0 (-6)	2.0 (-7)
Reynolds Metals	2.0 (-6)	1.9 (-5)
Muscle Shoals	2.0 (-6)	2.9 (-5)
Wilson Dam	2.0 (-6)	9.6 (-6)
Sheffield	2.0 (-6)	5.4 (-5)
Colbert Steam Plant	2.0 (-6)	1.3 (-6)
Cherokee	1.9 (-6)	1.0 (-5)
Tri-County Utility District	1.9 (-6)	6.0 (-6)
Clifton	1.8 (-6)	3.6 (-6)
New Johnsonville	1.6 (-6)	3.0 (-6)
Camden	1.6 (-6)	9.6 (-6)
Foote Mineral	1.6 (-6)	5.2 (-7)
Johnsonville Steam Plant	1.6 (-6)	1.2 (-6)
Bass Bay Resort	1.6 (-6)	3.8 (-7)
Paris Landing State Park	1.6 (-6)	3.1 (-7)
Grand Rivers	1.6 (-6)	2.0 (-6)
Paducah	1.6 (-6)	1.9 (-4)
Population Total		1.5 (-3) man-rem

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River

Individual Dose Commitment 1.5 (-3) mrem

C. Eating Fish Taken from the Tennessee River

Maximum Individual Dose Commitment 6.1 (-8) mrem

Population Dose Commitment 2.1 (-5) man-rem

a. Estimates are internal dose commitments for each annual intake of tritium
b. Normalized to 1.0 Ci total annual release
c. Based on the estimated population in the year 2020
d. 5.2×10^{-6}
e. Assuming a continuous discharge of 30,000 GPM

Table H-3 (Continued)

D. Use of the Tennessee River for Water Sports

	Individual (mrem)
Maximum Individual Dose[f]	4.7 (-6) mrem
Population Dose	7.3 (-4) man-rem

f. Assuming continuous immersion for 5 months

Table H-4

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

Nuclide	Half-Life (d)	Concentration Factors: Fish	Invertebrates	Plants
H-3	4.5 (+3)	1.0 [a]	1.0 [a]	1.0 [a]
Cr-51	2.8 (+1)	2.0 (+2)[a]	2.0 (+3)[a]	4.0 (+3)[a]
Mn-54	3.0 (+2)	2.5 (+1)[a]	1.4 (+5)[b]	3.5 (+4)[b]
Fe-59	4.6 (+1)	3.0 (+2)[a]	3.2 (+3)[a]	5.0 (+3)[a]
Co-58	7.1 (+1)	2.1 (+1)[b]	1.3 (+3)[a]	6.2 (+3)[b]
Co-60	1.9 (+3)	4.8 (+1)[b]	1.5 (+3)[a]	6.2 (+3)[b]
Br-84	2.2 (-2)	1.3 (+2)[a]	1.0 (+2)[a]	7.5 (+2)[a]
Rb-88	1.2 (-2)	2.0 (+3)[a]	2.0 (+3)[a]	1.0 (+3)[a]
Sr-89	5.3 (+1)	3.5 [c]	4.0 (+3)[b]	3.0 (+3)[b]
Sr-90	1.0 (+4)	9.9 [c]	4.0 (+3)[b]	3.0 (+3)[b]
Sr-91	4.0 (-1)	4.0 (-2)[c]	3.2 (+3)[b]	3.0 (+3)[b]
Sr-92	1.1 (-1)	1.1 (-2)[c]	2.1 (+3)[b]	3.0 (+3)[b]
Y-90	2.7	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Y-91	5.9 (+1)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Zr-95	6.6 (+1)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Nb-95	3.5 (+1)	3.0 (+4)[a]	1.0 (+2)[a]	1.0 (+3)[a]
Mo-99	2.8	1.0 (+2)[a]	1.0 (+2)[a]	1.0 (+2)[a]
Ru-106	3.7 (+2)	1.0 (+2)[a]	2.0 (+3)[a]	2.0 (+3)[b]
I-129	6.2 (+9)	5.0 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-131	8.1	4.5 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-132	9.4 (-2)	4.3 [b]	1.0 (+3)[b]	2.0 (+2)[b]
I-133	8.5 (-1)	2.3 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
I-134	3.6 (-2)	1.7 [b]	1.0 (+3)[b]	2.0 (+2)[b]
I-135	2.8 (-1)	1.1 (+1)[b]	1.0 (+3)[b]	2.0 (+2)[b]
Cs-134	7.5 (+2)	1.0 (+3)[a]	9.9 (+3)[b]	2.5 (+4)[b]
Cs-136	1.4 (+1)	9.3 (+2)[a]	5.8 (+3)[b]	2.5 (+4)[b]
Cs-137	1.1 (+4)	1.0 (+3)[a]	1.0 (+4)[b]	2.5 (+4)[b]
Cs-138	2.2 (-2)	2.2 (+1)[a]	2.2 (+1)[b]	2.5 (+4)[b]
Ba-140	1.3 (+1)	1.0 (+1)[a]	2.0 (+2)[a]	5.0 (+2)[a]
La-140	1.7	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Ce-144	2.8 (+2)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]
Pr-144	1.2 (-2)	1.0 (+2)[a]	1.0 (+3)[a]	1.0 (+4)[a]

