Regulatory File Cy.

Received w/Ltr Dated 8/28/72

AUG 28 1972

TENNESSEE VALLEY AUTHORITY

ENVIRONMENTAL STATEMENT

50-390
50-391

PRELIMINARY

RETURN TO REGULATORY CENTRAL FILES
ROOM 016

WATTS BAR NUCLEAR PLANT

DOCKETED
USAEC
AUG 28 1972
REGULATORY
MAIL SECTION
DOCKET CLERK

4719

8505280209 720828
PDR ADOCK 05000390
A PDR

SUMMARY SHEET

ENVIRONMENTAL STATEMENT

WATTS BAR NUCLEAR PLANT UNITS 1, 2, AND 3

[ ] Draft [X] 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 two-unit nuclear power generating station in Rhea County, Tennessee.

3. Environmental impacts associated with the construction and operation of the Watts Bar Nuclear Plant include:

   (1) Minute additions of radioactivity to the air and water.
   (2) Release of major quantities of heat to the atmosphere and minor quantities to Chickamauga Reservoir.
   (3) Change in approximately 967 acres of land for the plant site from farming to industrial use and easements on 3,165 acres of land for transmission lines.
   (4) Release of small quantities of nonradioactive materials to the air and water.
   (5) Temporary stress on social infrastructure (schools, roads, housing, and similar services).
   (6) Stimulus to area economic development (jobs, attraction of visitors, etc.).

   No significant adverse environmental effects are expected to occur as a result of these impacts.

4. To meet projected peak loads, TVA considered the following alternatives: (1) base-loaded coal-fired units and (2) nuclear-fueled units. The second alternative provides the lowest cost of generating power and the least environmental impact. The purchase of power in the quantities needed is not a realistic alternative.

   Alternative systems were considered for waste heat dissipation and reduction of releases of radioactive products from the plant.

   Alternative heat dissipation systems considered included:

   (1) Mechanical draft cooling towers
   (2) Natural draft cooling towers
   (3) Spray canal system
   (4) Cooling lake

   Considering feasibility, environmental impact, and cost, the natural draft cooling towers represent the best balance and have been adopted.

Alternatives considered in addition to the original 45-day holdup system to further reduce gaseous radioactive emissions included:

(1) 60-day holdup system
(2) Hydrogen recombiners
(3) Solvent absorption system
(4) Cryogenic distillation system

Selection of a 60-day holdup system was made as a result of balancing feasibility, environmental benefit, and cost.

Tritium recycle by segregating drains and steam generator blowdown treatment by an evaporator were adopted instead of controlled releases as alternate means to further reduce radioactive liquid discharges. Consideration of feasibility, environmental benefit, and cost shows that tritium recycle and the evaporator for blowdown treatment represents the best balance and TVA is proceeding with plans to install this alternative.

5. Comments have been received from the following agencies:

   Atomic Energy Commission
   Department of Agriculture
   Department of the Interior
   Department of Housing and Urban Development
   Department of the Army
   Department of Health, Education, and Welfare
   Southeast Tennessee Development District
   Environmental Protection Agency
   Department of Transportation
   Office of Urban and Federal Affairs, State of Tennessee
     Tennessee Department of Conservation
     Tennessee Department of Public Health
     Tennessee Historical Commission
     Department of Highways
     Tennessee State Planning Commission
     Tennessee Game and Fish Commission
   Department of Commerce
   Federal Power Commission

6. The draft statement was sent to the Council on Environmental Quality and made available to the public on May 14, 1971. Supplements and additions to the draft was sent to the Council and made available to the public on April 7, 1972. The final statement was sent to the Council and made available to the public on September 15, 1972.

DETAILED TABLE OF CONTENTS

	Page No.
SUMMARY SHEET	frontispiece
DETAILED TABLE OF CONTENTS	(i)
PREFACE	
1.0 INTRODUCTION	1.0-1
1.1 General Information	1.1-1
1. Location of the Facility	1.1-1
2. Physical Characteristics of the Facility	1.1-1
3. Environment in the Area	1.1-2
(1) Topography	1.1-2
(2) History	1.1-3
(3) Geology	1.1-4
(4) Seismology	1.1-5
(5) Geography	1.1-5
(6) Climatology and Meteorology	1.1-7
(7) Hydrology	1.1-9
(a) Ground Water	1.1-9
(b) Surface Water	1.1-10
(c) Water Use	1.1-10
(8) Land Use	1.1-13
(a) Industrial Operations	1.1-14
(b) Transportation	1.1-15
(c) Farming	1.1-15
(d) Forestry	1.1-15

	Page No.
(e) Recreation	1.1-16
(f) Wildlife Management Areas and Preserves	1.1-16
(g) Population Distribution	1.1-17
(h) Waterways	1.1-17
(i) Government Reservations and Installations	1.1-17
(9) Ecology	1.1-18
(a) Waterfowl	1.1-18
(b) Fish and Other Aquatic Life	1.1-19
(10) Chemical and Physical Characteristics of Air and Water	1.1-22
(a) Air	1.1-22
(b) Water	1.1-22
(c) Temperature	1.1-25
(11) Historical and Archaeological Significance of the Watts Bar Site	1.1-26
1.2 Electric Power Supply and Demand	1.2-1
1. Power Needs	1.2-2
2. Consequences of Delays	1.2-3
1.3 Environmental Approvals and Consultations	1.3-1
1.4 Emergency Planning	1.4-1
1. Meetings with Outside Agencies	1.4-3
2. Responsible Agencies to be Notified in Case of Accident	1.4-3
2.0 ENVIRONMENTAL IMPACT OF THE PROPOSED FACILITY	2.0-1
2.1 Transportation of Nuclear Fuel and Radioactive Wastes	2.1-1
1. New Fuel Shipment	2.1-1
(1) Method and Frequency of Shipment	2.1-2

Page No.

(a) Shipping Routes 2.1-3

(b) Shipment Activity 2.1-3

(2) Environmental Effects 2.1-4

(a) Normal Shipments 2.1-5

(b) Accident Occurrences 2.1-5

2. Spent Fuel Shipment 2.1-6

(1) Method and Frequency of Shipment 2.1-6

(a) Shipping Routes 2.1-7

(b) Shipment Activity 2.1-8

(2) Environmental Effects 2.1-9

(a) Normal Shipment 2.1-9

(b) Accident Occurrences 2.1-11

3. Radioactive Waste Shipment 2.1-13

(1) Method and Frequency of Shipment 2.1-13

(a) Shipping Routes 2.1-14

(b) Shipment Activity 2.1-15

(2) Environmental Effects 2.1-15

(a) Normal Shipment 2.1-16

(b) Accident Occurrences 2.1-17

4. Shipping Safeguards 2.1-19

(1) Governing Regulations 2.1-20

(2) Package Design 2.1-22

(a) New Fuel Container Description and Licensing 2.1-22

(b) Spent Fuel Container Description and Licensing 2.1-23

(c) Radwaste Container Description and Licensing 2.1-26

Page No.

(3) Transportation Procedures 2.1-29

(a) Onsite Procedures 2.1-29

(b) Offsite Procedures 2.1-29

(c) Normal Conditions of Transport 2.1-30

(d) Accident Occurrences During Transport . . . 2.1-30

5. Conclusion 2.1-32

2.2 Environmental Aspects of Transmission Lines 2.2-1

1. General Considerations 2.2-2

2. Beneficial Uses of Transmission Line Right of Way . . 2.2-5

(1) Shear Cutting of Right of Way 2.2-5

(2) Multiple Use of Right of Way 2.2-8

3. Solid Waste Disposal 2.2-9

4. Erosion Control Practices 2.2-10

5. Miscellaneous Impacts 2.2-11

(1) Ozone 2.2-11

(2) Compatibility with Communications Equipment . . . 2.2-13

(3) Historical and Archaeological Compatibility . . . 2.2-14

(4) Impacts on Aviation 2.2-14

(5) General Impacts 2.2-14

6. Tentative Transmission Line Route Selection 2.2-15

(1) Watts Bar-Volunteer 500-kV Transmission Line . . 2.2-15

(2) Watts Bar-Bull Run and Watts Bar-Sequoyah No. 1 500-kV Transmission Lines 2.2-18

(3) Watts Bar-Roane 500-kV Transmission Line 2.2-19

(4) Watts Bar-Sequoyah No. 2 500-kV Transmission Line 2.2-20

(5) 161-kV Transmission Lines for Station Service . . 2.2-22

7. Conclusion 2.2-23

	Page No.
2.3 Radiological Effects of Accidents	2.3-1
2.4 Radioactive Discharges	2.4-1
1. Basis for Evaluation of Radioactive Discharges	2.4-2
(1) Liquid Discharges	2.4-5
(a) Liquid Treatment Systems	2.4-5
(b) Tritium Recycle	2.4-8
(c) Extended Treatment of Steam-Generator Leaks	2.4-12
(d) Conclusion	2.4-16
(2) Gaseous Discharges	2.4-16
(a) Gaseous Treatment Systems	2.4-16
(b) Alternative Gaseous Radwaste Systems	2.4-21
(c) Conclusion	2.4-24
(3) Solid Radwaste Disposal	2.4-25
2. Estimated Increase in Annual Environmental Radioactivity Levels and Potential Annual Radiation Doses from Principal Radionuclides	2.4-26
(1) Radionuclides in Liquid Effluents	2.4-26
(2) Radionuclides in Gaseous Effluents	2.4-27
(3) Summary of Radiological Impact	2.4-29
3. Environmental Radiological Monitoring Program	2.4-31
(1) General	2.4-31
(2) Atmospheric Monitoring	2.4-33
(3) Terrestrial Monitoring	2.4-34
(4) Reservoir Monitoring	2.4-35
(a) Water	2.4-37
(5) Quality Control	2.4-40

Page No.

2.5 Nonradioactive Discharges 2.5-1

1. Chemical Discharges 2.5-1

(1) Cooling Tower Blowdown and Drift 2.5-2

(2) Raw Cooling Water and Essential Raw Cooling Water Systems 2.5-6

(3) Makeup Water Filter Plant 2.5-8

(4) Water Treatment Plant Demineralizers 2.5-8

(5) Steam-Generator Blowdown 2.5-10

(6) Component Cooling Water System 2.5-11

(7) Reactor Coolant System 2.5-11

(8) Auxiliary Steam-Generator Blowdown 2.5-11

(9) Chemical Cleaning During Construction 2.5-12

(10) Miscellaneous 2.5-12

2. Yard Drainage System 2.5-14

3. Transformers and Electrical Machinery 2.5-15

4. Sanitary Wastes 2.5-16

5. Gaseous Emissions 2.5-17

6. Normal Solid Waste Disposal 2.5-18

2.6 Heat Dissipation 2.6-1

1. Description of the Cooling System 2.6-3

2. Impact of Heat Dissipation Facilities 2.6-8

(1) Physical and Chemical Characteristics of the Tower Effluent 2.6-8

(2) Local Fogging and Icing 2.6-13

(3) Aesthetics 2.6-19

(4) Noise 2.6-19

Page No.

3. Applicability of Section 21(b) Permit 2.6-20

4. Alternative Heat Dissipation Facilities 2.6-20

(1) Once-Through Cooling 2.6-20

(2) Mechanical Draft Cooling Towers 2.6-22

(a) Feasibility 2.6-22

(b) Land Requirements 2.6-22

(c) Environmental Considerations 2.6-22

(d) Economic Considerations 2.6-27

(e) Construction Schedule 2.6-28

(3) Natural Draft Cooling Towers 2.6-28

(a) Feasibility 2.6-28

(b) Land Requirements 2.6-29

(c) Environmental Considerations 2.6-29

(d) Economic Considerations 2.6-29

(e) Construction Schedule 2.6-29

(4) Spray Canal System 2.6-30

(5) Cooling Lake System 2.6-30

(6) Evaluation of Alternative Heat Dissipation Facilities 2.6-32

2.7 Biological Impact 2.7-1

1. Ecological Studies and Analyses Performed or Planned . 2.7-1

(1) Identification of Species Important to Sport and Commercial Use 2.7-1

(2) Importance of Locale to Existence of Important Species, Considering States in Life History . . 2.7-3

(3) Time and Space Changes in Temperature Distribution 2.7-4

(4) Implications of Withdrawal and Return of Cooling Water 2.7-6

Page No.

(5) Effect of Passage Through Condensers on Planktonic Forms and Fish Larvae 2.7-8

(6) Siltation and Turbidity Effects 2.7-11

(7) Measures Taken to Assure Adequate Ecological Studies 2.7-14

2. Studies to be Conducted or Continued 2.7-15

2.8 Construction Effects 2.8-1

1. General Construction Considerations 2.8-1

(1) General Clearing 2.8-2

(2) General Grading and Excavation 2.8-4

2. Siltation Control 2.8-8

3. Solid Waste 2.8-10

4. Sanitary Waste 2.8-11

5. Chemical Cleaning 2.8-11

6. Miscellaneous 2.8-12

7. Monitoring 2.8-13

2.9 Socioeconomic Impact 2.9-1

1. Construction Employment Impact 2.9-1

2. Permanent Employment Impact 2.9-3

3. Mitigation of Impacts 2.9-4

2.10 Other Impacts 2.10-1

1. Land Use Compatibility 2.10-1

2. Water Use Compatibility 2.10-2

3. Aesthetics 2.10-3

4. Archaeology 2.10-4

3.0 ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED . . 3.0-1

1. Water Pollution 3.0-1

Page No.

2. Air Pollution 3.0-3
3. Impacts on Land Use 3.0-4
4. Damage to Life Systems 3.0-4
5. Threats to Health 3.0-5
6. Conclusions 3.0-5

4.0 ALTERNATIVES 4.0-1

1. Alternative Systems for Reductions of Radioactive Discharges 4.0-1
(1) Liquid Radwaste Alternatives 4.0-1
(2) Gaseous Radwaste Alternatives 4.0-2
2. Alternative Heat Dissipation Methods 4.0-2

4.1 Alternative Generation 4.1-1

4.2 Alternative Sites 4.2-1

1. Site Studies 4.2-1
2. Environmental Considerations 4.2-2
(1) Chickamauga and Watts Bar Reservoir Sites 4.2-2
(a) Hydrology 4.2-2
(b) Seismology 4.2-3
(c) Meteorology 4.2-4
(d) Population 4.2-5
(e) Land Requirements 4.2-5
(f) Conclusion 4.2-5
(2) Guntersville Reservoir Sites 4.2-5
(a) Hydrology 4.2-5
(b) Seismology 4.2-6
(c) Meteorology 4.2-6

Page No.

(d) Population 4.2-8
(e) Land Requirements 4.2-8
(f) Conclusion 4.2-8
3. Feasibility 4.2-8
(1) Access Facilities 4.2-8
(2) Site Grading 4.2-9
(3) Proximity to Populated Areas 4.2-9
(4) Distance to Nearest Transmission Lines 4.2-9
(5) Conclusion 4.2-9
4. Additional Considerations 4.2-10
(1) Schedule 4.2-10
(2) Cost 4.2-10
(3) Fuel Availability 4.2-10
5. Conclusion 4.2-11
5.0 SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY 5.0-1
6.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES . 6.0-1
7.0 AGENCY REVIEW COMMENTS 7.0-1
7.1 Atomic Energy Commission 7.1-1
7.2 Department of Agriculture 7.2-1
7.3 Department of the Interior 7.3-1
7.4 Department of Housing and Urban Development 7.4-1
7.5 Department of the Army 7.5-1
7.6 Department of Health, Education and Welfare 7.6-1
7.7 Southeast Tennessee Development District 7.7-1
7.8 Environmental Protection Agency 7.8-1
7.9 Department of Transportation 7.9-1

Page No.

7.10 Office of Urban and Federal Affairs, State of Tennessee . 7.10-1

7.11 Department of Commerce 7.11-1

7.12 Federal Power Commission 7.12-1

8.0 BENEFIT-COST WEIGHING AND BALANCING 8.0-1

8.1 Benefits 8.1-1

1. Electric Power Produced and Sold 8.1-1

2. Payments in Lieu of Taxes 8.1-3

3. Regional Gross Product 8.1-4

4. Recreation 8.1-5

5. Air Quality 8.1-5

6. Employment 8.1-6

7. Education 8.1-6

8.2 Monetary and Environmental Costs 8.2-1

1. Effects on Natural Surface Water Body 8.2-1

(1) Cooling Water Intake Structure 8.2-1

(2) Passage Through the Condensers and Retention in Closed-Cycle Cooling Systems 8.2-2

(a) Primary Producers and Consumers 8.2-2

(b) Fish 8.2-3

(3) Discharge Area and Thermal Plume 8.2-5

(a) Physical Water Quality 8.2-5

(b) Dissolved Oxygen 8.2-5

(c) Aquatic Biota 8.2-5

(d) Wildlife 8.2-5

(e) Migratory fish 8.2-5

Page No.

(4) Chemical Effluents 8.2-6

(5) Radionuclides Discharged to Water Body 8.2-6

(a) Aquatic Organisms 8.2-6

(b) People - External 8.2-7

(c) People - Ingestion 8.2-7

(6) Consumption of Water 8.2-7

(7) Plant Construction 8.2-8

(a) Physical Water Quality 8.2-8

(b) Chemical Water Quality 8.2-8

(8) Other Impacts 8.2-8

(9) Combined or Interactive Effects 8.2-8

(10) Net Effect on Chickamauga Reservoir 8.2-9

2. Effects on Ground Water 8.2-9

(1) Raising or Lowering of Ground Water Levels . . . 8.2-9

(2) Chemical Contamination of Ground Water 8.2-9

(3) Radionuclide Contamination of Ground Water . . . 8.2-9

(a) People 8.2-9

(b) Plants and Animals 8.2-10

(4) Other Impacts on Ground Water 8.2-11

3. Effects on Air 8.2-12

(1) Fogging and Icing Caused by Evaporation and Drift 8.2-12

(a) Effects on Local Ground Transportation . . . 8.2-12

(b) Effects on Air Transportation 8.2-12

(c) Local Effects on Water Transportation . . . 8.2-12

(d) Effects on Plants 8.2-12

Page No.