a. W. H. Chapman, L. H. Fisher, and M. W. Pratt, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Lawrence Livermore Laboratory Report, UCRL-50564 (1968).

b. D. E. Reichle, P. B. Dunaway, and D. J. Nelson, "Turnover and Concentration of Radionuclides in Food Chains," Nuclear Safety, 11, (1) (January-February, 1970).

c. Personal Communication D. J. Nelson, Oak Ridge National Laboratory, to W. H. Wilkie 1972.

d. Personal Communication S. V. Kaye, Oak Ridge National Laboratory, to W. H. Wilkie, 1972.

Table H-5

DOSES[a] TO DUCKS AND MUSKRATS LIVING NEAR THE BELLEFONTE NUCLEAR PLANT

	0.93 Ci Mixture	1.0 Ci Tritium
Internal	1.6 (2) mrad	5.1 (-5)[b] mrad
External	2.4 (-4) mrad	0
Total	1.6 (2) mrad	5.1 (-5) mrad

a. Internal dose commitments for each annual intake and external doses from each annual exposure.
b. 5.1×10^{-5}

Table H-6

DOSES TO AQUATIC ORGANISMS LIVING IN THE TENNESSEE RIVER

NEAR THE BELLEFONTE NUCLEAR PLANT

A. Doses from an Annual Release of a 0.93 Ci Radionuclide Mixture[a]

	Internal (mrad)		External (mrad)	
	3-cm	30-cm		
Plants	3.6	8.5	6.3 (-4)[b]	
Invertebrates	1.6	3.5	6.3 (-4)	suspended
			120	benthic
Fish	0.1	0.3	6.3 (-4)	

B. Doses from an Annual Release of 1.0 Ci Tritium

Plants, invertebrates, and fish	1.1 (-5) mrad (internal)

a. Excluding tritium
b. 6.3×10^{-4}

Appendix I

RADIOLOGICAL IMPACT OF GASEOUS EFFLUENTS

Estimation of doses due to gaseous effluents from the Bellefonte Nuclear Plant is an important consideration in assessing the environmental impact of the plant. The methods of calculation and the results presented in this appendix should provide a realistic estimate of the impact from radionuclides released in gaseous effluents during normal operation. Where assumptions are necessary in developing these methods of calculation, they are chosen to yield conservative results. The following doses to humans are calculated for the routine releases of radionuclides listed in Table I-1.

1. External beta doses
2. External gamma doses
3. Thyroid doses due to inhalation of radioactive iodine
4. Thyroid doses due to concentration of radioactive iodine in milk

The doses and radioiodine concentrations which appear in Tables I-3, I-4, and I-5 are calculated assuming operation of two units for one year at full power with 0.25 percent failed fuel. Doses are calculated for routine releases with a waste treatment system with 60-day holdup and for an alternate system with cryogenic removal.