(2) Chemical Discharge to Ambient Air 8.2-13

(3) Radionuclides Discharged to Ambient Air 8.2-13

(a) People - External 8.2-13

(b) People - Ingestion 8.2-14

(c) Plants and Animals 8.2-14

(4) Other Impacts on Air 8.2-14

4. Effects on Land 8.2-14

(1) Preemption of Land 8.2-14

(2) Plant Construction 8.2-14

(a) Noise Effect on People 8.2-14

(b) Accessibility of Historical Sites 8.2-15

(c) Accessibility of Archaeological Sites 8.2-15

(d) Wildlife 8.2-15

(e) Erosion Effects 8.2-15

(3) Plant Operation 8.2-15

(a) Noise Effects on People 8.2-15

(b) Aesthetic Effects on People 8.2-16

(c) Wildlife 8.2-16

(d) Flood Control 8.2-16

(4) Salts Discharged in Drift from Cooling Towers . . 8.2-16

(5) Transmission Route Selection 8.2-16

(a) Preemption of Land 8.2-16

(b) Land Use and Land Value 8.2-17

(c) Aesthetic Effects on People 8.2-18

(6) Transmission Facilities Construction 8.2-18

(a) Land Adjacent to Rights of Way 8.2-18

	Page No.
(b) Land Erosion	8.2-18
(c) Wildlife	8.2-18
(7) Transmission Line Operation	8.2-19
(a) Land Use	8.2-19
(b) Wildlife	8.2-19
(8) Other Land Impacts	8.2-19
(9) Combined or Interactive Effects	8.2-21
(10) Net Effects on Land	8.2-21
5. Cross Category Effects	8.2-21
(1) Transportation	8.2-21
(2) Accidents	8.2-21
8.3 Weighing and Balancing of Alternative Generating, Alternative Sites, and Alternative Subsystems	8.3-1
1. Alternative Generating Capacity	8.3-1
2. Alternative Sites	8.3-1
3. Heat Dissipation	8.3-1
4. Gaseous Radwaste System	8.3-3
5. Liquid Radwaste Treatment	8.3-4
APPENDIX A Radiological Analysis for Transportation of Spent Fuel and Radioactive Waste	A-1
APPENDIX B Relation of 10 CFR Part 71 Accident Requirements to Actual Shipping Environment	B-1
APPENDIX C Ozone Production and Its Potential Effects	C-1
APPENDIX D Outline of Accident Analyses	D-1
APPENDIX E Radiological Impact of Liquid Effluents	E-1

Page No.

APPENDIX F Radiological Impact of Gaseous Effluents F-1

APPENDIX G Radiological Impact of External Dose from Refueling and Primary Water Storage Tanks G-1

APPENDIX H Cumulative Radiological Impact from Operation of Watts Bar and Sequoyah Nuclear Plants H-1

APPENDIX I Terrestrial Ecosystem Survey and Analyses I-1

PREFACE

This detailed statement of environmental considerations, prepared by the Tennessee Valley Authority, evaluates the effects on the environment of the construction and operation of the Watts Bar Nuclear Plant (AEC Docket Nos. 50-390, 50-391) and is made in accordance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. Section 4331 et seq).

TVA, a corporate agency of the Federal government, and the Atomic Energy Commission, a regulatory agency of the Federal government, have agreed that TVA is the lead agency for the preparation and circulation of detailed statements of environmental considerations for TVA nuclear plants. For the Watts Bar plant a draft statement was circulated for review and comments by other government agencies on May 14, 1971. This was supplemented on April 7, 1972, with additional information responding to AEC's revisions to 10 CFR Part 50, made pursuant to the Calvert Cliffs decision (Calvert Cliffs' Coordinating Committee v. Atomic Energy Commission, 449 F.2d 1109 (D.C. Cir. 1971)).

Comments have been received on both the draft and supplement. The information contained in the draft and supplement as well as the agency comments and TVA's response thereto have been incorporated into this statement.

On May 18, 1971, TVA filed an application for a construction permit for units 1 and 2. At the same time TVA submitted the draft environmental statement along with the preliminary safety analysis report to the AEC in support of the application.

In accordance with the lead agency agreement, TVA has consulted AEC in the preparation of this final detailed environmental statement.

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 (1964; Supp. V, 1965-69)). 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 hydrogenerating plants and 11 fossil-fueled steam-generating plants now in operation. In addition, power from Corps of Engineers' dams on the Cumberland River and dams owned by the Aluminum Company of America on Tennessee River tributaries is made available to TVA under long-term contracts. Figure 1.2-1 shows the location of TVA's present generating facilities and those under construction, as well as the location of the above Corps and Alcoa dams. 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 major system capacity additions since 1949 are shown on Table 1.2-1.

As part of TVA's construction program designed to meet increased requirements for generation, in August 1970 the TVA Board tentatively approved the Watts Bar Nuclear Plant. An application to construct and operate units 1 and 2 was filed with the Atomic Energy Commission (AEC) on May 18, 1971. 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, an Atomic Safety and Licensing Board is expected to grant a construction permit late in 1972. 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 full power level. Under the current schedule, TVA expects to begin to load the nuclear fuel for unit 1 in December 1976. Full operation of unit 1 is expected in the summer of 1977; unit 2 is expected to go into operation in the winter of 1977-78.

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 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 ensure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making as required by NEPA. The draft statement on the environmental considerations relating to the Watts Bar Nuclear Plant has been sent to state and Federal agencies for review and comment pursuant to NEPA 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 at Watts Bar 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.

This statement is arranged in nine principal sections. The first section provides a baseline inventory of environmental information. The following eight sections cover the environmental considerations set out in Section 102(2)(C) of NEPA, as implemented by the CEQ and AEC guidelines. After weighing and balancing the environmental costs, and the technical, economic, and 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 Watts Bar Nuclear Plant.

1.1 General Information - The purpose of this section is to provide a basic knowledge of the existing environment and the important characteristics and values of the Watts Bar site as it now exists in order to establish a basis for consideration of the environmental impact of the facility.

1. Location of the facility - The plant will be in Rhea County, Tennessee, located on a tract of land adjacent to the TVA Watts Bar Dam Reservation at Tennessee River mile (TRM) 528 on the west shore of Chickamauga Lake about 8 miles southeast of Spring City, Tennessee. The Watts Bar Dam Reservation, together with the 967 acres of additional land required, will comprise approximately 1,770 acres. The proximity of the site to local towns, rivers, and county boundaries is indicated on the vicinity map. (Figure 1.1-1)

2. Physical characteristics of the facility - The plant will consist of the following principal structures: two reactor containment buildings, turbine building, service building, diesel generator building, intake pumping station, water treatment plant, two cooling towers, auxiliary building, transformer yard, 500-kV and 161-kV switchyard, and sewage treatment plant. Figure 1.1-2 shows the general arrangement of these facilities. Figure 1.1-3 is an artist's concept of how the plant will appear on completion of construction. A further description of the site and structures is in Section 2.10, Other impacts.

The 2-unit plant will have a total nameplate electrical generating capacity of approximately 2,540 megawatts. The two reactor containment buildings each house a Westinghouse pressurized water reactor. 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 heated coolant flows in four 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 reactor power is controlled by control rods and a soluble neutron absorber boric acid.

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

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

3. <u>Environment of the area</u> - The following summary description provides a baseline inventory of the important characteristics of the region.

(1) <u>Topography</u> - The Watts Bar Reservation is a moderately wooded area with rolling hills, located in a valley approximately 10 miles wide, flanked on the west by Walden Ridge (900 to 1,800 feet) and by a series of lower ridges (800 to

1,000 feet) on the east, on the west bank of a bend in the Tennessee River. The nuclear plant will be located in the less-wooded southern portion of the reservation. In the vicinity of the plant the land rises from the water surface (normal maximum level elevation 682.5 feet above mean sea level) to approximately 735 feet above mean sea level.

The highest point on the reservation (elevation 900 feet MSL) is approximately 1/2 mile to the north of the plant.

(2) History - The Watts Bar site is in Rhea County in east Tennessee. Prior to settlement, the area had been lands of the Cherokee, Chickamauga, and Creek Indians. The county was formed by an act of the Tennessee legislature on December 3, 1807. The county boundaries fluctuated frequently in the early years following formation, but eventually stabilized to contain an area of approximately 360 square miles. The original county seat was at Washington, but in 1890 the county seat was removed to Dayton, its present location. To the west and nearer the site location is Spring City, which developed in the latter half of the nineteenth century.

In 1939 TVA authorized construction of the Watts Bar Dam, at a point about 2 miles upstream of the nuclear plant site. The dam has five generators with a total nameplate capacity of 150 MW. All units were operational by 1944.

In 1940 TVA authorized construction of the Watts Bar Steam Plant, 2/3 mile downstream from the Watts Bar Dam. The total nameplate capacity of this 4-unit coal-fired plant is 240

MW. All units were operational by 1945. The plant was seldom used during the 15-year period from 1955 to 1969 due to the availability of more efficient generating units. In the past three years operation has increased but this higher level of use is not expected to continue when Watts Bar Nuclear Plant begins operation.

(3) Geology - Geological studies of the bedrock at the site show that it is overlain by approximately 40 feet of unconsolidated terrace deposits laid down by the Tennessee River when flowing at a higher level. Drilling has shown that the upper half of the terrace deposits consist of sandy, silty clay. The lower half is much coarser, consisting of pebbles, cobbles, and small boulders of quartz or quartzitic sandstone embedded in a sandy clay matrix.

Beneath the terrace cover are the interbedded limestone and shales of the Conasauga Formation of Middle Cambrian Age. Stratigraphically, the Conasauga is overlain to the southeast by 2,500 to 3,000 feet of massive limestone and dolomite of the Knox Group and is underlain to the northwest by 800 to 1,000 feet of sandstone and shale of the Rome Formation. During the geologic past, folding and faulting compressed the Conasauga Formation between the more competent overlying Knox and underlying Rome Formations with the result that the thin-bedded limestones and shales of the Conasauga are complexly folded, crumpled, contorted, sheared, and broken by small faults.

In spite of the structural complexities, the Conasauga Formation will provide a satisfactory and competent foundation for the plant structures. Cores from 56 holes drilled in the plant area indicate no evidence of weathering below the upper

5 feet of rock which will be removed under normal construction procedures. Physical testing, both static and dynamic, has shown that the unweathered rock is capable of supporting loads in excess of those that will be imposed by the plant structures.

The Conasauga Formation at the site is relatively unfossiliferous and has no known areas of unique paleontologic significance.

(4) Seismology - The Watts Bar site lies within the borders of the Southern Appalachian seismotectonic province. Figure 1.1-4 locates the nearest faults in the region.

The nearest local quakes with Modified Mercalli intensities of V were centered 20 miles from the site. The nearest known epicenter of a damaging quake (MM VII) is 75 miles northeast of the site. The maximum intensity to have been felt at the site in the recorded history of the area is probably MM V and certainly no more than MM VI. On the basis of present knowledge, the maximum historic felt intensity was derived from major earthquakes centered at distant points, especially in the Mississippi Valley. Accelerations at the site from a recurrence of any of these shocks would be far less than the proposed design accelerations.

(5) Geography - The Watts Bar site is located in the western portion of the Appalachian Valley physiographic province in the Valley and Ridge subprovince, known locally as the Great Valley of east Tennessee. The Valley and Ridge differ greatly from the adjacent physiographic provinces in geography, physiography,

stratigraphy, and structure. As a physiographic unit, the area is well defined and rather consistent throughout. It is outlined sharply on the southeast by the high front of the Blue Ridge and on the northwest by the abrupt escarpment of the Cumberland Plateau. Its surface is characterized by long narrow ridges and somewhat broader intervening valleys having a northeast-southwest trend. The ridges are roughly parallel and fairly even-topped. They are developed in areas underlaid by resistant sandstones and the more siliceous limestones and dolomites. The valleys have been excavated in the areas underlaid by the easily erodible shales and the more soluble limestone formations.

In the vicinity of the Watts Bar site, the Tennessee River, prior to the impoundment of Chickamauga Lake, had entrenched its course to an elevation of 670 feet above mean sea level. The small tributary valley floors slope from the river up to around elevation 800, while the crests of the intervening ridges range between 900 and 1,000 feet above sea level.

At present no mineral deposits are being worked in the Watts Bar area and there is no basis for assuming that any will be developed in the future. In the early part of the present century there was sporadic mining of low-grade iron ore 5 to 15 miles northeast of the site, but these deposits are uneconomical under present market conditions. Even if they should become economically attractive sometime in the future, they are far enough removed from the area that the presence of the plant would not affect them. Commercially valuable deposits of zinc ores exist in the lower portions of the Holston River basin between Knoxville and Jefferson City, Tennessee. At present these deposits are being actively mined at three locations. The mining operation closest to the Watts Bar

Nuclear Plant is located near Mascot, Tennessee, about 138 miles upstream from the plant site. Coal is produced from the Cumberland Plateau to the northwest of the site, but here again the distance--10 to 15 miles--precludes any interference from the plant.

There is no indicated potential for any oil or gas production in the Watts Bar area. The nearest test wells that have been drilled, without production, are about 10 miles from the plant site. Location of the plant on the Watts Bar site would not interfere with recovery of oil or gas should it be discovered in the area.

(6) Climatology and meteorology - The Watts Bar site is in the eastern Tennessee portion of the Southern Appalachian Region, which is dominated much of the year by the Azores-Bermuda anticyclonic circulation. This circulation is more pronounced in the fall (October) and is accompanied by extended periods of fair weather.

The probability of tornado occurrence at the Watts Bar site is extremely low. For nearly a half-century, 1916-64, there have been no tornadoes recorded in this area of Rhea County. Two tornadoes were recorded in the adjacent Meigs County. Tornadoes in that area generally moved northeastward up the Great Valley, covering an average surface path 5 miles long and 100 feet wide.

Severe windstorms may occur several times a year, particularly during winter, spring, and summer, with winds reaching 35 mi/h and on occasion exceeding 60 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 winds may also accompany thunderstorms which occur approximately 60 times a year, with maximum frequency in July.

The climate of the Watts Bar site is interchangeably continental and maritime in winter and spring, predominantly maritime in the summer, and continental in the fall. Data collected over a 35-year period in Decatur, Tennessee, indicate the average annual temperature is 59°F, with monthly averages ranging from 35.4°F in January to 77.6°F in July. The maximum annual range, from 108°F in July to -20°F in February, is 128°F. Detailed air temperature data are shown in Table 1.1-1.

About 60 percent of the annual average precipitation in the site area results from migratory storms in late November through April. Detailed precipitation information is shown in Table 1.1-2. Table 1.1-3 contains snowfall data.

Based on a U.S. Public Health Service study of 21 years of data,[3] it is anticipated that, on the average, the Watts Bar site will experience each year two atmospheric stagnations lasting for 4 or more days.

The Watts Bar site data are supplemented by data from Chattanooga and Knoxville airports, Kingston Steam Plant, and Oak Ridge National Laboratory which show a predominant northeast-southwest alignment. Kingston Steam Plant data also indicate that the highest occurrence of directional persistence is with southwest winds. Wind speed data from Chattanooga and Knoxville indicate an average wind speed of 7 and 9 mi/h respectively and a fall wind speed of 5 and 6 mi/h respectively. Tables 1.1-4, 1.1-5, and 1.1-6 contain wind data for Kingston Steam Plant, Chattanooga, and Knoxville, respectively.

Wind data collected from 130-foot tower level at the Watts Bar temporary meteorological facility during the first year of operation (July 1, 1971 through June 28, 1972) indicate a predominantly southwesterly and northeasterly flow which parallels the local valley-ridge terrain. Data also indicate the longest periods of directional persistence are associated with south-southwest winds (Table 1.1-7). Annually, and during the winter and summer, winds are predominantly from the south-southwest (Tables 1.1-8, 1.1-9, and 1.1-10). During the spring winds are predominantly from the southwest (Table 1.1-11) and during the fall from the northeast (Table 1.1-12).

Periods of calm (wind speeds less than 0.6 mi/h) occur about 8 percent of the time, and wind speeds in the 1-3 mi/h range and the 4-7 mi/h range occur about 36 and 34 percent of the time, respectively (Table 1.1-8). The strongest wind recorded onsite during this period was 35 mi/h.

The one year of onsite measurements indicates that surface-based inversions occur 55 percent of the time. Inversions occur most frequently in spring and summer (63 percent and 59 percent, respectively) and least often in fall and winter (55 percent and 48 percent, respectively). The 8- to 16-hour period between early to midevening (6 to 10 p.m.) and early to midmorning (7 to 10 a.m.) are normally associated with calm conditions or wind speeds less than about 6 miles per hour which are conducive to surface-based inversions.

(7) Hydrology -

(a) Ground water - Ground water at Watts Bar is derived principally from precipitation which, over the past 30 years of record, has averaged 52.9 inches per year. There is no distinct aquifer in the Conasauga Formation at the Watts Bar site. The shales and limestones are essentially impervious, and the majority of the ground water flows through the terrace deposits overlying bedrock. Water level readings made in the exploration holes show that the water table stands approximately 20 feet above rock in the terrace material.

Preliminary ground water investigations made by measuring ground water levels in exploratory holes in the proposed plant area indicate a ground water gradient sloping toward Chickamauga Lake through the terrace deposits overlying bedrock. Migration of ground water through bedrock is insignificant as shown by the refusal of the rock to accept water at pressures of 50 lb/in^2 by water testing the exploratory holes. TVA will install a series of monitor wells to determine the seasonal ground water fluctuations and to provide baseline data.

(b) Surface water - Surface water is derived from precipitation remaining after losses due to evaporation and transpiration. It can be generally classified as local surface runoff or streamflow.

(c) Water use - The Tennessee River from its head near Knoxville to its mouth near Kentucky Dam is a series of highly controlled multiple-use reservoirs. The primary uses for which this chain of reservoirs was built are flood control, navigation, and the generation of electric power. In addition to these, other industrial and public uses have developed, such as sport and commercial fishing, industrial and public water supply, recreation, and waste disposal.

There are five public water supplies taken from Watts Bar and Chickamauga Reservoirs within the reach from Lenoir City, Tennessee, 43 miles upstream of the site, to

Savannah Utility District, 44 miles downstream of the site. The intakes for two of these systems, Lenoir City, Tennessee, and TVA's Watts Bar Reservation, are located on Watts Bar Reservoir some 43 miles and 2.0 miles, respectively, upstream from the Watts Bar Nuclear Plant site. In the future the Watts Bar Reservation will discontinue using a surface supply and will obtain its potable water supply from the ground water system to be developed to serve the nuclear plant. There are no public water supplies taken from the Tennessee River between the Watts Bar Dam and plant site. The closest downstream surface water supply is Dayton, Tennessee, at TRM 503.8 (25 miles downstream), which serves 6,900 people. The Daisy-Soddy-Falling Water Utility District, which serves about 8,750 people, has a water intake on Soddy Creek embayment of Chickamauga Reservoir about 45 miles below the plant site. The present water intake for the Savannah Utility District, which serves about 1,610 persons, is located on the Tennessee River (TRM 483.6) some 44 miles downstream from the plant site. However, the Savannah intake is to be relocated in conjunction with the construction of TVA's Sequoyah Nuclear Plant, located at TRM 484.5.

The present water supply intake for the City Water Company, which serves a population of about 290,000 in the metropolitan Chattanooga area, is located in the headwaters of Nickajack Reservoir at TRM 465.5 approximately 62 miles downstream from the site and 6 miles downstream from Chickamauga Dam. Studies are being made by a task force organized by the Tennessee Department of Public Health to evaluate the present water supply source and intake location for the City of Chattanooga and recommend any needed action to the State Health Department.

The East Side Utility District had developed plans to locate a surface water supply intake on the Wolftever Creek embayment of Chickamauga Reservoir about 52 miles downstream from the site. However, the district has subsequently decided to continue using its present ground water supply (wells) and has abandoned any definite plans to develop a surface water supply in the foreseeable future.

There are 19 public water systems within a 20-mile radius of the proposed site that depend either totally or in part on ground water as a source of supply. The City of Decatur now obtains its supply from Breedenton Spring, located near the left bank of the Tennessee River about 5 miles downstream from the site. Engineering studies have been made to evaluate the feasibility of a proposed regional water system that would serve both the cities of Decatur and Spring City, as well as numerous small communities and outlying areas. The engineer's report recommends that the intake for such a regional system be located on Watts Bar Reservoir (TRM 532L) about 4 miles upstream from the site. Watts Bar Dam, located between the proposed intake location and the plant site, would preclude any adverse impact resulting from the discharge of liquid effluents from the plant. The ground water supply and the distribution system to be developed for the nuclear plant and the Watts Bar Reservation have been designed so as to be readily incorporated within the regional system whenever it is developed. Public water supply information is included in Table 1.1-13 and the locations are shown on figure 1.1-5.

There are five industrial water supplies taken from Watts Bar and Chickamauga Reservoirs between Tennessee River mile 592 and mile 473. This includes the supply for TVA's Watts Bar Steam Plant which is taken from the Tennessee River at mile 529.3 just downstream from Watts Bar Dam. The industrial water supplies located within a 20-mile radius of the plant and those industrial supplies obtained from the Tennessee River between miles 592 and 473 are summarized in Table 1.1-14. Those industrial supplies in the table marked with a double asterisk also use the supply for potable water within the plant. All other industrial users purchase potable water.

The major industrial water users are downstream from the plant site. These industries withdraw a total of about 53 million gallons of process water from Chickamauga Reservoir each day. Seven industrial water supplies are taken from wells and springs within a 20-mile radius of the plant site. Olin Mathieson Chemical Corporation and Bowaters Southern Paper Corporation obtain water from the Hiwassee River, 22 and 23 miles upstream from its mouth, respectively. The Watts Bar Nuclear Plant will use a maximum of about 86 million gallons of process water each day.

(8) Land use - The existing land use around the Watts Bar Nuclear Plant site reflects the trends of development taking place within the larger Great Valley of east Tennessee. This pattern is essentially the development of small satellite cities focusing on the major metropolitan centers of Knoxville and Chattanooga.

The smaller cities within the economic orbit of these larger centers are growing up along the major transportation routes.

The area around the Watts Bar site is predominantly rural as shown in figure 1.1-3. A 1970 survey of McMinn, Meigs, and Rhea Counties by the TVA Division of Forestry, Fisheries, and Wildlife Development indicates that approximately 57 percent of the land is forested, 38 percent is nonforested, and 5 percent is covered with water.

The minimum exclusion distance for the site is 1,200 meters (∿3,650 feet). No one will be allowed to reside in the exclusion area (figure 1.1-2). The nearest domestic residence is approximately 1,460 meters (∿4,450 feet) from the nuclear plant.

Specific land uses in the surrounding area are discussed below.

(a) Industrial operations - Scattered industry, including two TVA steam plants and a dam, Oak Ridge National Laboratory, and several small industrial plants, have begun to shift the region from an agricultural to a mixed land usage.

The major portion of the Watts Bar Nuclear Plant site will be located on a large tract of land that for many years has been designated by local communities and by state industrial development groups as a potential industrial area. The remainder will be on land best adapted to agriculture.

(b) Transportation - Two highways, Tennessee Highway 29 (U.S. 27) and Highway 58, connecting Chattanooga and Knoxville pass within 10 miles of the site. I-75, when completed, will pass 12 miles to the east of the plant. A Southern Railway spur terminates at the Watts Bar Steam Plant. The nearest airport is located about 9 miles southeast of the plant. The 9-foot navigation channel provides access to the plant by barge traffic.

(c) Farming - The total area of Rhea County and nearby Meigs County is 558 square miles, about 8 percent of which is occupied by Watts Bar and Chickamauga Reservoirs. Forested land in these counties occupies 336 square miles, or 65 percent of the land area. Nonforested farmland accounts for an additional 25 percent, leaving 10 percent (about 50 square miles) of the land area around the plant site for purposes other than farming or forest.

According to the 1964 Census of Agriculture, there were 988 farms in the two counties with gross sales of $2,894,169. Of these, 476 were classified as commercial and 512 as subsistence farms. The commercial farms accounted for gross sales of $2,493,117, while subsistence farms had gross sales of only $501,052. There were 72 dairy farms with gross sales of $722,070.

(d) Forestry - Forests in the area tend to be scattered along narrow ridges. The Walden Ridge area in western Rhea County contains extensive forests (figure 1.1-6). Approximately one-third of forested land consists of Virginia and loblolly pine, the latter being planted during various reforestation programs. Hardwood forests, chiefly of the oak-hickory type, cover 44 percent of forested land; the remainder supports mixtures of pine, cedar, and hardwoods. Volume of timber in the 3-county unit has increased markedly since 1956. The increase includes growing stock of softwoods and hardwoods and an increased volume of sawtimber.

(e) Recreation - Watts Bar and Chickamauga Reservoirs are attractive to water-based recreation. During April 15 through October 15, recreational activities around the site increase substantially. A privately operated resort and restaurant are located on Watts Bar Dam Reservation. Meigs County Park is located on the left bank of the reservoir just upstream from the dam. A short distance upstream from this park is Fooshee Bend, a 890-acre peninsula, which is under consideration as a potential state park site. Several other resorts are located within a 25-mile radius. TVA has provided a boat-launching ramp and parking area on each side of the river below Watts Bar Dam. A public-use area upstream on the left bank of Watts Bar Dam Reservation provides an improved swimming beach, turnouts with picnic tables, toilet facilities, boat-launching ramp, and parking area. Demand for recreation results in a large influx of daytime and overnight users.

(f) Wildlife management areas and preserves - The Hiwassee Waterfowl Refuge, Ocoee Wildlife Management Area, and the Yellow Creek Wildlife Management Area are located within

40 miles of the Watts Bar site. There are also three state forests and one national forest within 40 miles of the site: Fall Creek Falls State Park and Forest, Bledsoe State Forest, Mt. Roosevelt State Forest, and the Cherokee National Forest.

(g) Population distribution - Rhea and Meigs Counties are sparsely settled. The net population growth in these counties between 1960 and 1970 totaled only 400. Dayton, the county seat of Rhea County, is the largest city in the area with a 1970 population of 4,225. The 1970 population distribution within 10 miles of the plant site is shown in figure 1.1-7. Figures 1.1-8 and 1.1-9 show the projected population distribution for years 1980 and 2000, respectively. The projected population distribution out to 50 miles for the year 2000 is shown on Table D-3 of Appendix D.

Between 1960 and 1970 the regional population grew 6.5 percent--from 893,674 to 955,752. Several small towns and the Chattanooga and Knoxville metropolitan areas are located within a 60-mile radius from the site.

Socioeconomic impacts due to the construction and operation of the plant are discussed in section 2.9.

(h) Waterways - Tennessee River traffic at the Watts Bar Lock for 1970 was estimated to be about 435 thousand tons, exclusive of sand and gravel. For the Tennessee River the total tonnage in 1971 was estimated to be about 27.5 million tons.

(i) Government reservations and installations - The Tennessee Valley Authority's reservations which contain the Watts Bar Steam Plant and Dam are the only Government installations in the immediate vicinity of the plant.

(9) Ecology - The region around Watts Bar supports wildlife, waterfowl, fish, and other aquatic life. The important species are discussed in the paragraphs below. The three counties around the site--Rhea, Meigs, and McMinn--contain a large percentage of upland wildlife habitat, as noted in Table 1.1-15. These evaluations of suitable land were based on several factors, including type, distribution, and quality of cover, presence of travel lanes, presence of food and water, and suitable den and nesting sites.

The possible ecological impacts which the plant may have on upland wildlife, waterfowl, and aquatic life, and the ecological monitoring programs are described in Sections 2.4 and 2.7.

(a) Waterfowl - The Yellow Creek Waterfowl Management Area is located approximately 1 mile south-southwest of the present TVA reservation boundary and is separated from the reservation by a ridge line having an elevation about 150 to 200 feet above the elevation of the management area. The area, used by the Tennessee Game and Fish Commission, is one of only three such state areas in east Tennessee which now has the capability for control of water levels for waterfowl management purposes. Its location, 27 river miles north of the principal waterfowl refuge area (Hiwassee Island, TRM 501) enhances its significance in attracting waterfowl flights upstream from the principal refuge, thus contributing to more successful hunting on all waterfowl management units between Hiwassee Island and Watts Bar Dam. Data on hunting use and kill success over the period 1966-71 indicate that Yellow Creek has furnished 25 percent of hunting recreation and has, through its influence on other management area, accounted for approximately 58 percent of ducks harvested on Chickamauga Reservoir.

(b) <u>Fish and other aquatic life</u> - There is an abundance of aquatic life in the tailwater area of Watts Bar Dam. This area is characterized by a bedrock substrate with interstices filled with gravel, rock, clay, and other sediment. The substrate and characteristics of waterflow provide favorable habitat for fish and larger invertebrates such as the seven species of mussels of which the pigtoe mussel is probably the most abundant.[2] A 3-mile area of the river from the dam (TRM 529.9) downstream to TRM 526.9 was designated a mussel sanctuary by the State of Tennessee on July 1, 1965. Records show mussel beds at the following Tennessee River miles:

503.0 to 503.5	519.5 to 520.5
504.0 to 504.5	527.5 to 528.0
517.0 to 518.0	528.5 to 529.0 (wing wall of dam)

Historic harvests have been large, but there have been no harvests from Chickamauga Reservoir since 1970 when about $3,000 worth of pigtoe mussel shells were harvested. Recent harvests have been limited and no harvesting is legal in the sanctuary reach.

The Asiatic clam has become prominent in the benthos communities of the river during the past 10 years. Densities vary from a few individuals to approximately 2,000 per square meter, depending on type of substrate and waterflow. Generally, open water populations of Asiatic clams are smaller, a few to many individuals per square meter. Bottom fauna populations in the reservoir are not diverse. The most abundant insects are the burrowing mayfly and the midges of the family Tendipedidae which occur at densities approaching 200 per square meter.

The water entering Chickamauga Reservoir through Watts Bar Dam contains a moderate concentration of suspended phytoplankton and zooplankton. The phytoplankton populations are dominated by diatoms of the genus *Melosira*. The generic diversity includes more than 10 genera of diatoms depending on the season, as many as 22 genera of green algae, and as many as 4 genera of bluegreen algae. Representative grab samples of phytoplankton taken several miles miles downstream contained more than 600 cells per milliliter.

Zooplankton near Watts Bar Dam is commonly dominated by rotifers and cyclopoid copepods except during April and May when a predatory cladoceran, *Leptodora kindtii*, exceeds all other forms. In general, seasonal zooplankton abundance exceeds 100,000 individuals per cubic meter in the spring. Zooplankton and phytoplankton species observed in the Watts Bar Dam forebay are listed in Table 1.1-16.

Upstream in Watts Bar Reservoir macrophyte production and standing crop have reached exceedingly high levels in the past when Eurasian watermilfoil invaded the reservoir. Chickamauga Reservoir has not had this problem; only persistent, non-expanding, and native macrophyte colonies occur on overbanks, a distance of 12 to 20 miles below the nuclear plant.

The tailwater area is considered favorable spawning habitat for sauger, white bass, and smallmouth bass and may prove favorable for yellow perch. Species of fish taken in the 1970 fish population inventory on Chickamauga Reservoir are listed in Table 1.1-17. The list is prepared from the results of 12 cove-rotenone samples taken between July 6 and August 5, 1970; although it is not a complete species list for the reservoir, it identifies the important game, rough (including commercial), and forage species. The inclusion of yellow perch represents an invasion via the Hiwassee River from stock introduced in Chatuge and Nottely Reservoirs. Results of cove samples indicate that yellow perch are successfully reproducing in Chickamauga Reservoir; their ultimate importance to the sport fishery and to the total piscine community is unknown. Watts Bar tailwater has supported approximately 6.1 percent of fishing trips in TVA's 12 tailwaters over the period 1965-69.

Fish population surveys based on complete sampling of 12 coves in 1970 yielded an average total of 182 pounds of fish per acre; of this, game and pan fish contributed 12 percent, forage fish 33 percent, and rough and commercial fish 55 percent. Bluegill and other sunfishes, 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 (commercial) fish.

In a 1970 fish inventory, total fish poundage was significantly greater in the 3-cove area (approximately TRM 505-509) nearest the plant site. Although specific conclusions cannot be made, the data indicate that the upper end of Chickamauga Reservoir plays a significant role in production of the fisheries resource of the reservoir, especially in terms of the reproduction and early growth of game and forage species.

Data for 1971-72 indicate an annual commercial fish harvest of approximately 307,000 pounds in Chickamauga Reservoir and the principal commercial species were catfish, buffalo, and carp.[3]

(10) Chemical and physical characteristics of air and water -

(a) Air - The general physical characteristics were described previously under Climatology and Meteorology. The only air quality data collected from the vicinity of the plant are from two settled particulate samplers that were placed in operation in April 1969. The location of these samplers is shown in figure 1.1-10. The data collected to date are summarized in Table 1.1-18 and represent measurement of settled particulate from all sources. The highest monthly reading registered was 21 tons per square mile and occurred in June 1971.

Additional baseline data on the chemical and physical characteristics of the air in the vicinity of the plant will be gathered as monitoring programs are instituted prior to plant operation.

(b) Water - The Watts Bar Nuclear Plant will be located on Chickamauga Reservoir approximately 2 miles below Watts Bar Dam. The drainage area of the Tennessee River at the site amounts to 17,320 square miles. At the plant site Chickamauga Reservoir is about 1,100 feet wide with the depths ranging up to 25 feet at normal pool, elevation 682.5. A 9-foot navigation channel is maintained past the site. The reservoir lies generally in a northeast-southwest direction with flow toward the southwest.

The Watts Bar Dam discharge records, maintained since its closure on January 1, 1942, indicate that the average discharge at the dam has been 26,480 ft^3/s. The maximum discharge occurred on December 30, 1942, and was 187,000 ft^3/s. Flow data for water years 1951-65 indicate an average flow of about 21,500 ft^3/s during the summer months and about 35,500 ft^3/s during the winter months. These data reflect for all practical purposes the volume of water that passes the plant site since there is less than 1 percent difference between the drainage areas at the plant site and the Watts Bar Dam.

Channel velocities at the plant site average 2.3 feet per second under average winter flow conditions and 1.0 foot per second under average summer conditions.

A year-long water quality survey of Chickamauga Reservoir was made by TVA beginning in May 1960.[4] In addition, some special sampling was continued into January 1962. At 6-day intervals during July, August, and September 1960, and again during May and June 1961, 22 locations along the main stem and principal tributaries of the reservoir were sampled for bacteriological determinations. In general, the bacteriological quality of water in Chickamauga Reservoir was found to be good. The water at Hamilton County

Park, 56 river miles below the plant site, was of exceptionally good bacteriological quality.

Monthly sanitary-chemical analyses of samples from 13 stations show the water in the main stem of the reservoir to be relatively low in organic content. Color and odor concentrations were also low.

During the winter and spring months, the dissolved oxygen concentrations in Chickamauga Reservoir are quite high. However, during the summer and fall months, the dissolved oxygen concentration in the upper 20 miles of Chickamauga Reservoir are depressed because of low DO concentrations occurring in the release from Watts Bar Dam. The dissolved oxygen concentrations of the Watts Bar Dam releases for the years 1960-71 are summarized in Table 1.1-19.

The principal reasons for the low DO releases from Watts Bar Dam are (1) inadequate waste treatment of organic waste discharges originating in the vicinity of Knoxville, Tennessee, and (2) the release of water low in DO through the low-level intakes from the much deeper headwater reservoirs located farther upstream. The recent installation of secondary treatment at Knoxville should result in somewhat higher DO concentrations in the release at Watts Bar Dam. TVA is now investigating methods of increasing the DO levels in the releases from its headwater reservoirs.