Radionuclides will be released from the Bellefonte Nuclear Plant through vents located near the top of various plant buildings. To calculate downwind, ground-level air concentrations of these radionuclides, a ground-level, volume-source dispersion equation as described by Davidson[1,2] is used (equation 1). It is assumed that the gaseous effluents are initially diluted in the turbulent wake downwind of the building.

$$\chi_{km} = \sum_i \sum_j \frac{\sqrt{2}\, Q f_{ijk}}{\sqrt{\Pi}\, \Sigma_{zim} u_j\, \theta x_m} \exp\left(\frac{-\lambda x_m}{u_j}\right) \qquad (1)$$

and

$$\Sigma_{zim} = \left(\sigma_{zim}{}^2 + \frac{cA}{\Pi}\right)^{1/2}$$

where

χ_{km} = average annual, ground-level concentration of a radionuclide in sector k at distance x_m, (Ci/m^3),

Q = release rate of a particular radionuclide, (Ci/s),

f_{ijk} = fraction of the release period during which the wind blows in direction k, with speed j, and atmospheric stability condition i,

σ_{zim} = vertical standard deviation of the plume for stability condition i at distance x_m, (m),

Σ_{zim} = vertical standard deviation of the plume (modified for the effect of building wake dilution) for stability condition i at distance x_m, (m),

c = a parameter which relates the cross-sectional area of the building to the size of a turbulent wake caused by the building,

A = cross-sectional area of the reactor building, (m^3),

x_m = downwind distance at which the radionuclide concentration is calculated, (m),

u_j = wind speed j, (m/s),

θ = sector width, (radians),

λ = radioactive decay constant for a particular nuclide, (s^{-1}).

Equation 1 is used to predict the average annual, ground-level concentration of the radionuclides across a 22.5° (θ = 22.5° = 0.39 radian). In equation 1, c is assumed to be 0.5 and A is assumed to be 2,450 m^2 which is the minimum cross-sectional area of the reactor building.

For these calculations Pasquill vertical plume standard deviations[1] are used. Values for the joint meteorological frequencies, f_{ijk}, in equation 1 are determined by methods discussed in Section 1.2.5, Climatology, meteorology, and air quality. In this section, the joint meteorological frequencies for the seven Pasquill stability conditions A through G are presented as a function of wind direction and wind speed in Table 1.2-6 through 1.2-12. The data are grouped for five wind speed ranges (0-0.5, 0.6-3.4, 3.5-7.4, 7.5-12.4, 12.5 mi/h) and for 16 standard wind directions, (N, NNE, NE, . . ., NW, NNW).

The concentration of a radionuclide in sector k at distance x_m for a release rate of 1 Ci/s is expressed as a dispersion factor (χ_{km}/Q). The maximum value for the average annual dispersion factor at the site boundary is 1.1 x 10^{-5} s/m^3. The maximum value occurs in the NNE sector where the distance to the site boundary is 950 meters.

1. External beta doses - Beta doses to individuals are computed using an immersion dose model described by the equation:

$$D_B = 4.64 \times 10^9 \, \overline{E}_B \, \chi \, , \qquad (2)$$

where

D_B = external beta dose due to immersion in a cloud, (mrem/yr),

4.64×10^9 = a constant used in calculating external beta dose,

$$\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$$

$\overline{E}_B$ = average beta energy of nuclide being considered, (MeV/dis)

X = average-annual, ground-level radionuclide concentration as calculated by equation 1, $\frac{Ci}{m^3}$.

In this equation, a correction factor of 0.64 is included to account for cloud geometry, and a correction factor of 0.5 is included to account for self-shielding by the human body.

The χ in equation 2 is the same as χ_{km} in equation 1. To compute the total beta dose from a mixture of radionuclides, equation 2 is applied for each nuclide and the resulting doses are summed. The average beta energies for the nuclides are calculated from information contained in reference 3 and are listed in Table I-1.

In computing the beta dose to the population within 50 miles of the Bellefonte Nuclear Plant, the area is divided into 16 directional sectors and 10 concentric rings, i.e., 160 small area elements. A beta dose computed at the center of each element is multiplied by the number of people residing in that element. A summation of these products over all elements gives the total population dose within 50 miles of the plant. The projected population for the year 2020, as listed in Table I-2, is used in calculating population dose.

The individual and population external beta doses for gaseous effluents are reported in Table I-3.

2. External gamma doses - Gamma doses to individuals are computed using an immersion dose model described by the equation:

$$D_\gamma = 7.21 \times 10^9 \, \bar{E}_\gamma \chi, \qquad (3)$$

where

D_γ = external gamma dose due to immersion in a cloud, (mrem/yr),

7.21×10^9 = a constant used in calculating external gamma dose,

$$\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$$

$\bar{E}_\gamma$ = average gamma energy of nuclide being considered, (MeV/dis),

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3).