The mineral quality of water in Chickamauga Reservoir was determined by monthly samples collected from four locations in the reservoir. The water in the main stem of the Tennessee River portion of Chickamauga Reservoir during the sampling period was slightly hard (about 60 to 80 mg/l) but satisfactory for practically all industrial uses. The water quality data observed at the two sampling points nearest the proposed plant site are shown in Tables 1.1-20 and 1.1-21. A summary of observed DO concentrations in the Watts Bar Dam tailrace are listed in Table 1.1-19.

The trace metal concentrations observed in the Fort Loudoun Dam Tailrace (TRM 602.3) for the period from January 1971 to December 1971 are summarized in Table 2.5-3. As indicated, background concentrations of zinc and other trace metals associated with zinc deposits are higher than would normally be expected in surface streams because of the mining of the zinc deposits in the lower Holston River basin.

Radiological determinations made on samples collected daily at both Watts Bar and Chickamauga Dams and composited into weekly samples for examination, together with determinations from other available samples, showed the concentrations of all radionuclides present were well below the permissible drinking water concentrations.

(c) Temperature - Water temperature observations at selected Tennessee River stations were included in the data collected during the 1960-61 survey. These observations indicate that Chickamauga Reservoir is stratified during summer months, although stratification does not occur in the 20 miles immediately downstream from Watts Bar Dam. Bottom temperature observed at TRM 487.7 (Table 1.1-22) ranged from 41.5°F in January (1961) to 77.9°F in August

(1960); surface temperatures ranged from 41.7°F in January (1961) to 81.9°F in July (1960). Temperature data at TRM 487.5 (Table 1.1-23) collected over a 5-year period (1943-48) by TVA indicate little variation in these temperature patterns. It may be concluded that water in Chickamauga Reservoir is well mixed except during the summer period when stratification occurs in the downstream one-half of the reservoir.

Water temperature records for releases from Watts Bar Hydro Plant for 1967-71 are shown in Table 2.6-1 and show a maximum natural water temperature of 80.6°F.

(11) Historical and archaeological significance of the Watts Bar site - No sites listed in the *National Register of Historic Places*, or known to be under consideration for such listing, are located at or near the proposed Watts Bar Nuclear Plant.

The project has been reviewed by the Tennessee Historical Commission and other appropriate agencies, and no specific items of particular historical significance have been identified.

An archaeological survey of the site was made in December 1970 by the University of Tennessee, Department of Anthropology. Investigations to determine archaeological significance of the site are discussed in Section 2.10, Other impacts.

Table 1.1-1

AIR TEMPERATURE DATA[a]

Month	Average Temp. (°F)	Average Max. Temp. (°F)	Average Min. Temp. (°F)	Extreme Max. Temp. (°F)	Extreme Min. Temp. (°F)
December	40.3	50.8	29.9	76	- 4
January	35.4	50.6	29.4	76	- 9
February	41.6	53.0	30.3	73	- 20
Winter	39.1	51.5			
March	50.5	63.0	38.1	91	2
April	58.5	72.0	45.0	94	20
May	67.1	80.8	53.5	99	30
Spring	58.7	71.9			
June	74.6	87.2	62.0	103	40
July	77.6	89.8	65.3	108	48
August	76.9	89.3	64.5	107	49
Summer	76.4	88.8			
September	71.9	85.1	58.7	106	34
October	60.0	74.1	45.9	96	19
November	48.4	61.3	35.5	82	7
Fall	60.1	73.5			
Annual	58.6	71.4	46.5	108	- 20

a. U.S. Weather Bureau, Cooperative Observer Station, Decatur, Tennessee; period of record, 35 years (1896-1930).

Table 1.1-2

PRECIPITATION DATA[a]

Month	Avg. No. of Days With 0.01 Inch or More	Monthly Average (Inches)	Extreme Monthly Maximum (Inches)	Extreme Monthly Minimum (Inches)	Max. In 24 Hrs. (Inches)
December	10	5.24	16.08	0.47	4.15
January	11	5.44	11.67	2.12	5.31
February	10	5.49	9.79	0.74	3.50
Winter	31	16.17			
March	11	5.77	10.93	2.28	5.00
April	10	4.49	8.66	1.28	2.81
May	9	3.71	7.48	0.56	2.00
Spring	30	13.97			
June	9	3.90	9.13	0.90	3.73
July	10	5.17	12.13	0.53	4.80
August	9	3.34	7.13	0.52	3.19
Summer	28	12.41			
September	7	3.58	14.78	0.45	3.58
October	6	2.67	7.91	0.00	3.05
November	8	4.10	14.06	0.94	3.57
Fall	21	10.35			
Annual	110	52.90			

a. TVA raingage station 421, Watts Bar Dam, Tennessee, located on roof of Control Building at Watts Bar Dam; period of record about 30 years from station activation September 1939-69.

Table 1.1-3

SNOWFALL DATA

-INCHES-

Month	Monthly Average[a]	Maximum Total[b]	Maximum Total in 24 Hrs.[b]
January	2.4	14.5	8.0
February	2.4	18.5	13.0
March	1.3	12.0	8.0
April	T	T	T
May	0	T	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	T
October	0	T	T
November	0.6	8.0	6.0
December	2.0	15.0	7.0
Annual	8.7		

a. Climatography of the United States No. 10-77; Climatic Summary of the United States; U.S. Department of Commerce Weather Bureau, Decatur, Tennessee, 1896-1930.

b. Cooperative Observer Meteorological Records, Form 1009; Decatur, Tennessee, 1896-1940, Obtained from National Climatic Center, Asheville, North Carolina, on November 24, 1970.

Table 1.1-4

WIND DIRECTION PERSISTENCE DATA[a]

Direction	Number of Occurrences - Wind Direction Persistence Periods (Hours) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	Total
N	72	37	29	15	12	6	2	4	2	1	-	2	2	-	1	185
NNE	134	42	22	16	7	6	2	4	1	1	-	-	-	-	-	235
NE	190	83	53	34	13	7	6	5	7	-	-	-	-	-	-	398
ENE	188	96	64	26	25	17	7	3	4	2	1	2	1	-	2	438
E	98	37	11	6	2	4	-	-	-	-	1	-	-	-	-	159
ESE	97	20	12	5	3	1	-	-	-	-	-	-	-	-	-	138
SE	69	19	5	2	-	1	-	-	-	-	-	-	-	-	-	96
SSE	123	34	16	5	2	-	1	-	-	-	-	-	-	-	-	181
S	201	62	29	21	9	4	3	-	-	-	1	-	-	-	1	334
SSW	226	90	61	28	18	11	13	5	8	3	6	2	1	-	5	477
SW	257	141	71	54	27	15	21	11	13	8	9	8	5	3	13	656
WSW	209	74	32	20	8	5	3	1	1	-	1	-	-	-	-	354
W	78	32	10	5	-	2	1	-	1	-	-	-	-	-	1	130
WNW	78	44	15	8	10	3	6	2	2	1	-	-	-	-	-	169
NW	103	41	25	10	5	1	7	1	-	1	-	-	-	-	2	197
NNW	152	107	67	38	46	31	25	18	12	13	6	8	-	6	30	559
Total	2275	959	522	293	187	114	97	57	51	30	24	23	9	10	55	4706
Freq., %[b]	100	51.65	31.27	20.19	13.96	9.99	7.57	5.50	4.29	3.21	2.57	2.00	1.57	1.38	1.17	

a. TVA Kingston Steam Plant (1967-69), station elevation - 1,134 feet MSL; instrument mounted 150 feet aboveground.

b. Percent frequency of wind direction persistence equal to or greater than stated value.

Table 1.1-5

AVERAGE WIND SPEED DATA[a]

CHATTANOOGA 1951-60

Average Wind Speeds (mi/h)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Avg.	% Calm
Dec.	8.6	8.2	6.7	4.8	4.1	4.1	4.3	7.4	8.4	8.2	7.2	8.0	9.1	10.6	9.6	10.8	6.4	22.0
Jan.	9.9	8.7	7.0	5.3	4.1	3.3	4.0	7.2	8.8	8.7	7.9	9.3	8.7	10.7	10.8	11.1	7.4	17.0
Feb.	8.7	8.0	7.3	5.4	4.6	4.4	5.0	8.6	9.7	9.2	8.3	9.7	9.8	10.5	10.4	10.7	7.5	16.1
Winter	9.1	8.3	7.0	5.2	4.3	3.9	4.4	7.7	9.0	8.7	7.8	9.0	9.2	10.6	10.3	10.9	7.1	18.4
March	8.5	8.0	7.2	6.2	4.2	5.2	5.3	8.6	9.4	9.6	9.0	10.5	11.6	11.3	10.8	10.9	8.0	13.2
April	8.7	8.7	7.1	5.9	4.8	5.5	6.7	10.5	10.0	10.0	8.9	11.5	10.3	11.9	10.8	9.8	7.8	17.8
May	7.4	8.0	6.4	6.2	4.1	5.3	5.4	7.7	8.0	7.5	7.1	9.1	9.4	10.1	8.5	8.8	5.9	24.4
Spring	8.2	8.2	6.9	6.1	4.4	5.3	5.8	8.9	9.1	9.0	8.3	10.4	10.4	11.1	10.0	9.8	7.2	18.5
June	6.6	6.7	6.0	5.4	4.7	5.3	5.0	6.3	7.3	7.3	6.6	8.4	8.0	8.4	8.4	7.2	5.2	24.5
July	6.4	7.0	6.0	5.3	4.9	4.6	5.0	6.2	6.6	6.6	6.4	8.1	7.2	7.5	7.1	7.1	4.9	23.8
Aug.	6.2	6.8	6.2	5.4	4.5	4.5	4.7	5.7	6.0	6.3	5.4	6.8	6.9	7.0	6.6	6.8	4.3	30.6
Summer	6.4	6.8	6.1	5.4	4.7	4.8	4.9	6.1	6.6	6.7	6.1	7.8	7.4	7.6	7.4	7.0	4.8	26.3
Sept.	6.8	7.6	6.9	5.4	4.4	4.7	5.0	7.3	7.0	6.6	5.2	7.4	6.2	6.5	5.9	7.3	4.7	30.1
Oct.	7.9	8.0	7.5	6.2	4.4	4.3	5.6	7.2	7.0	6.2	5.4	7.5	7.0	7.8	7.7	8.8	4.8	33.1
Nov.	8.7	8.5	6.8	5.7	3.9	3.6	4.8	8.3	9.0	8.2	6.6	7.9	8.2	9.9	9.3	10.4	6.1	27.2
Fall	7.8	8.0	7.1	5.8	4.2	4.2	5.1	7.6	7.7	7.0	5.7	7.6	7.1	8.1	7.6	8.8	5.2	30.1
Annual	8.1	7.9	6.8	5.6	4.5	4.7	5.1	7.5	8.2	8.1	7.2	8.8	8.7	9.8	9.3	9.6	6.1	23.4

a. Climatography of the United States No. 82-40, Decennial Census of United States Climate - Summary of Hourly Observations, Chattanooga, Tennessee, Lovell Field, 1951-60, U.S. Department of Commerce, Weather Bureau.

Table 1.1-6

AVERAGE WIND SPEED DATA[a]

KNOXVILLE 1951-60

Average Wind Speeds (mi/h)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Avg.	% Calm
Dec.	7.8	8.1	6.5	6.2	4.1	4.2	4.1	4.8	6.5	8.4	11.3	12.1	10.8	11.6	8.4	7.7	7.8	9.0
Jan.	8.5	9.2	7.2	7.0	4.7	4.8	4.4	4.7	6.8	10.1	12.8	11.9	11.5	11.6	9.0	8.2	8.7	7.6
Feb.	7.5	8.9	7.0	7.0	4.8	4.7	4.6	5.3	7.5	10.1	12.6	12.5	11.4	13.0	9.3	7.6	7.6	8.2
Winter	7.9	8.7	6.9	6.7	4.5	4.6	4.4	4.9	6.9	9.5	12.2	12.2	11.2	12.1	8.9	7.8	8.4	8.3
March	8.2	9.2	7.7	7.4	5.3	5.1	4.9	6.8	6.5	9.3	12.9	13.4	12.0	13.1	10.5	9.3	9.5	6.0
April	8.4	9.6	7.6	7.0	5.1	5.9	5.5	7.9	8.3	10.7	12.8	13.9	12.2	12.6	9.9	8.6	9.6	7.3
May	8.0	8.0	7.0	7.3	5.0	5.8	5.0	6.1	6.1	8.0	10.3	10.7	9.7	10.0	8.3	8.1	7.7	10.0
Spring	8.2	8.9	7.4	7.2	5.1	5.6	5.1	6.9	7.0	9.3	12.0	12.7	11.3	11.9	9.6	8.7	8.9	7.8
June	7.6	7.6	6.6	6.3	5.5	5.4	5.1	5.3	5.6	7.9	9.3	9.2	9.0	8.4	7.7	7.2	6.9	10.4
July	7.0	7.6	6.4	6.3	4.8	5.0	5.0	4.7	5.7	7.6	8.8	9.0	7.7	8.1	7.2	6.1	6.3	12.8
Aug.	7.1	7.5	5.9	5.9	4.8	4.5	4.7	4.7	4.9	7.4	7.8	8.5	8.3	8.2	7.3	6.8	5.8	15.1
Summer	7.2	7.6	6.3	6.2	5.0	5.0	4.9	4.9	5.4	7.6	8.6	8.9	8.3	8.2	7.4	6.7	6.3	12.8
Sept.	6.9	7.4	6.4	6.9	5.0	4.8	4.6	4.9	5.7	7.0	7.6	8.9	7.5	7.2	6.5	7.1	5.7	15.4
Oct.	7.5	8.0	6.9	6.3	4.1	4.1	4.1	4.1	5.0	7.3	8.2	8.7	8.9	8.8	8.0	7.4	6.0	14.8
Nov.	7.9	7.9	6.4	5.8	4.3	4.5	4.1	4.8	6.6	8.3	10.5	10.4	10.1	11.3	8.7	7.1	7.1	11.3
Fall	7.4	7.8	6.6	6.3	4.5	4.5	4.3	4.6	5.8	7.5	8.8	9.3	8.8	9.1	7.7	7.2	6.3	13.3
Annual	7.7	8.3	6.8	6.6	4.8	4.9	4.7	5.3	6.2	8.5	10.6	11.1	10.1	10.8	8.4	7.6	7.5	10.7

a. Climatography of the United States No. 82-40, Decennial Census of United States Climate - Summary of Hourly Observations, Knoxville, Tennessee, McGhee Tyson Airport, 1951-60, U.S. Department of Commerce, Weather Bureau.

Table 1.1-7

WIND DIRECTION PERSISTENCE DATA[a]

July 1, 1971-June 28, 1972
Annual

Direction	Number of Occurrences - Wind Direction Persistence Periods (hours)																								
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	>25	Total
N	42	26	12	8	6	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98
NNE	52	28	23	9	5	2	2	4	4	2	-	1	1	-	-	2	-	1	-	-	-	-	-	-	-	137
NE	70	34	18	13	7	3	2	1	1	-	-	2	-	2	1	-	-	-	-	-	-	-	-	-	1	155
ENE	62	21	9	7	3	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	108
E	14	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
ESE	7	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
SE	8	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
SSE	22	7	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34
S	62	30	16	10	2	3	1	3	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	131
SSW	71	38	33	13	17	9	5	10	7	2	2	4	2	2	1	-	-	-	1	1	-	-	-	-	-	218
SW	48	40	17	9	2	4	3	4	-	1	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	132
WSW	36	10	5	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54
W	30	8	9	2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54
WNW	21	14	6	8	4	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56
NW	27	10	3	4	7	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53
NNW	27	18	7	6	4	3	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69
Total	599	292	166	91	61	29	19	27	15	9	5	7	4	5	3	3	-	1	1	1	-	-	-	-	2	1340
Acc. Total	1340	740	449	283	192	131	102	83	56	41	32	27	20	16	11	8	5	5	4	3	2	2	2	2	2	
≥Acc. Freq. (%)	100	55.3	33.5	21.1	14.3	9.8	7.6	6.2	4.2	3.1	2.4	2.0	1.5	1.2	.8	.6	.4	.4	.3	.2	.2	.2	.2	.2	.2	

a. Watts Bar Meteorological Facility. Wind instrument at 130 feet aboveground.

NOTE: Persistent wind is defined in this analysis as a wind blowing continuously from one of the named 22-1/2° sectors (i.e., north-northwest) except that it is not considered to be interrupted if it departs from that sector for one hour and then returns, or if there are up to two hours of missing data followed by a continued directional persistence.

Table 1.1-8

PERCENT OCCURRENCE OF WIND SPEED[a]

FOR ALL WIND DIRECTIONS

July 1, 1971 - June 28, 1972
Annual

Wind Direction	Wind Speed (mi/h)[b] 1-3	4-7	8-12	13-18	19-24	≥25
N	2.36	3.07	1.06	0.10	0.01	-
NNE	2.83	4.29	2.28	0.25	-	-
NE	3.25	4.37	1.58	0.06	-	-
ENE	3.48	2.38	0.63	0.07	0.01	-
E	1.40	0.45	0.15	0.02	0.01	-
ESE	0.93	0.21	0.05	0.01	-	-
SE	1.03	0.28	0.02	0.02	0.06	-
SSE	1.71	0.67	0.14	0.05	0.04	-
S	3.34	3.27	0.95	0.33	0.17	0.03
SSW	4.07	5.63	4.22	1.03	0.14	-
SW	2.96	3.25	2.00	0.52	0.09	-
WSW	2.05	1.67	0.49	0.06	-	-
W	1.82	0.93	0.78	0.26	0.04	-
WNW	1.30	1.04	1.18	0.21	-	-
NW	1.36	0.94	1.18	0.21	0.01	-
NNW	2.08	1.78	0.97	0.26	0.04	0.05
Total	35.97	34.23	17.68	3.48	0.62	0.08

Calm = 7.91

a. Watts Bar meteorological facility. Wind instrument at 130 feet aboveground.

b. Wind speed class 1-3 mi/h includes values 0.6-3.5 mi/h; class 4-7 mi/h includes values 3.6-7.5 mi/h, etc.

Valid observations only - represents 93 percent of total annual record.