In this equation, a correction factor of 0.5 is included to account for cloud geometry.

The χ in equation 3 is the same as χ_{km} in equation 1. When several nuclides are released, the dose due to each nuclide is computed and a summation is executed to obtain the total external gamma dose. The average gamma energies used in calculating external gamma doses are computed from data contained in reference 3 and are listed in Table I-1.

The total population gamma dose within 50 miles of the Bellefonte Nuclear Plant is calculated using the method described for the population beta dose. The annual individual and population external gamma doses for gaseous effluents are reported in Table I-3.

3. Thyroid doses due to iodine inhalation - The equation used in calculating inhalation doses for routine releases of radioiodine from the Bellefonte Nuclear Plant is:

$$D = 8.76 \times 10^3 \chi(BR)(DCF), \qquad (4)$$

where

D = thyroid dose committed, (mrem committed/yr),

8.76×10^3 = hours per year,

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3),

BR = breathing rate, (m^3/h),

DCF = dose commitment factor for iodine inhalation (mrem/Ci inhaled).

Maximum individual thyroid doses due to intake of radioiodine are calculated for a 1-year-old child in accordance with the recommendations of the Federal Radiation Council.[4] Population doses are calculated using adult parameters and the same method described for calculating population beta doses.

The breathing rate assumed for a 1-year-old child[5] is 0.29 m^3/h and for an adult[6] is 0.83 m^3/h. The iodine inhalation dose commitment factors for the 1-year-old child and for the adult are obtained from reference 7.

The calculated annual individual and population iodine inhalation doses for gaseous effluents are reported in Table I-4.

4. Thyroid doses due to iodine ingestion - The equation used in calculating the thyroid doses due to iodine ingestion through the milk food chain is:

$$D = 3.15 \times 10^7 (\chi)(v_g)(M)(CR)(DCF) \qquad (5)$$

where

D = thyroid dose committed, (mrem committed/yr),

3.15×10^7 = seconds per year,

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, (Ci/m^3),

v_g = radioiodine deposition velocity, (m/s),

M = empirically determined value for concentration of radioiodine in milk per unit deposition rate, $\left(\frac{Ci/liter}{Ci/m^2\text{-day}}\right)$,

CR = milk consumption rate, (liter/day),

DCF = dose commitment factor for iodine ingestion (mrem/Ci ingested).

Only Iodine-131 and 133 are considered in calculating milk ingestion doses due to routine releases of radioiodine. Iodine-132, 134, and 135 have short half-lives (<7 hours) and will have essentially disappeared due to decay before significant concentration in the milk occurs.

The 1-year-old child is assumed to be the critical receptor in calculating the maximum dose to an individual drinking milk produced at the nearest dairy farm (11 miles SSW of the plant). Population doses to persons within 50 miles of the plant are calculated using adult parameters. The assumption is made that all milk produced within 50 miles of the Bellefonte Nuclear Plant is consumed within this area, and cows are assumed to graze the pastures during the entire year. County milk production data[8,9,10,11] are used in computing milk ingestion assuming that the population dose increases in direct proportion to the increase in the population.

The numerical values used for the parameters, v_g, M, CR, and DCF are taken from references 7, 12, 13, 14, and 15.

The individual and population milk ingestion doses are reported in Table I-4.

5. <u>Maximum average-annual radioiodine concentration</u> - The maximum average-annual radioiodine concentrations occur in the NNE sector at the site boundary (950 m). The maximum iodine concentrations for routine gaseous releases are calculated using equation 1 and are reported in Table I-5.

REFERENCES FOR APPENDIX I

1. D. H. Slade, "Meteorology and Atomic Energy, 1968," AEC Report, TID-24190, July 1968.

2. "Atmospheric Diffusion Experiments with SF_6 Tracer Gas at Three Mile Island Nuclear Station Under Low Wind Speed Inversion Conditions," Pickard, Lowe, and Associates, Inc., The Research Corporation of New England, General Public Utilities Service Corporation, January 1972.

3. C. M. Lederer, et al., Table of Isotopes, Sixth Edition, John Wiley and Sons, New York, 1968.

4. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council Report No. 2, September 1961.

5. Neil Gaeta, "An Evaluation of the Offsite Radiological Health Aspects from the Nuclear Facility of the Yankee Atomic Electric Company," U.S. Department of Health, Education, and Welfare, Public Health Service, Nuclear Facilities Environmental Analysis Section.

6. "Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press, New York, New York, 1959.

7. K. E. Cowser, et al., "Dose Estimation Studies Related to Proposed Construction of an Atlantic-Pacific Interoceanic Canal with Nuclear Explosives: Phase I," Oak Ridge National Laboratory Report, ORNL-4101, March 1967.

8. Census of Agriculture, County Data Reports for Alabama, Georgia, and Tennessee, U.S. Bureau of Census, 1969.

9. State Crop Reporting Services for Alabama, Georgia, and Tennessee, 1972.

10. Personal Communications, County Agents within states of Alabama, Georgia, and Tennessee, September 1972.

11. Personal Communication, Harold C. Young, National Fertilizer Development Center, USTVA, Muscle Shoals, Alabama, October 1972.

12. T. J. Burnett, "A Derivation of the 'Factor of 700' for ^{131}I," Health Physics, Vol. 18, pp. 73-75, 1970.

13. H. J. Dunster, "District Surveys Following the Windscale Incident, October 1957," Proceedings of the Second U.N. International Conference on the Peaceful Uses of Atomic Energy, Vol. 18, p/ 316, p. 306, 1958.

REFERENCES FOR APPENDIX I
(continued)

14. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council Report No. 5, July 1964.

15. A. R. Tamplin, "I-131, I-133, and Cow Milk," University of California, Lawrence Radiation Laboratory, Livermore, California, UCRL-14146, April 1965.

Table I-1

AVERAGE GAMMA AND BETA ENERGIES USED TO ESTIMATE EXTERNAL DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS

Isotope	Average Gamma Energy (MeV/dis)	Average Beta Energy (MeV/dis)
I-131	3.8 (-1)	2.0 (-1)
I-132	2.5	5.0 (-1)
I-133	6.7 (-1)	4.4 (-1)
I-134	2.4	5.2 (-1)
I-135	1.7	3.3 (-1)
Kr-83m	9.0 (-3)	0
Kr-85m	1.5 (-1)	2.5 (-1)
Kr-85	2.0 (-3)	2.4 (-1)
Kr-87	1.5	1.3
Kr-88	1.7	3.9 (-1)
Kr-89	3.9	1.7
Xe-131m	2.5 (-2)	1.2 (-1)
Xe-133m	5.3 (-2)	1.6 (-1)
Xe-133	4.9 (-2)	1.2 (-1)
Xe-135m	4.3 (-1)	9.9 (-2)
Xe-135	2.3 (-1)	3.3 (-1)
Xe-137	3.2 (-1)	1.7
Xe-138	2.9	9.4 (-1)

Table I-2

PROJECTED 2020 POPULATION DISTRIBUTION WITHIN 50 MILES OF THE BELLEFONTE NUCLEAR PLANT

Direction from Plant	Distance from Plant (miles)									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
	Population within Segment									
N	-	15	100	10	-	200	350	450	6,915	3,795
NNE	-	-	30	115	45	640	5,030	13,735	2,910	4,295
NE	-	-	-	-	30	100	3,035	13,525	25,015	148,535
ENE	-	-	5	10	30	50	2,755	10,700	80,960	308,365
E	-	-	40	50	105	705	3,080	2,550	17,480	5,195
ESE	-	-	35	40	305	680	2,015	1,570	19,565	6,645
SE	-	5	25	-	40	540	2,335	12,275	4,370	13,705
SSE	-	-	-	10	10	495	11,020	17,515	4,820	16,880
S	-	-	-	5	30	840	4,530	3,345	2,495	86,775
SSW	-	-	-	5	15	795	1,750	4,010	62,230	12,245
SW	-	55	610	305	1,355	18,385	6,970	4,625	20,565	24,475
WSW	5	50	600	1,610	5,835	22,800	1,150	4,490	4,680	7,465
W	-	-	2,150	2,225	1,475	2,875	1,500	3,090	365,865	74,145
WNW	-	1,320	2,810	1,385	35	210	1,030	785	8,985	12,550
NW	5	25	70	10	25	185	555	485	5,755	18,365
NNW	5	30	20	10	15	225	155	170	26,360	34,995

Table I-3

ESTIMATED ANNUAL EXTERNAL GAMMA AND BETA DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal System
Maximum Individual Gamma Dose at Site Boundary (mrem)	5.6 (-1)[b]	5.5 (-1)
Maximum Individual Beta Dose at Site Boundary (mrem)	1.1	4.7 (-1)
Total Population Gamma Dose Within 50 miles (man-rem)	1.8	1.7
Total Population Beta Dose Within 50 miles (man-rem)	6.1	2.2

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 5.6×10^{-1}.