Table 1.1-9

PERCENT OCCURRENCE OF WIND SPEED[a]

FOR ALL WIND DIRECTIONS

December 1, 1971 - February 29, 1972
Winter

Wind Direction	Wind Speed (mi/h)[b] 1-3	4-7	8-12	13-18	19-24	≥25
N	2.44	0.98	0.49	0.05	-	-
NNE	2.78	4.29	3.12	0.29	-	-
NE	2.15	2.88	1.46	-	-	-
ENE	2.34	1.37	0.24	-	-	-
E	0.73	0.15	-	-	-	-
ESE	0.39	-	-	-	-	-
SE	0.73	0.05	-	-	-	-
SSE	0.59	0.10	0.05	-	-	-
S	2.10	1.27	0.68	0.20	0.39	0.15
SSW	4.19	5.07	5.41	1.51	0.39	-
SW	3.27	3.27	2.15	-	-	-
WSW	2.19	1.85	0.39	-	-	-
W	1.46	1.02	0.49	-	-	-
WNW	1.02	1.02	1.71	0.05	-	-
NW	0.98	0.59	0.63	0.10	-	-
NNW	2.00	1.02	0.29	0.59	-	-
Total	29.36	24.93	17.11	2.79	0.78	0.15

Calm = 24.91

a. Watts Bar meteorological facility. Wind instrument at 130 feet aboveground.

b. Wind speed class 1-3 mi/h includes values 0.6-3.5 mi/h; class 4-7 mi/h includes values 3.6-7.5 mi/h, etc.

Valid observations only - represents 94 percent of total winter record.

Table 1.1-10

PERCENT OCCURRENCE OF WIND SPEED[a]

FOR ALL WIND DIRECTIONS

July 1, 1971-August 31, 1971 and June 1-28, 1972
Summer

Wind Direction	Wind Speed (mi/h)[b] 1-3	4-7	8-12	13-18	19-24	≥25
N	1.96	3.50	1.21	0.27	-	-
NNE	3.22	4.76	1.77	0.19	-	-
NE	3.45	4.34	1.26	0.05	-	-
ENE	3.68	2.15	0.70	0.19	0.05	-
E	1.21	0.42	0.47	0.09	0.05	-
ESE	1.31	0.14	0.19	0.05	-	-
SE	0.88	0.47	-	0.09	0.23	-
SSE	1.87	0.88	0.19	0.19	0.14	-
S	4.29	6.01	1.26	0.37	0.28	-
SSW	4.57	7.79	4.06	0.84	0.05	-
SW	2.43	2.52	0.98	0.33	0.05	-
WSW	1.91	1.54	0.33	0.05	-	-
W	1.58	0.79	0.75	0.28	-	-
WNW	0.88	0.84	0.98	0.23	-	-
NW	1.16	1.12	1.17	0.28	-	-
NNW	1.87	0.79	0.79	0.28	0.14	0.19
Total	36.27	38.06	16.11	3.78	0.99	0.19

Calm = 0.19

a. Watts Bar meteorological facility. Wind instrument at 130 feet aboveground.

b. Wind speed class 1-3 mi/h includes values 0.6-3.5 mi/h; class 4-7 mi/h includes values 3.6-7.5 mi/h, etc.

Valid observations only - represents 96 percent of total summer record.

Table 1.1-11

PERCENT OCCURRENCE OF WIND SPEED[a]

FOR ALL WIND DIRECTIONS

March 1, 1972 - May 31, 1972
Spring

Wind Direction	Wind Speed (mi/h)[b] 1-3	4-7	8-12	13-18	19-24	≥25
N	1.39	2.88	1.34	0.05	0.05	-
NNE	2.35	3.22	2.83	0.43	-	-
NE	2.74	4.08	2.06	0.19	-	-
ENE	2.64	3.12	0.91	0.10	-	-
E	1.34	0.77	0.10	-	-	-
ESE	0.91	0.43	-	-	-	-
SE	1.20	0.43	0.10	-	-	-
SSE	1.78	0.91	0.29	-	-	-
S	2.83	2.69	1.15	0.58	-	-
SSW	2.74	4.37	4.90	1.58	0.10	-
SW	3.12	4.51	4.13	1.78	0.29	-
WSW	1.63	2.26	1.10	0.05	-	-
W	1.54	1.44	1.06	0.72	0.14	-
WNW	1.30	1.20	1.58	0.48	-	-
NW	1.10	1.15	2.02	0.38	0.05	-
NNW	1.49	1.63	0.91	0.10	-	-
Total	30.10	35.09	24.48	6.44	0.63	-

Calm = 3.26

a. Watts Bar meteorological facility. Wind instrument at 130 feet aboveground.

b. Wind speed class 1-3 mi/h includes values 0.6-3.5 mi/h; class 4-7 mi/h includes values 3.6-7.5 mi/h, etc.

Valid observations only - represents 94 percent of total spring record.

Table 1.1-12

PERCENT OCCURRENCE OF WIND SPEED[a]

FOR ALL WIND DIRECTIONS

September 1, 1971 - November 30, 1971
Fall

Wind Direction	Wind Speed (mi/h)[b] 1-3	4-7	8-12	13-18	19-24	≥25
N	3.70	4.91	1.16	-	-	-
NNE	2.85	4.75	1.22	0.05	-	-
NE	4.65	6.13	1.48	-	-	-
ENE	5.23	2.80	0.63	-	-	-
E	2.32	0.42	-	-	-	-
ESE	1.06	0.26	-	-	-	-
SE	1.27	0.16	-	-	-	-
SSE	2.59	0.74	-	-	-	-
S	4.01	2.80	0.63	0.16	-	-
SSW	4.65	4.91	2.17	0.05	-	-
SW	2.91	2.54	0.58	-	-	-
WSW	2.43	0.90	0.11	0.16	-	-
W	2.69	0.37	0.79	-	-	-
WNW	2.01	1.06	0.32	0.05	-	-
NW	2.22	0.85	0.79	0.05	-	-
NNW	2.96	3.54	1.90	0.05	-	-
Total	47.55	37.14	11.78	0.57	-	-

Calm = 2.96

a. Watts Bar meteorological facility. Wind instrument at 130 feet aboveground.

b. Wind speed class 1-3 mi/h includes values 0.6-3.5 mi/h; class 4-7 mi/h includes values 3.6-7.5 mi/h, etc.

Valid observations only - represents 87 percent of total fall record.

Table 1.1-13

WATER SUPPLIES WITHIN 20-MILE RADIUS OF SITE INCLUDING
SUPPLIES TAKEN FROM TENNESSEE RIVER BETWEEN FORT LOUDOUN AND CHICKAMAUGA DAMS

Public Supplies

Water Supply	Distance From Site*	Estimated Population Served	Average Daily Use	Source
	Miles		Gallons	
1. Athens	13.7	15,000	2,086,000	Surface (Oostanaula Cr. 50%) and Ground, spring 50%
2. Cedar Valley Elementary School	12.5	252	6,300	Ground, well
3. Dayton	24.2	4,500	1,000,000	Surface (TRM 503.8)
4. Decatur	3.3	900	101,000	Ground, spring
5. Eastview Elementary School	19.7	190	4,750	Ground, well
6. E. K. Baker School	9.2	344	8,600	Ground, well
7. Englewood	19.2	4,000	150,000	Surface (Middle Creek 1.8)
8. Evensville Elementary School	12.3	127	3,175	Ground, well
9. Fairview Elementary School	3.0	252	6,300	Ground, well
10. Frazier Elementary School	11.7	162	4,050	Ground, well
11. Idlewild Elementary School	8.6	186	4,650	Ground, well
12. Midway High School	19.2	297	7,425	Ground, spring
13. Niota	17.1	2,000	150,000	Ground, spring
14. Paint Rock Elementary School	18.9	189	4,725	Ground, well

*Radial distance to all supplies except those that take water directly from the Tennessee River which are shown as river mile distance from TRM 528.0.

Table 1.1-13
(Continued)

WATER SUPPLIES WITHIN 20-MILE RADIUS OF SITE INCLUDING
SUPPLIES TAKEN FROM TENNESSEE RIVER BETWEEN FORT LOUDOUN AND CHICKAMAUGA DAMS

Public Supplies

Water Supply	Distance From Site*	Estimated Population Served	Average Daily Use	Source
	Miles		Gallons	
15. Riceville Utility District	17.0	581	18,000	Ground, spring
16. Rockwood	17.6	5,500	1,200,000	Ground, spring
17. Spring City	7.6	1,900	300,000	Surface (Piney River 33%) and Ground, spring 67%
18. Sweetwater	17.5	4,300	593,000	Ground, spring 80% and Surface 20%
19. Ten Mile Elementary School	7.9	200	4,200	Ground, well
20. Union Grove Elementary	10.9	188	4,700	Ground, well
21. Watts Bar Reservation[a]	1.9	300** 40***	109,000** 40,300***	Surface, (TRM 529.9)
22. Daisy-Soddy-Falling Water Utility District	44.7	8,500	400,000	Soddy Creek 4.2 (67%) and Ground, well 33%
23. Lenoir City	73.3	6,500	995,400	TRM 601.3
24. Savannah Utility District	44.4	1,610	122,000	TRM 483.6

*Radial distance to all supplies except those that take water directly from impounded waters of the Tennessee River, which are shown as river mile distance from TRM 528.0.

a. Includes water supply to Watts Bar Resort, **Summer use and ***Winter use.

Table 1.1-14

INDUSTRIAL WATER SUPPLIES

	Water Supply	Distance From Site* (Miles)	Number of Employees	Average Daily Use (Gallons)	Source
1-I	Athens Hosiery Mill, Inc.	13.0	185	271,350	Ground, well
2-I	Athens Stove Works	13.8	405	32,100	Ground, well
3-I	Cherokee Photo Finishers	12.7	52	59,000	Ground, well
4-I	Crescent Hosier Mills	15.6	120	25,000	Ground, well
5-I	Edwards Laundry	18.8	42	120,000	Surface (Sweetwater Creek)
6-I	Mayfield Dairy Farms, Inc.	15.0	300	81,200	Ground, well
7-I	Plastic Industries, Inc.	13.4	225	10,000	Ground, well
8-I	Southern Silk Mills	9.2**	680	165,000	Surface (Piney Creek)
9-I	Sweetwater Hosiery Mills	16.6**	90	25,000	Ground, well
10-I	Watts Bar Steam Plant	1.3	36	-	Surface (TRM 529.3)
11-I	Atlas Chemical Industries, Inc. (Volunteer Army Ammunition Plant	55.0	2,000	50,000,000	TRM 473.0
12-I	Charles H. Bacon Company	63.5**	600	285,000	TRM 591.5 and spring
13-I	Farmers Chemical Association, Inc.	55.0**	225	2,000,000	TRM 473.0
14-I	Union Carbide Corporation	64.0	430	2,000,000	TRM 592.0

*Radial distance to all supplies except those that take water directly from impounded waters of the Tennessee River which are shown as river mile distance from TRM 528.0.

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

Table 1.1-15

HABITAT EVALUATION FOR SEVEN GAME SPECIES

	Habitat Rating (Percent of Total Land Area)			
	Suitable		Unsuitable	
Species	Good	Average	Poor	Nonhabitat
White-tailed deer	9	74	17	-
Gray Squirrel	13	28	39	20
Raccoon	13	51	34	2
Wild Turkey	5	77	18	-
Ruffed Grouse	4	77	18	1
Cottontail Rabbit	8	59	30	3
Bobwhite Quail	7	59	32	2

Table 1.1-16

ZOOPLANKTON AND PHYTOPLANKTON SPECIES

OBSERVED IN WATTS BAR DAM FOREBAY - JUNE 1972

Zooplankton

Rotifera

Branchionus angularis
Branchionus bidentata
Branchionus budapestinensis
Branchionus calyciflorus
Branchionus caudatus
Keratella bostoninensis
Keratella cochlearis
Keratella earlinae
Keratella spp.
Platy patulas
Polyarthra spp.
Notholca spp.
Lecane spp.
Filinia spp.
Synchaeta spp.
Trichocera spp.

Cladocera

Bosmina longirostris
Diaphanosoma spp.
Daphnia galeata mendotae
Daphnia parvula
Daphnia retrocurva
Daphnia spp. (immature)
Leptodora kindtii

Copepoda

Cyclops bicuspidatus
Diaptomus pallidus
Diaptomus reighardi
Cyclops vernalis
Macrocyclops ater
Mesocyclops edax
Calanoida (immature)
Cyclopoida (immature)
Nauplii

Phytoplankton

Diatoms

Gyrosigma
Tabellaria
Cymbella
Asterionella
Cyclotella
Dinobryon
Eunotia
Fragilaria
Melosira
Navicula
Stephanodiscus
Synedra
Caloneis

Greens

Staurastrum
Cosmarium
Rhizodenia
Ulothrix
Tetraspora
Tetraedron
Ankistrodesmus
Chlorella
Gleocystis
Kirchneriella
Mallamonas
Pandorina
Scenedesmus
Tetradesmus
Oocystis
Protococcus
Chlamydomonas
Chlorococcum
Pediastrum

Bluegreens

Aphanizomenon
Arthrospira
Coelosphearium
Dactylococcopsis
Oscillatoria
Chroococcus
Anabaena

Other

Gymnodinium
Euglena
Phacus
Ceratium

Table 1.1-17

COMMON AND SCIENTIFIC NAMES* OF FISHES IN ROTENONE SAMPLES

CHICKAMAUGA RESERVOIR, 1970

Game

White bass - Morone chrysops
Largemouth bass - Micropterus salmoides
Spotted Bass - Micropterus punctulatus
White crappie - Pomoxis annularis
Black crappie - Pomoxis nigromaculatus
Bluegill - Lepomis macrochirus
Warmouth - Lepomis gulosus
Longear sunfish - Lepomis megalotis
Green sunfish - Lepomis cyanellus
Redear sunfish - Lepomis microlophus
Rock bass - Ambloplites rupestris
Yellow perch - Perca flavescens
Sauger - Stizostedion canadense

Rough

Spotted gar - Lepisosteus oculatus
Longnose gar - Lepisosteus osseus
Skipjack herring - Alosa chrysochloris
Mooneye - Hiodon tergisus
Carp - Cyprinus carpio
Quillback -Carpiodes cyprinus
Smallmouth buffalo - Ictiobus bubalus
Bigmouth buffalo - Ictiobus cyprinellus
Black buffalo - Ictiobus niger
Spotted sucker - Minytreme melanops
Black redhorse - Moxostoma duquesnei
Golden redhorse - Moxostoma erythrurum
Blue catfish - Ictalurus furcatus
Channel catfish - Ictalurus punctatus
Flathead catfish - Pylodictis olivaris
Drum - Aplodinotus grunniens

Forage

Gizzard shad - Dorosoma cepedianum
Threadfin shad - Dorosoma petenense
Golden shiner - Notemigonus crysoleucas
Emerald shiner - Notropis atherinoides
Spotfin shiner - Notropis spilopterus
Bluntnose minnow - Pimephales notatus
Brook silversides - Labidesthes sicculus
Logperch - Percina caprodes

---

*From American Fisheries Society Publication Special Publication Number 6, Third Edition, 1970.

Table 1.1-18

SETTLED PARTICULATE DATA FROM VICINITY OF WATTS BAR SITE

TONS PER SQUARE MILE PER MONTH

	1969		1970		1971		1972	
	Sampler #1	Sampler #2	Sampler #1	Sampler #2	Sampler #1	Sampler #2	Sampler #1	Sampler #2
January			1.9	2.4	3.2	6.4	0.0	0.2
February			3.9	4.4	-	3.4	4.6	5.7
March			5.8	6.2	8.7	6.4	9.0	7.5
April	5.0	5.1	8.5	-	6.6	7.0	11.0	-
May	6.5	18.0	6.5	4.3	-	-	11.0	12.4
June	-	15.4	6.4	3.6	6.4	21.0		
July	-	8.4	6.6	10.1	19.3	6.7		
August	4.9	4.4	1.8	5.3	1.1	10.3		
September	1.9	2.2	3.3	7.1	2.8	2.0		
October	1.4	4.0	4.9	5.4	4.1	-		
November	0.9	1.5	3.9	1.9	2.8	3.1		
December	4.1	4.7	5.5	-	3.6	2.6		
Mean	3.5	7.1	4.9	5.1	5.9	6.9		
Minimum	0.9	1.5	1.8	1.9	1.1	2.0	0.0	0.2
Maximum	6.5	18.0	8.5	10.1	19.3	21.0	11.0	12.4

Table 1.1-19

SUMMARY OF WEEKLY OBSERVED DISSOLVED OXYGEN

CONCENTRATIONS IN THE TAILRACE OF WATTS BAR DAM

1960-71

Year	Observed Dissolved Oxygen Concentrations mg/l		Number of Days Dissolved Oxygen Less than Stated Concentration			
	Minimum	Maximum	3.0 mg/l Days	4.0 mg/l Days	5.0 mg/l Days	6.0 mg/l Days
1960	3.3	10.5	0	6	47	101
1961	4.7	11.8	0	0	3	73
1962	2.9	10.5	4	30	77	144
1963	2.3	11.5	11	50	98	121
1964	3.2	11.2	0	25	39	116
1965	2.7	10.7	6	46	95	131
1966	2.1	12.6	32	43	82	120
1967	3.9	13.5	0	2	23	71
1968	3.3	12.4	0	25	78	133
1969	2.2	11.0	10	66	96	122
1970	2.9	11.6	2	66	116	148
1971	3.0	10.8	0	36	86	146