Table I-4

ESTIMATED ANNUAL THYROID DOSE COMMITMENTS FROM RADIOIODINE

RELEASED IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal Syster
Iodine Inhalation		
Maximum Individual Thyroid Dose at Site Boundary (mrem)	1.7 (-2)[b]	1.3 (-2)
Total Population Thyroid Dose Within 50 miles (man-rem)	4.2 (-2)	3.0 (-2)
Iodine Ingestion via Milk		
Maximum Individual Thyroid Dose at Nearest Dairy Farm (mrem)	4.5 (-2)	3.1 (-2)
Total Population Thyroid Dose Within 50 miles (man-rem)	3.3 (-1)	2.2 (-1)

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 1.7×10^{-2}

Table I-5

ESTIMATED MAXIMUM ANNUAL IODINE CONCENTRATIONS

FROM RELEASES IN GASEOUS EFFLUENTS[a]

	Total Routine Releases Including 60-day Holdup	Total Routine Releases Including Cryogenic or Absorption Removal System
Maximum Annual Concentration of I-131, μCi/cc	4.4 (-16)[b]	3.0 (-16)
Maximum Annual Concentration of I-132, μCi/cc	1.3 (-16)	1.3 (-16)
Maximum Annual Concentration of I-133, μCi/cc	4.0 (-16)	4.0 (-16)
Maximum Annual Concentration of I-134, μCi/cc	3.8 (-17)	3.8 (-17)
Maximum Annual Concentration of I-135, μCi/cc	2.0 (-16)	2.0 (-16)

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 4.4×10^{-16}

Appendix J

CUMULATIVE RADIOLOGICAL IMPACT ON THE TENNESSEE RIVER FROM THE OPERATION OF TVA NUCLEAR PLANTS

TVA has calculated the expected radiation doses to man and to species other than man resulting from radionuclides in liquid effluents released to the Tennessee River from the operation of the Watts Bar, Sequoyah, Bellefonte, and Browns Ferry Nuclear Plants in the year 1980. A summary of these doses is given in Table J-1. Data were generated for reaches and drinking-water supplies between Watts Bar Dam and Paducah, Kentucky, and the Tennessee Valley population doses are summations of all the appropriate populations within this region. Population figures are derived from 1960 and 1970 census values for a 125-county Tennessee Valley region using linear interpolation of recent data for public water supplies, commercial[1] and sport[2] fish harvests, and the use of the Tennessee River for water sports.[3] Doses are calculated using the models and assumptions described in Appendix I. Estimated doses are listed for Guntersville Lake and for the individual drinking-water supplies within approximately 50 miles downstream from the Bellefonte site. Doses are estimated to be smaller at water supplies farther downstream.

The maximum dose* to an individual from eating fish and drinking water near the Bellefonte site from the cumulative releases of radionuclides in the liquid effluents from TVA nuclear plants is calculated

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*Tritium doses are not included in the values listed in Table J-1. Doses from tritium released from TVA nuclear plants in liquid effluents are estimated to be less than 10 percent of the doses from the mixture of radionuclides excluding tritium.

to be less than 0.2 mrem per year which is less than 0.2 percent of the total dose that an individual receives from natural background radiation. The Tennessee Valley population dose*,** from the cumulative releases of radionuclides in liquid effluents from TVA nuclear plants is calculated to be 37 man-rem which is less than 0.04 percent of the dose from naturally occurring background radiation.

It is concluded that the combined doses resulting from the normal operation of the Watts Bar, Sequoyah, Bellefonte, and Browns Ferry Nuclear Plants will present no significant risk to the health and safety of the public.

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*Tritium doses are not included in the values listed in Table J-1. Doses from tritium released from TVA nuclear plants in liquid effluents are estimated to be less than 10 percent of the doses from the mixture of radionuclides excluding tritium.

**Based on a projection for the year 1980 of 720,000 people served by the water supplies listed in Table H-1 of Appendix H with a conservative assumption that all edible fish harvested from the Tennessee River are consumed by this population.

REFERENCES FOR APPENDIX J

1. U.S. Department of the Interior, "Estimated Commercial Fish Harvest, Tennessee Valley, 1969," Bureau of Commercial Fisheries.

2. Tennessee Game and Fish Commission, Tennessee Valley Authority, and Kentucky Department of Fish and Wildlife Resources, "Kentucky Lake Fishing."

3. Tennessee Department of Conservation, "Statistical Summary--State Demand, Supply, and Comparisons," Tennessee Statewide Comprehensive Outdoor Recreation Plan - 1969, Final Report, Appendix IV, Table 27, 1969.

Table J-1

RADIOLOGICAL IMPACT OF TVA'S NUCLEAR PLANTS ON THE TENNESSEE RIVER IN 1980[a]

	Tennessee Valley Authority Nuclear Plants				
	Watts Bar	Sequoyah	Bellefonte	Browns Ferry	Total
Average Annual Radioactivity[b] Released	0.92	2.0	0.93	0.43	4.0 Ci/yr
I. Average Annual Doses to Humans					
A. Ingestion of Tenn. River Water					
1. Water supplies					
Scottsboro					
a. individual	6.7 (-3)	1.8 (-2)	1.4 (-2)	-	3.9 (-2) mrem[c]
b. population	8.4 (-2)	1.3 (-1)	1.7 (-1)	-	3.8 (-1) man-rem[c]
Sand Mountain Water Authority	6.1 (-2)	1.6 (-1)	1.2 (-1)	-	3.4 (-1) man-rem[c]
Christian Youth Camp	8.3 (-4)	2.2 (-3)	1.7 (-3)	-	4.7 (-3) man-rem[c]
Guntersville	4.0 (-2)	1.1 (-1)	7.9 (-2)	-	2.3 (-1) man-rem[c]
N. E. Morgan Co., Water and Fire	1.9 (-2)	5.0 (-2)	1.8 (-2)	-	8.7 (-2) man-rem[c]
Huntsville	7.6 (-1)	2.0	7.4 (-1)	-	3.5
2. Tenn. Valley[d] population dose	5.1[c]	14[c]	1.4[c]	8.2 (-3)[e]	21 man-rem
B. Eating Fish Taken from the Tenn. River					
1. Guntersville Lake downstream from the Bellefonte Nuclear Plant site					
a. maximum individual	2.0 (-2)[e]	3.7 (-2)[c]	1.9 (-2)[e]	-	7.2 (-2) mrem
b. population	7.0 (-1)[e]	1.2[c]	6.2 (-1)[e]	-	2.1 man-rem
2. Tenn. Valley population dose	5.0[e]	7.3[e]	3.6[e]	5.0 (-1)[f]	16 man-rem

Table J-1
(continued)

	Tennessee Valley Authority Nuclear Plants				
	Watts Bar	Sequoyah	Bellefonte	Browns Ferry	Total
C. Use of the Tenn. River for Water Sports					
1. Guntersville Lake below the Bellefonte Nuclear Plant site					
a. above water	2.4 (-4)	4.3 (-4)	2.9 (-4)	-	9.6 (-4) man-rem[g]
b. in water	9.1 (-5)	1.6 (-4)	1.1 (-4)	-	3.6 (-4) man-rem[g]
2. Tenn. Valley population dose					
a. above water	9.0 (-4)	1.7 (-3)	8.6 (-4)	5.9 (-5)	3.5 (-3) man-rem[g]
b. in water	3.4 (-4)	6.5 (-4)	3.3 (-4)	2.3 (-5)	1.3 (-3) man-rem[g]
II. <u>Doses to Organisms Living near the Bellefonte Nuclear Plant Site</u>					
A. Terrestrial Vertebrates	7.9 (+1)	1.2 (+2)	1.6 (+2)	-	3.6 (+2) mrad[h]
B. Aquatic Organisms					
1. Plants	4.1	6.3	8.5	-	1.9 (+1) mrad[h]
2. Invertebrates	1.6	2.4	3.5	-	7.5 mrad[h]
3. Fish	1.7 (-1)	2.6 (-1)	3.5 (-1)	-	7.8 (-1) mrad[h]

a. Assuming normal operation full time
b. Excluding tritium
c. Doses to thyroid tissue
d. Between Watts Bar Dam and Paducah, Kentucky
e. Dose to bone tissue
f. Dose to G.I. tract tissue
g. Dose to skin tissue
h. Dose to the total organism