Table 1.1-20

WATER QUALITY AT TENNESSEE RIVER MILE 518.0

Date	Time	Location in Stream	Depth	Total Coliforms	Temp.	D.O.	5-Day 20°C. BOD	Color	Turb.	Thresh-old Odor	Alkalinity Phen.	Alkalinity Tot.	Hard. $CaCO_3$	pH	Spec. Resist-ance	Cl
1960			ft.	MPN/100 ml	°C.	mg/1	mg/1	PCU	JCU	No.	mg/1	mg/1	mg/1		ohms	mg/1
7-13	4:30 p.	Middle	Surf.	3,900	24.2	5.17	1.62	10	12	1+	0.00	52.3	82.6	7.8	4,500	14.8
8-5	9:55 a.	Middle	Surf.	110	25.5	4.15	-	10	9.8	-	0.00	58.5	82.0	7.4	4,800	15.2
8-24	1:20 p.	Middle	Surf.	36	24.3	4.65	2.39	10	10	-	0.00	55.9	76.6	-	5,100	9.48
9-23	8:35 a.	Middle	Surf.	11	23.9	5.66	0.91	10	18	-	0.00	51.0	80.3	7.6	4,500	24.3
10-18	11:55 a.	Middle	Surf.	-	22.1	6.19	0.83	10	8.2	2	0.00	56.7	81.0	-	4,500	19.3
11-15	11:55 a.	Middle	Surf.	-	-	8.43	1.05	20	4.5	None	0.00	52.3	78.5	-	4,300	23.4
12-13	10:40 a.	Middle	Surf.	-	6.8	10.66	1.18	20	18	None	0.00	53.1	76.6	7.6	4,700	19.7
1961																
1-18	10:50 a.	Middle	Surf.	-	6.1	11.17	1.88	25	13	None	0.00	43.4	61.4	7.5	5,600	16.4
2-22	11:00 a.	Middle	Surf.	-	8.3	12.07	1.47	25	22	None	0.00	57.5	75.1	7.6	4,800	14.3
3-21	12:10 p.	Middle	Surf.	-	10.4	9.85	1.12	10	30	None	0.00	54.8	69.1	7.5	6,100	9.77
4-18	11:05 a.	Middle	Surf.	-	13.3	9.71	1.00	15	25	None	0.00	43.4	57.2	7.4	7,400	5.60
5-16	10:50 a.	Middle	Surf.	110	18.8	8.10	2.07	10	15	None	0.00	54.0	68.4	7.7	6,600	7.30
6-14	12:05 p.	Middle	Surf.	230	21.8	5.74	1.55	10	19	None	0.00	54.9	68.7	7.4	6,400	7.80
Maximum Values					25.5	12.07	2.39	25	30	2	0.00	58.5	82.6	7.8	7,400	24.3
Minimum Values					6.1	4.15	0.83	10	4.5	None	0.00	43.4	57.2	7.4	4,300	5.60

Table 1.1-21

WATER QUALITY AT TENNESSEE RIVER MILE 529.9

Date	Time	Location in Stream	Depth	Total Coliforms	Temp.	D.O.	5-Day 20°C. BOD	Color	Turb.	Thresh-old Odor	Alkalinity Phen.	Alkalinity Tot.	Hard. $CaCO_3$	pH	Spec. Resist-ance	Cl	Ca	Mg	Na	K	Fe, Total	Nitrite + Nitrate Nitrogen	SiO_2	SO_4	Solids Sus.	Solids Dis.	Solids Tot.
1960			ft.	MPN/100 ml	°C	mg/1	mg/1	PCU	JCU	No.	mg/1	mg/1	mg/1		ohms	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1	mg/1
7-13	5:25 p.	Middle	Surf.	6,200	23.8	4.38	1.03	10	11	1+	0.00	52.8	83.2	7.5	4,500	15.2	26.0	9.41	7.90	0.80	0.13	0.12	0.50	14.5	24	100	124
8-6	9:10 a.	Middle	Surf.	94	24.3	3.60	1.37	10	12	-	0.00	59.5	82.3	7.4	4,800	13.7	25.1	5.45	7.50	1.00	0.55	0.18	6.16	16.4	27	80	107
8-24	2:15 p.	Middle	Surf.	23	24.7	4.95	1.76	10	13	-	0.00	54.0	76.1	-	5,200	13.9	22.4	5.72	7.40	0.95	0.33	0.08	3.00	17.3	6	116	122
9-23	9:15 a.	Middle	Surf.	55	24.1	5.98	2.61	10	18	-	0.00	42.9	80.3	7.4	4,400	22.0	24.0	5.79	10.2	1.20	0.50	0.18	6.64	15.0	26	127	153
10-18	11:55 a.	Middle	Surf.	36*	23.0	6.23	0.91	15	10	1+	0.00	54.6	82.9	-	4,400	21.5	23.0	7.23	9.50	1.00	0.19	0.48	6.16	14.6	5	90	95
11-15	12:05 p.	Middle	Surf.	36	-	8.19	0.74	20	4.2	None	0.00	50.8	75.7	-	4,400	23.0	18.6	8.37	11.0	1.10	0.38	0.00	6.48	15.5	54	83	137
12-13	9:35 a.	Middle	Surf.	230	7.8	9.87	1.18	20	13	None	0.00	53.7	74.4	7.6	4,700	19.7	22.3	5.35	10.2	1.15	0.22	0.15	7.94	18.2	37	85	122
1961													1961														
1-18	10:15 a.	Middle	Surf.	55	5.9	11.05	1.48	25	16	1+	0.00	42.7	62.0	7.4	5,400	17.4	19.1	3.90	9.20	0.80	0.12	0.37	6.28	16.4	21	72	93
2-21	9:50 a.	Middle	Surf.	2.6	8.1	12.41	3.28	20	15	1+	0.00	58.3	75.1	7.4	4,800	16.1	21.8	5.66	8.40	1.05	0.48	0.38	6.32	20.0	24	96	120
3-21	11:35 a.	Middle	Surf.	55	10.0	9.79	1.06	15	28	None	0.00	57.5	70.7	7.5	5,300	9.26	19.6	4.55	4.80	0.95	1.34	0.05	8.96	27.9	13	96	109
4-18	10:25 a.	Middle	Surf.	16	13.1	9.58	1.03	10	18	None	0.00	38.0	54.5	7.4	7,400	5.98	13.5	4.66	4.10	0.85	0.71	0.28	6.08	15.5	3	78	81
5-16	10:15 a.	Middle	Surf.	360	18.7	8.35	1.93	10	13	1+	0.00	54.3	68.2	7.7	6,500	7.95	20.5	5.09	4.83	0.95	0.23	0.15	4.30	10.9	6	54	60
6-14	10:40 a.	Middle	Surf.	23	21.4	5.55	1.75	15	12	None	0.00	54.5	68.0	7.4	6,400	9.26	20.8	3.59	5.28	0.95	0.14	0.15	5.92	13.6	6	91	97
Maximum Values					24.7	12.41	3.28	25	28	1+	0.00	59.5	83.2	7.7	7,400	23.0	26.0	9.41	11.0	1.20	1.34	0.48	8.96	27.9	54	127	153
Minimum Values					5.9	3.60	0.74	10	4.2	None	0.00	38.0	54.5	7.4	4,400	5.98	13.5	3.59	4.10	0.80	0.12	0.00	0.50	10.9	3	54	60

*Collected Oct. 25, 1960.

Table 1.1-22

OBSERVED WATER TEMPERATURES - CHICKAMAUGA RESERVOIR *

Tennessee River Mile 487.7

July 1960 - June 1961

Date	Distance From Right Bank (% of Width)	Surface - depth 1 ft. Temperature	Bottom Temperature	Bottom depth, ft
July 12, 1960	50	81.9	75.6	38
August 5, 1960	50	81.7	77.9	35
August 23, 1960	50	79.0	76.5	37
September 22, 1960	50	76.9	74.1	40
October 18, 1960	50	73.6	72.1	36
November 22, 1960	50	55.6	55.0	36
January 18, 1961	50	41.7	41.5	35
February 21, 1961	50	46.6	46.6	40
March 21, 1961	50	52.5	52.5	40
April 18, 1961	50	57.9	56.5	44
May 16, 1961	50	65.8	63.9	42
June 14, 1961	50	78.3	72.0	48

*Data from Quality of Water in Chickamauga Reservoir, 1960-1961, Division of Health and Safety, TVA

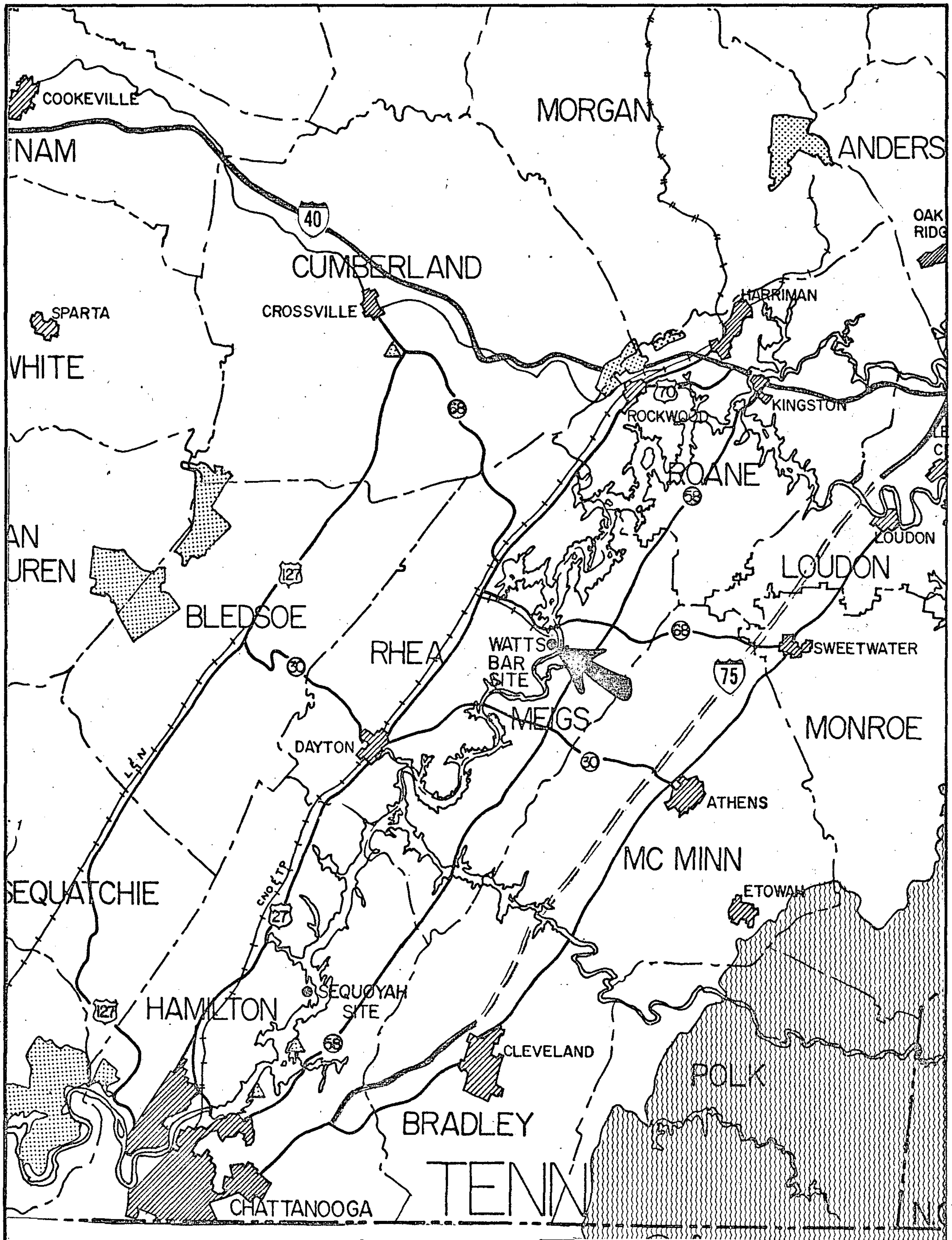
Table 1.1-23

OBSERVED MAXIMUM AND MINIMUM TEMPERATURES

Chickamauga Reservoir - Tennessee River Mile 487.5

Calendar Year	Surface Temperatures, °F. *	
	Maximum	Minimum
1943	84.2	44.6
1944	82.4	41.0
1945	84.2	41.0
1946	84.2	42.8
1947	82.4	39.2
1948	82.4	42.8

* Data from Water Temperature of Streams and Reservoirs in the Tennessee River Basin, Hydraulic Data Branch, TVA