Appendix K

RADIOLOGICAL IMPACT OF EXTERNAL DOSE FROM BORATED WATER AND CONDENSATE STORAGE TANKS

The direct gamma radiation dose rate at the site boundary from three borated water storage tanks and two condensate storage tanks has been calculated. The assumptions used in performing these analyses are given below:

1. The dose rate model considers the tanks to be cylindrical, "self-absorbing" volume sources surrounded by a thin steel slab.
2. The physical dimensions and volume of the tanks are: Borated water storage tank: 55'0" dia. x 40'0" high, 650,000 gallons/tank; Condensate storage tank: 51'3" dia. x 40'0" high, 600,000 gallons/tank.
3. Each tank is completely filled with water, with an assumed density of 1.0 g/cm^3.
4. The isotopic distribution of the radioactivity in each tank is shown in Table K-1. The specific activity in the borated water storage tanks is 0.0012 μCi/ml and in the condensate storage tanks is 0.0034 μCi/ml. The total activity, exclusive of tritium, in each borated water storage tank is 2.82 Ci and in each condensate storage tank is 7.67 Ci.
5. The isotopic mixture is considered uniformly distributed in the tank.
6. Decay of the isotopes is not considered in the calculation.

7. Only those gamma rays of significant energy (MeV) and intensity (number per disintegration) are included in the calculations.
8. The average gamma energy for the mixture of isotopes given in Table K-1 is calculated to be 0.70 MeV for the borated water storage tank and 0.68 MeV for the condensate storage tank.
9. The contribution from each nuclide to the total dose rate is weighted according to its fraction of the total activity.
10. The distance from the tanks to the nearest point on the site boundary is used for these calculations (991 meters for the borated water storage tanks and 610 meters for the condensate storage tanks).
11. Attenuation and buildup for air and for the 1/4" steel tank wall are considered in the calculations. Self-absorption and buildup due to the water in the tanks is also considered.
12. No credit for the air-earth interface absorption and scattering effect is taken in the calculations.

Using these assumptions, the direct gamma dose rate at the site boundary from activity contained in each borated water storage tank is calculated to be 0.0001 mrem/yr. For each condensate water storage tank, the direct gamma dose rate is 0.014 mrem/yr. The total direct gamma dose rate at the restricted area boundary from the three borated water storage tanks and the two condensate storage tanks is calculated to be 0.028 mrem/yr.

Table K-1

ISOTOPIC DISTRIBUTION OF ACTIVITY IN BORATED WATER AND CONDENSATE STORAGE TANKS[a]

Isotope	Borated Water Storage Tank Contents, Curie/tank	Condensate Storage Tank Contents, Curie/tank
Sr-89	4.03 (-3)	2.81 (-2)
Y-91		2.78 (-2)
Zr-95	8.80 (-4)	8.14 (-3)
Nb-95	7.22 (-4)	9.55 (-3)
Nb-95m		1.72 (-4)
Mo-99	1.10 (-1)	3.17 (-3)
Tc-99m		3.03 (-4)
I-131	8.25 (-1)	7.13 (-2)
Cs-134	2.93 (-1)	5.29 (-1)
Cs-136	7.21 (-2)	1.66 (-2)
Cs-137	1.49	6.25
Ba-137m		5.75 (-1)
Ba-140	7.20 (-4)	4.68 (-3)
La-140		5.39 (-3)
Ce-144	3.90 (-4)	5.77 (-3)
Pr-144		5.77 (-3)
Mn-54	9.20 (-4)	3.71 (-4)
Co-58	2.64 (-2)	6.81 (-3)
Co-60	9.10 (-4)	1.50 (-2)
Fe-59	1.02 (-3)	7.57 (-5)
Cr-51		3.38 (-4)
Sr-90	1.62 (-4)	9.50 (-3)
Y-90		9.50 (-2)
Total	2.82	6.67

a. Exclusive of tritium.