Map Symbols
State Parks or Forest
Cherokee National Forest

Figure 1.1-1

Proximity of Site to Towns, Rivers, and County Boundaries

WATTS BAR NUCLEAR PLANT

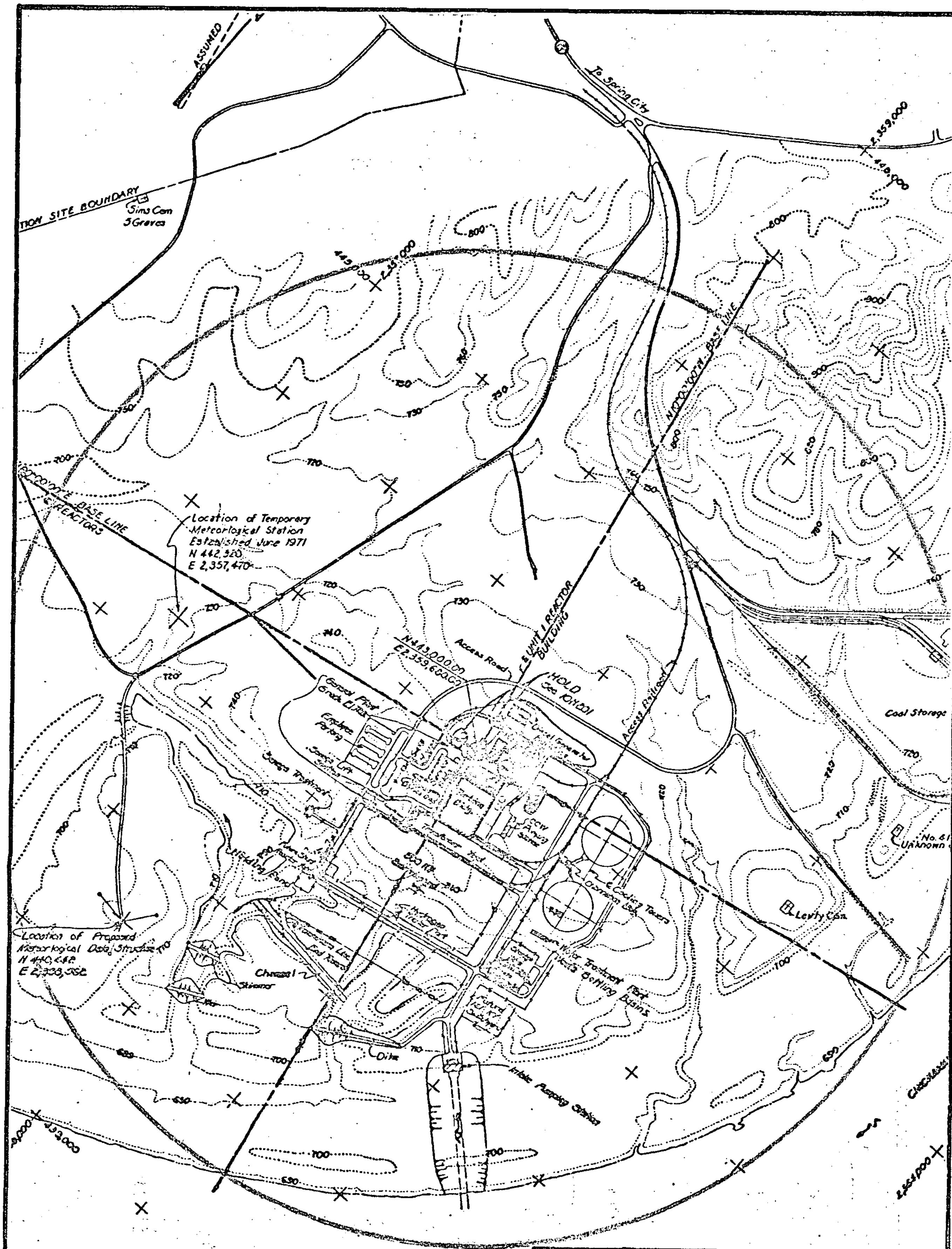


Figure 1.1-2
Minimum Exclusion
Distance and Site Layout
WATTS BAR NUCLEAR SITE

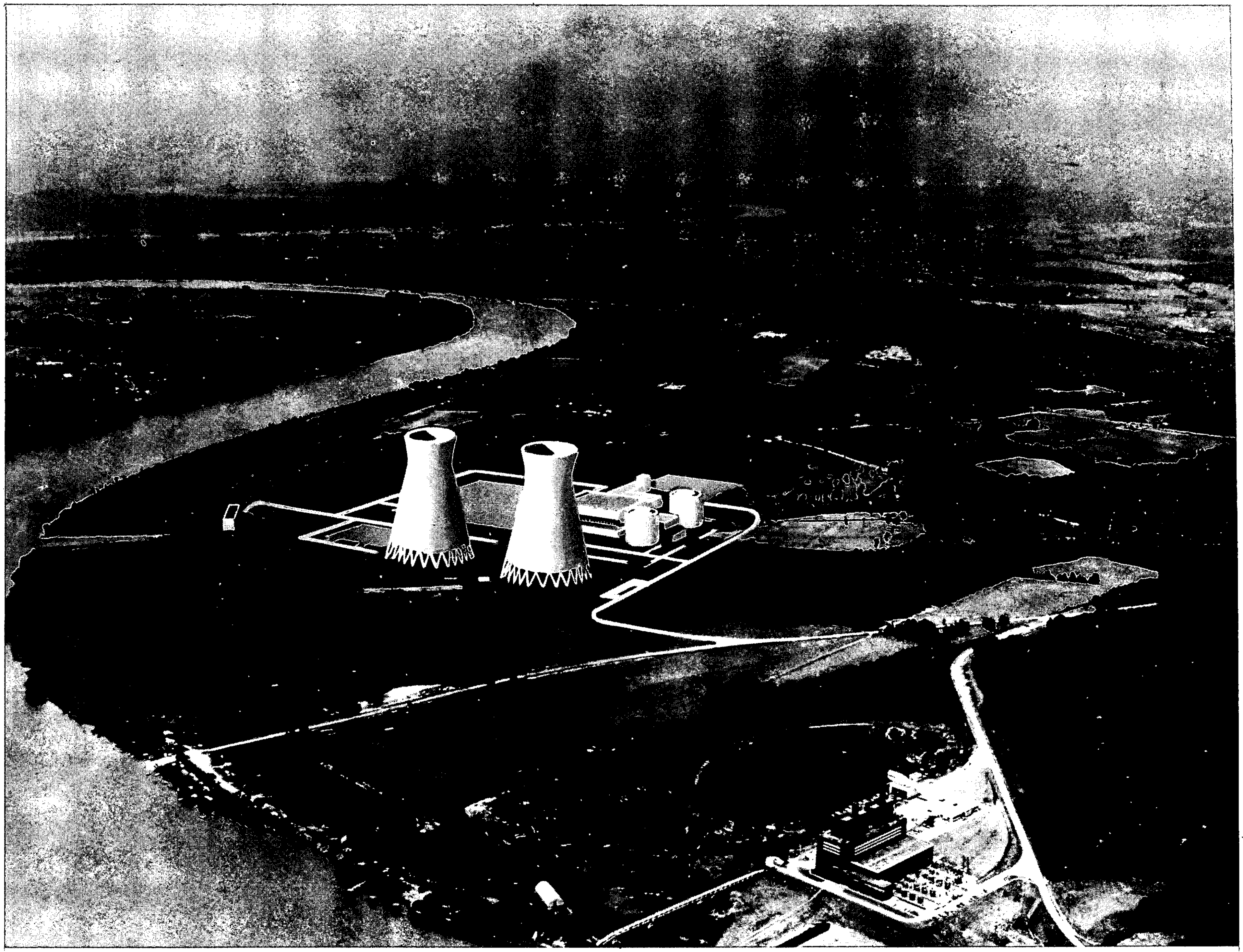


Figure 1.1-3

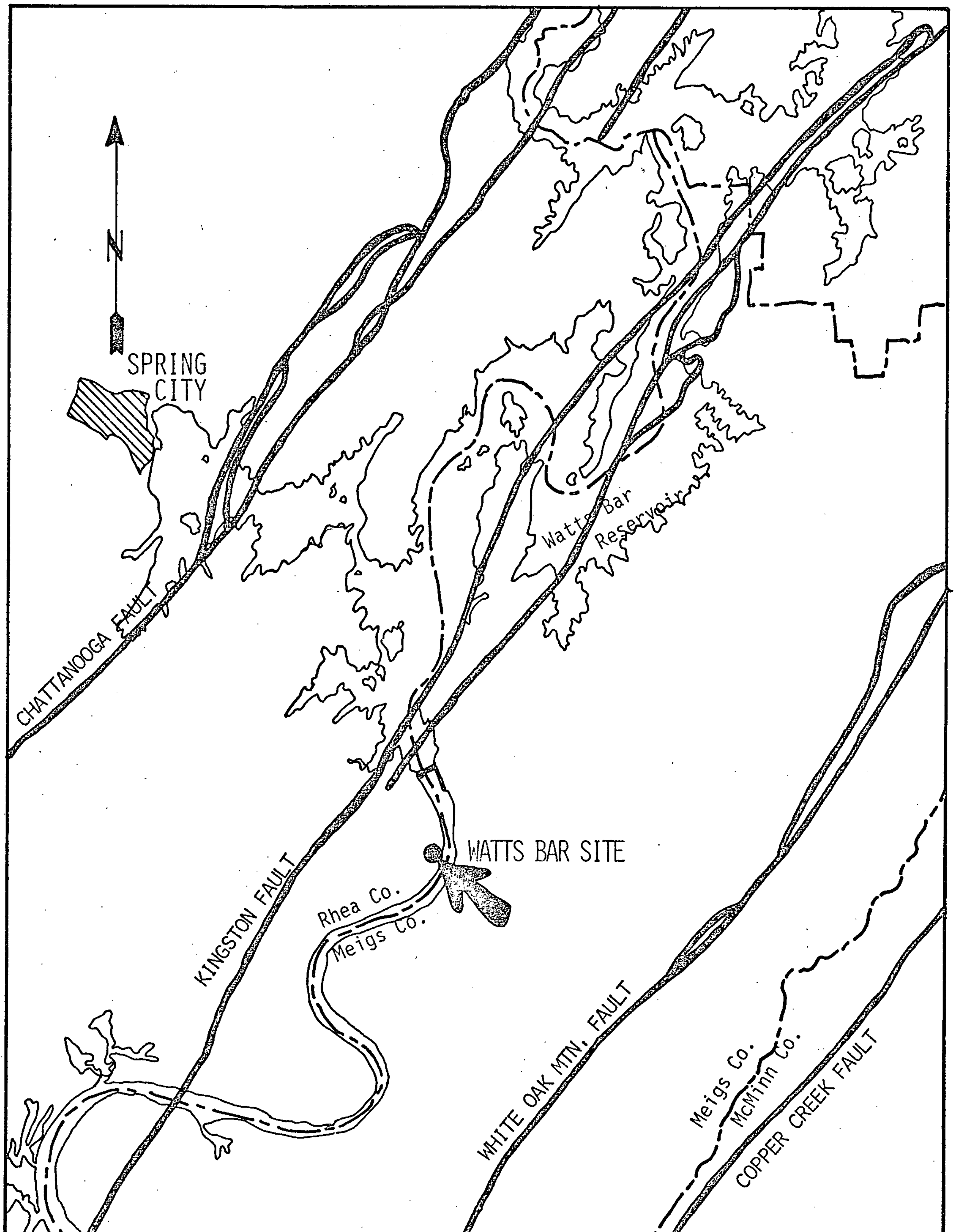
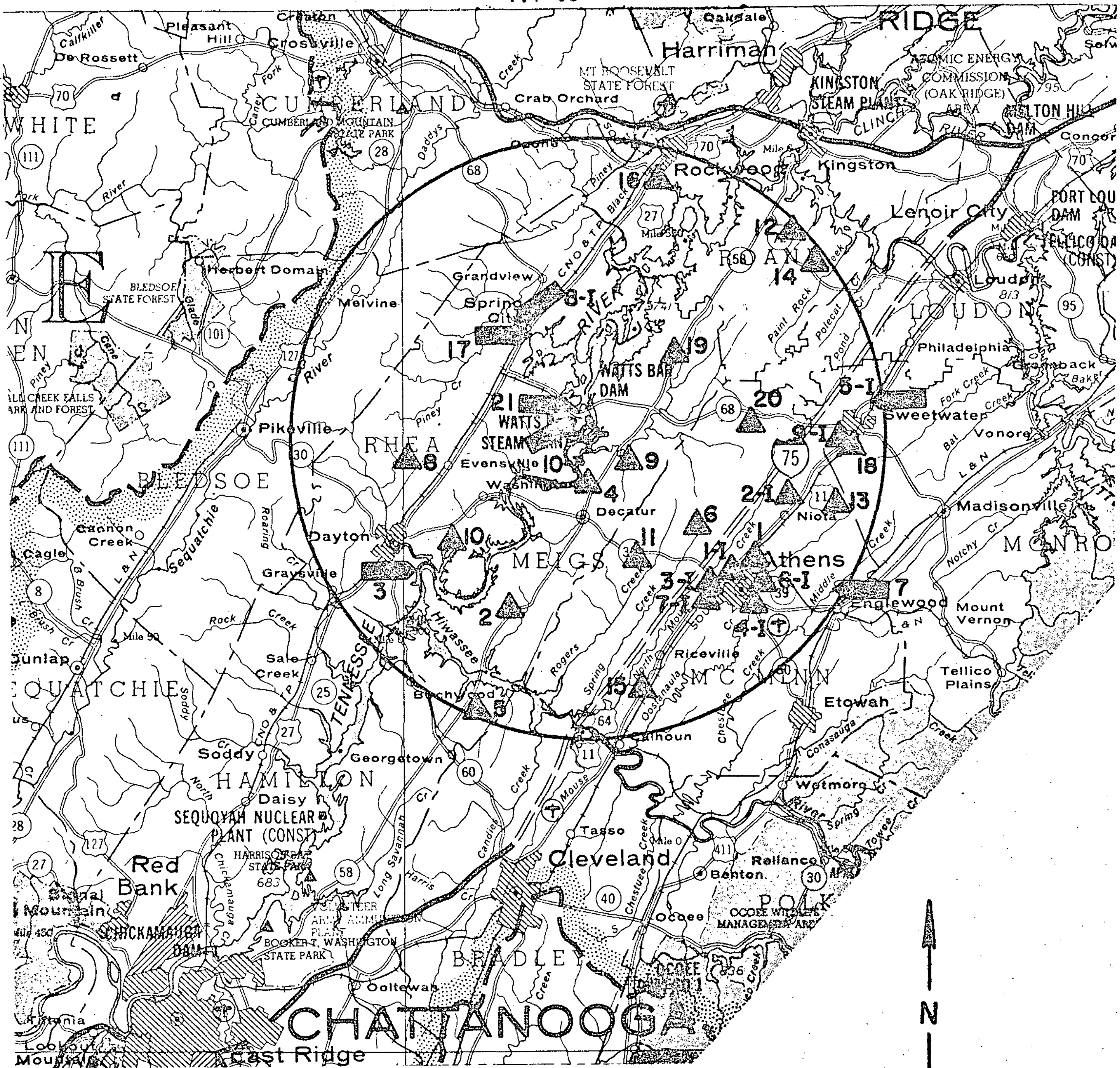


Figure 1.1-4

Location of Nearest Faults in Region

WATTS BAR NUCLEAR PLANT



⌖	WATTS BAR SITE
▭	Surface Water Supply
▲	Ground Water Supply
I	Industrial Water Supply Used for Potable Water

10 0 10 20

SCALE OF MILES

Figure 1.1-5

PUBLIC WATER SUPPLIES WITHIN TWENTY MILE RADIUS OF THE WATTS BAR NUCLEAR SITE

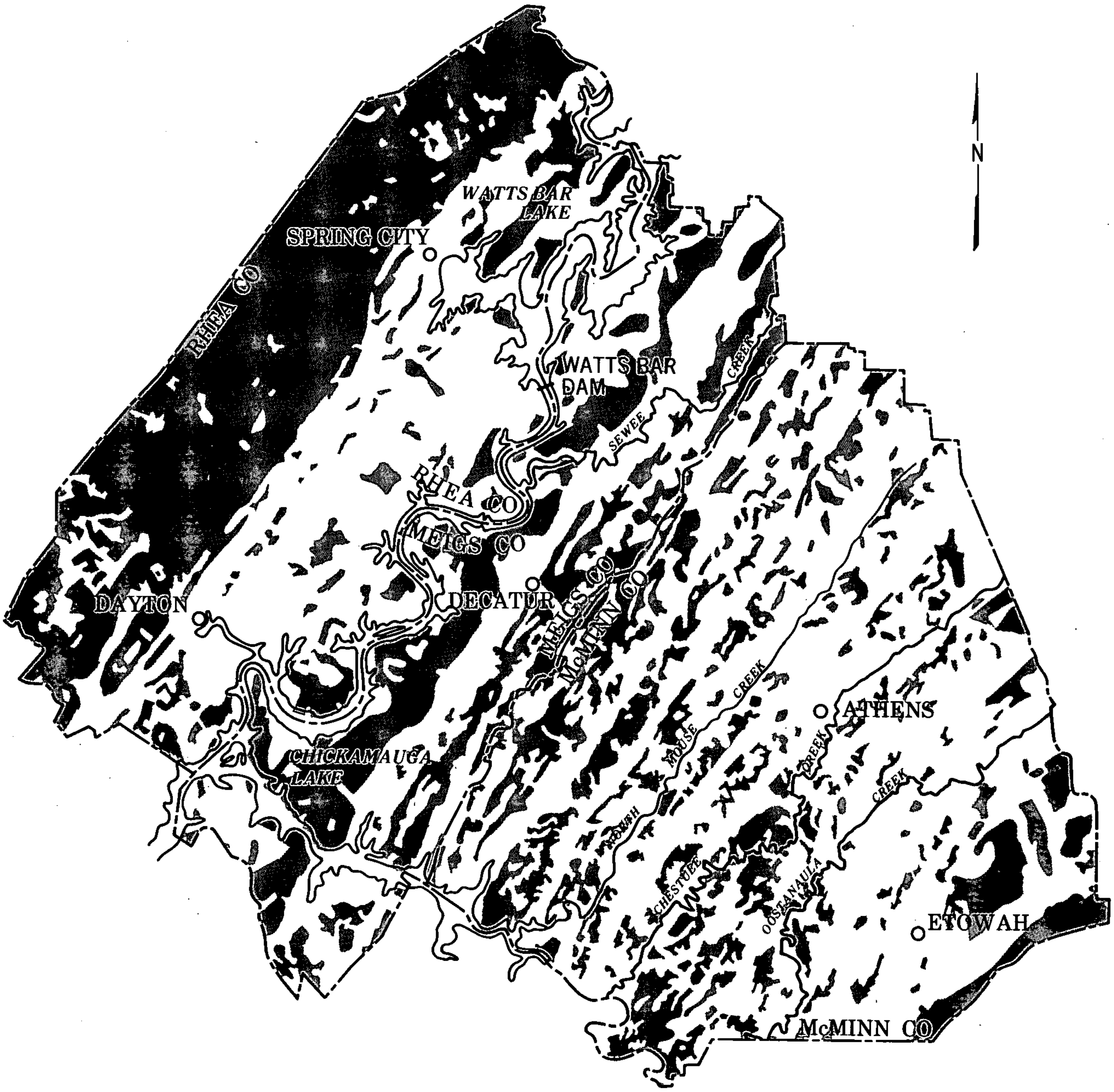


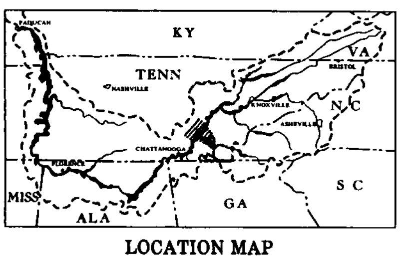
Figure 1.1-6

FOREST COVER

McMINN, MEIGS AND RHEA
COUNTIES, TENNESSEE

Scale of Miles
4 2 0 4 8

APRIL 1970



LOCATION MAP

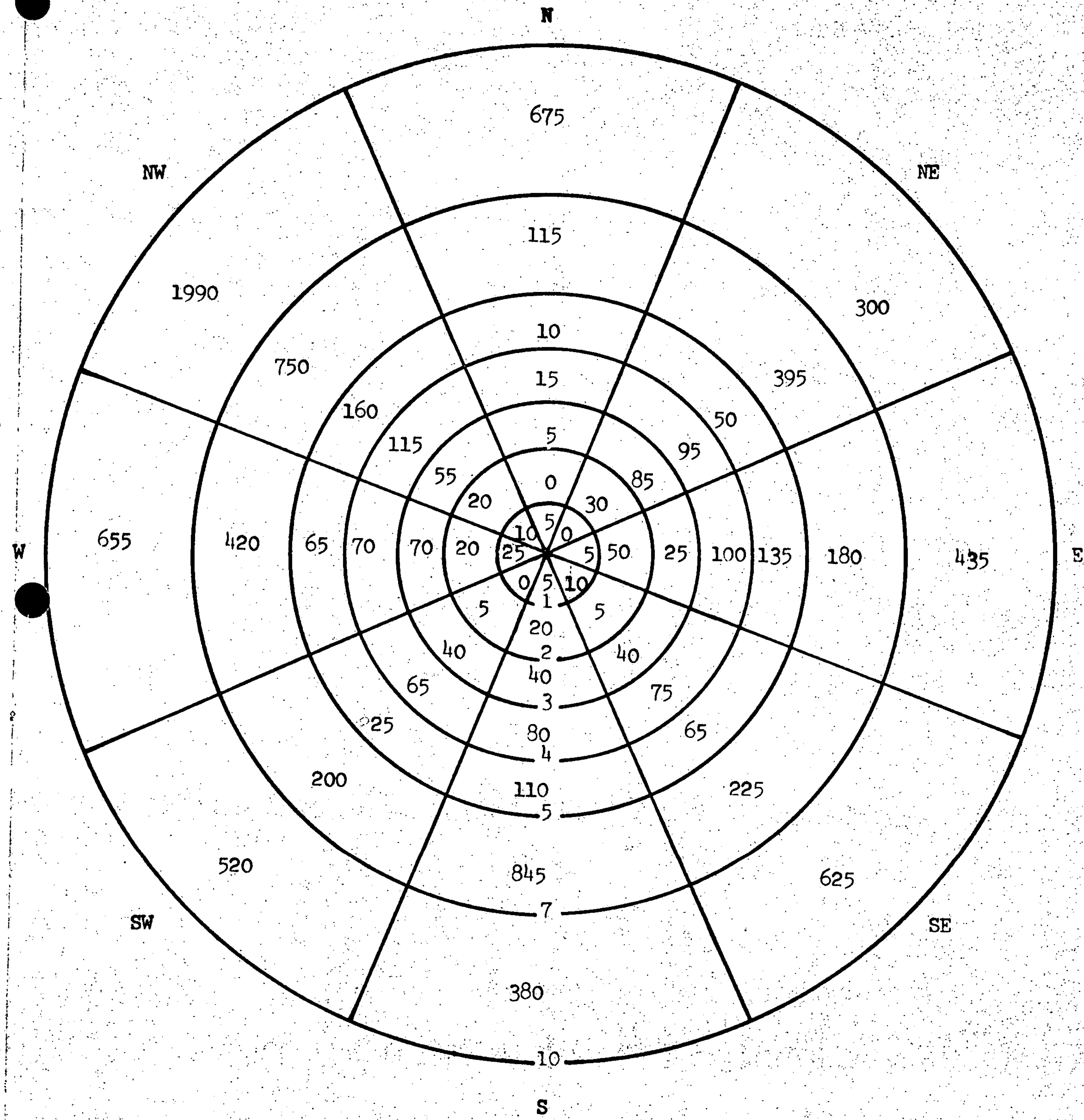


Figure 1.1-7

POPULATION DISTRIBUTION
WITHIN 10 MILES

1970

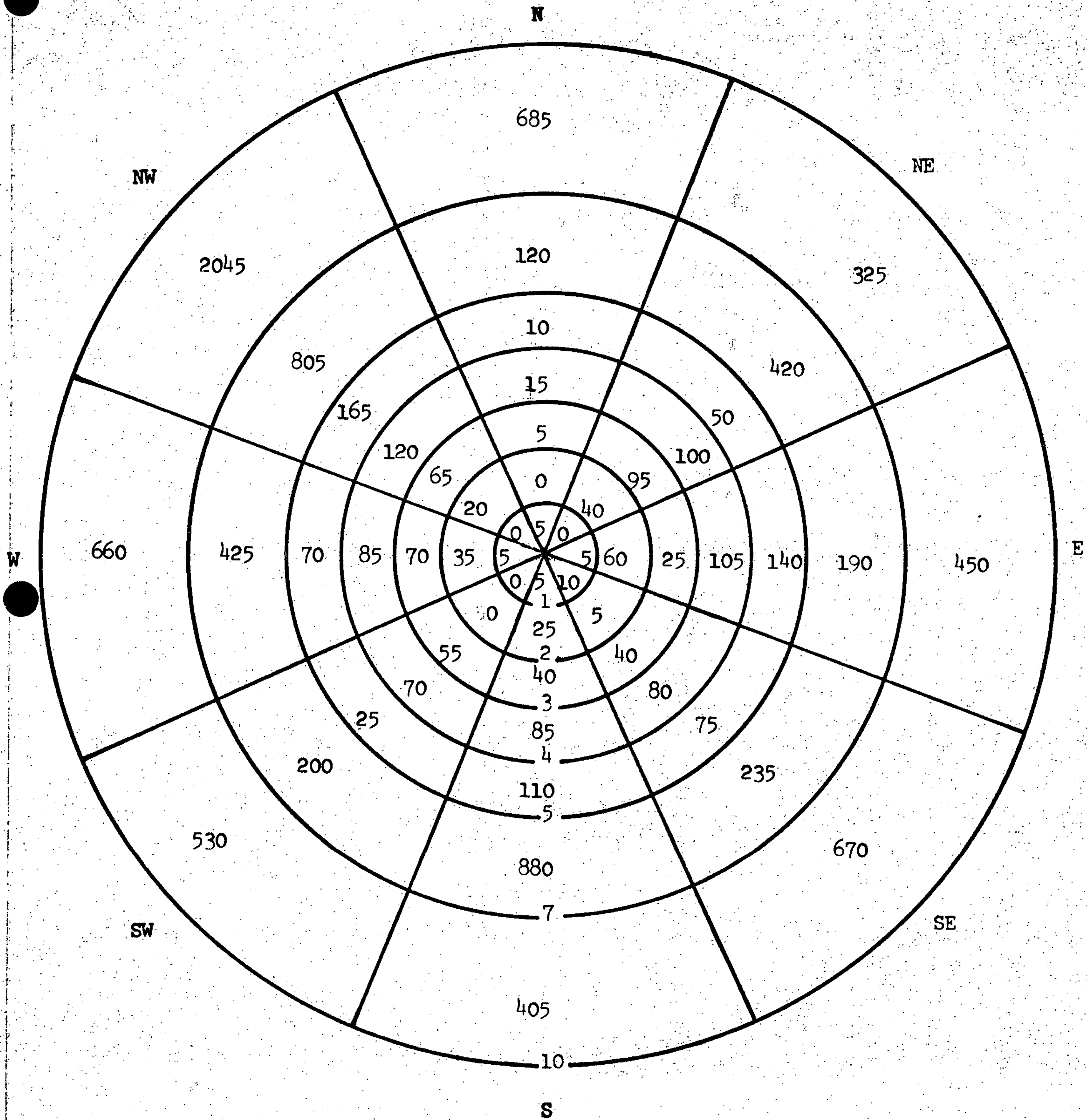


Figure 1.1-8

POPULATION DISTRIBUTION
WITHIN 10 MILES

1980

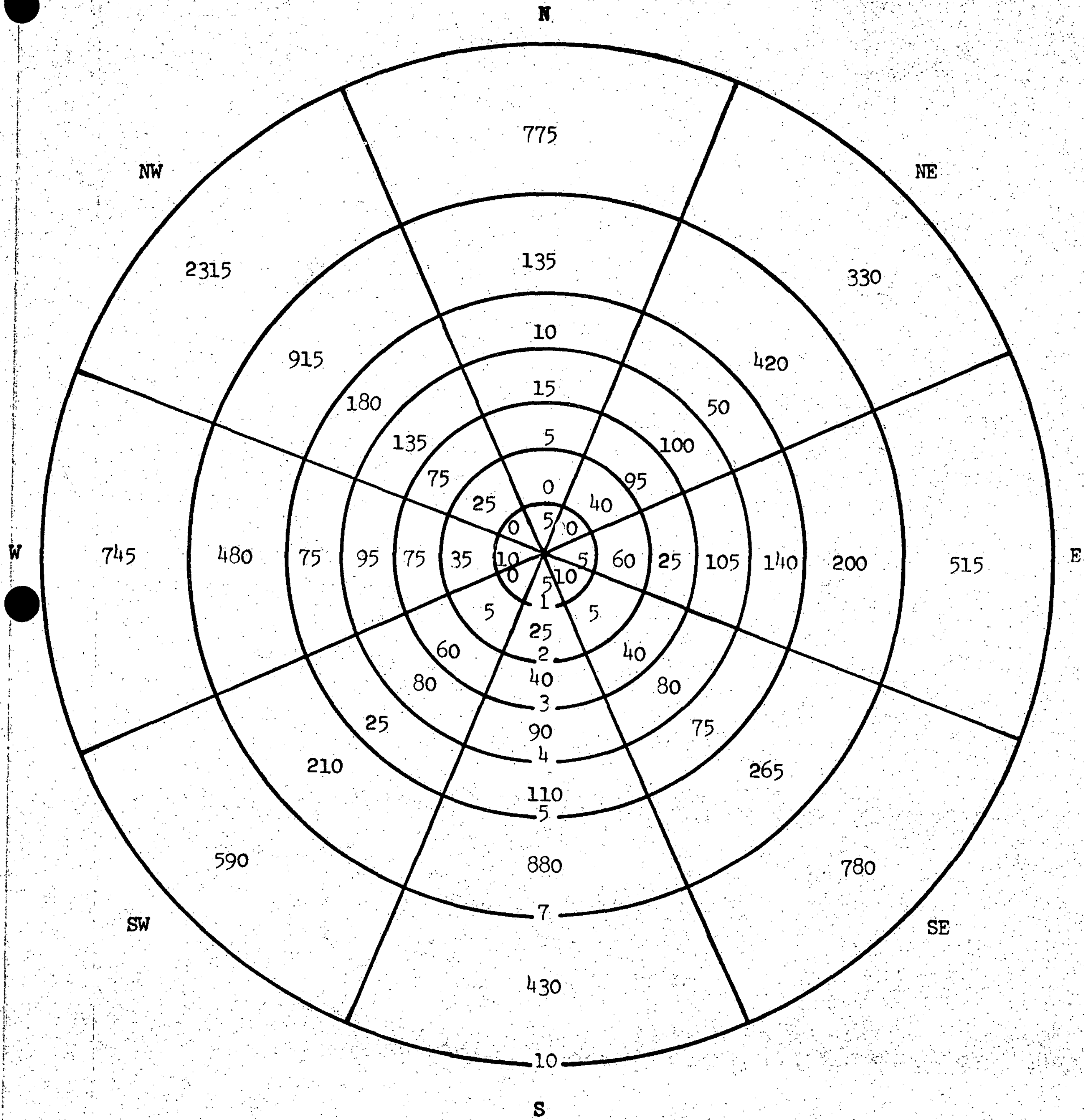


Figure 1.1-9

POPULATION DISTRIBUTION
WITHIN 10 MILES
2000

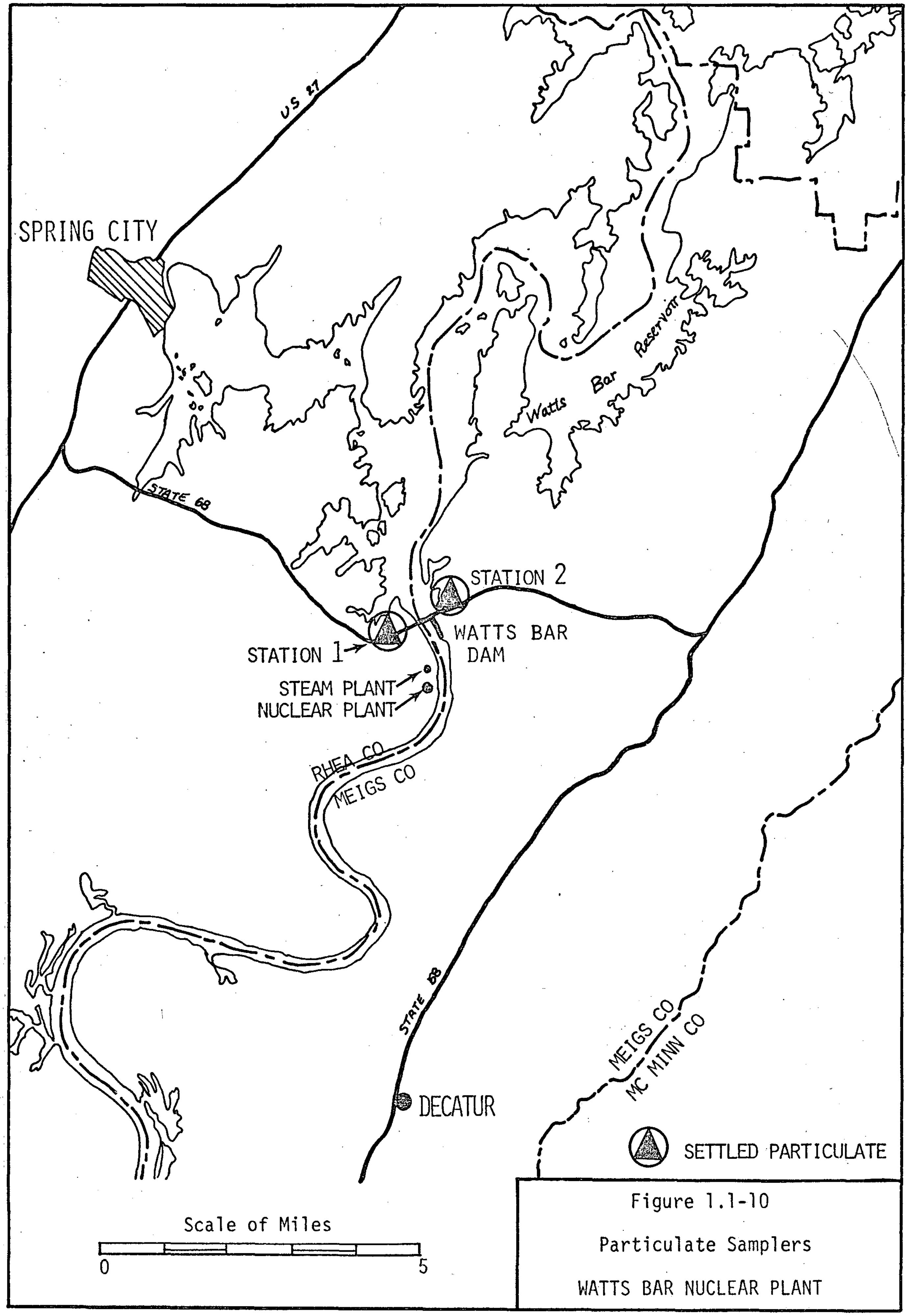


Figure 1.1-10

Particulate Samplers

WATTS BAR NUCLEAR PLANT

1.2 <u>Electric Power Supply and Demand</u> - TVA is the power supplier for an area of approximately 80,000 square miles containing about 6 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 1.2-1. 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 19.8 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 1.2-1 shows major TVA system capacity additions since 1949.

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.

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 1977-79 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 1976-77	26,050	-2,060	23,990	28,595	4,605	19.2
Summer 1977	22,700	+2,060	24,760	29,936	5,176	20.9
Winter 1977-78	27,400	-2,060	25,340	29,765	4,425	17.5
Summer 1978	23,830	+2,060	25,890	31,106	5,216	20.1
Winter 1978-79	28,800	-2,060	26,740	30,935	4,195	15.7

The above power supply projection is based on commercial operating dates on the Watts Bar nuclear units of May 1977 and February 1978. Both units have been rescheduled to nine months later than shown in the draft environmental statement.

2. <u>Consequences of delays</u> - The margins shown in the above tabulation are expected to be extremely tight, particularly during the winter 1978-79 period even if the now projected schedules of capacity additions are achieved. Any further delays in operation of the Watts Bar units could result in the inability of the TVA system to meet adequately its obligations under the peak load conditions during 1977-78 with presently scheduled generating capacity. The total consequences of such delays of the Watts Bar 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 of 1977-78, postulating a further delay of twelve months for each of the Watts Bar 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 Reserve Deficiencies Due to Watts Bar Unit Delays of 12 Months
Summer 1977	670[a]
Winter 1977-78	1,400
Summer 1978	670[a]
Winter 1978-79	1,850

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

Deficiencies of the magnitude caused by an additional twelve months' delay of the Watts Bar units must be replaced either by the installation of alternative capacity on the TVA system or by the import of power from other utility systems; otherwise, the reliability of power supply to TVA's customers will be drastically reduced. By the time that additional delays in the Watts Bar nuclear units would be confirmed, it is unlikely that additional fossil-fired capacity could be installed to meet these deficiencies since the period from decision until commercial operation for fossil units is about 5 to 6 years. Therefore, the only feasible means of obtaining additional reliable generation on the TVA system during the time period being considered is the installation of either combustion turbine or combined-cycle units since power in the magnitude being considered would most likely not be available from other utilities when it is needed on the TVA system.

The economic costs of any Watts Bar 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 1977-78 period is approximately $130 million. 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 present 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 Watts Bar nuclear units is estimated to cost about 2.1 to 2.2 mills per kWh during the 1977-78 period, while replacement energy which would be used in lieu of this nuclear energy in the event of further delays would cost from 3.5 to 10 mills per kWh, depending on the source of this replacement energy. Studies of the effects of Watts Bar unit delays indicate that each month's delay on these units would result in increased production expenses on the TVA system of approximately $3.5 million.

In addition to these economic costs, each month's delay on the two Watts Bar nuclear units could require that approximately 560,000 tons of additional coal and 6.1 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 Watts Bar Nuclear Plant will have a twofold effect on the TVA power system.

1. Costs to TVA's customers would be increased by at least \$3.5 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 Watts Bar delays, costs to TVA's consumers over and above those shown above could be increased by \$43 million. These costs could total nearly \$85 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 Watts Bar delays. Such operation would result in the increased emission of particulates, sulfur dioxide, and other materials into the atmosphere.

Table 1.2-1

MAJOR TVA SYSTEM CAPACITY ADDITIONS

SINCE CALENDAR YEAR 1949

Plant	Number of Units	Nameplate Capacity-kW Units	Nameplate Capacity-kW Total	Commercial Operating Date First Unit	Commercial Operating Date Last Unit
TVA Thermal					
Thomas H. Allen	3	330,000	990,000	5-22-59	10-25-59
Thomas H. Allen (Gas Turbines)	16	23,900	382,400	6-05-71	6-05-71
Bull Run	1	950,000	950,000	6-12-67	6-12-67
Colbert	5	2 @ 200,000 2 @ 223,250 1 @ 550,000	1,396,500	1-18-55	11-07-65
Gallatin	4	2 @ 300,000 2 @ 327,600	1,255,200	11-08-56	8-09-59
John Sevier	4	1 @ 223,250 3 @ 200,000	823,250	7-12-55	10-31-57
Johnsonville	10	4 @ 125,000 2 @ 147,000 4 @ 172,800	1,485,200	10-27-51	8-20-59
Kingston	9	4 @ 175,000 5 @ 200,000	1,700,000	2-08-54	12-02-55
Paradise	3	2 @ 704,000 1 @ 1,150,200	2,558,200	5-19-63	2-27-70
Shawnee	10	175,000	1,750,000	4-09-53	6-17-57
Widows Creek	8	5 @ 140,625 1 @ 149,850 1 @ 575,010 1 @ 550,000	1,977,985	7-01-52	2-07-65

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

Table 1.2-1
(Continued)

MAJOR TVA SYSTEM CAPACITY ADDITIONS

SINCE CALENDAR YEAR 1949

Plant	Number of Units	Nameplate Capacity-kW Unit	Nameplate Capacity-kW Total	Commercial Operating Date First Unit	Commercial Operating Date Last Unit
TVA Hydro					
Boone	3	25,000	75,000	3-16-53	9-03-53
Chatuge	1	10,000	10,000	12-09-54	12-09-54
Cherokee*	2	30,000	60,000	1-29-53	10-07-53
Chickamauga*	1	27,000	27,000	3-07-52	3-07-52
Douglas*	1	26,000	26,000	8-03-54	8-03-54
Fontana*	1	67,500	67,500	2-04-54	2-04-54
Ft. Patrick Henry	2	18,000	36,000	12-05-53	2-22-54
Guntersville*	1	24,300	24,300	3-24-52	3-24-52
Hiwassee*	1	59,500	59,500	5-24-56	5-24-56
Melton Hill	2	36,000	72,000	7-03-64	11-11-64
Nickajack	4	24,300	97,200	2-20-68	4-30-68
Nottely	1	15,000	15,000	1-10-56	1-10-56
Pickwick*	2	36,000	72,000	10-31-52	12-31-52
South Holston	1	35,000	35,000	2-13-51	2-13-51
Wheeler*	5	32,400	162,000	3-04-50	12-18-63
Wilbur*	1	7,000	7,000	7-19-50	7-19-50
Wilson*	6	3 @ 25,200 3 @ 54,000	237,600	1-06-50	4-12-62

*Other units in this plant installed in period prior to 1950.

1.2-8

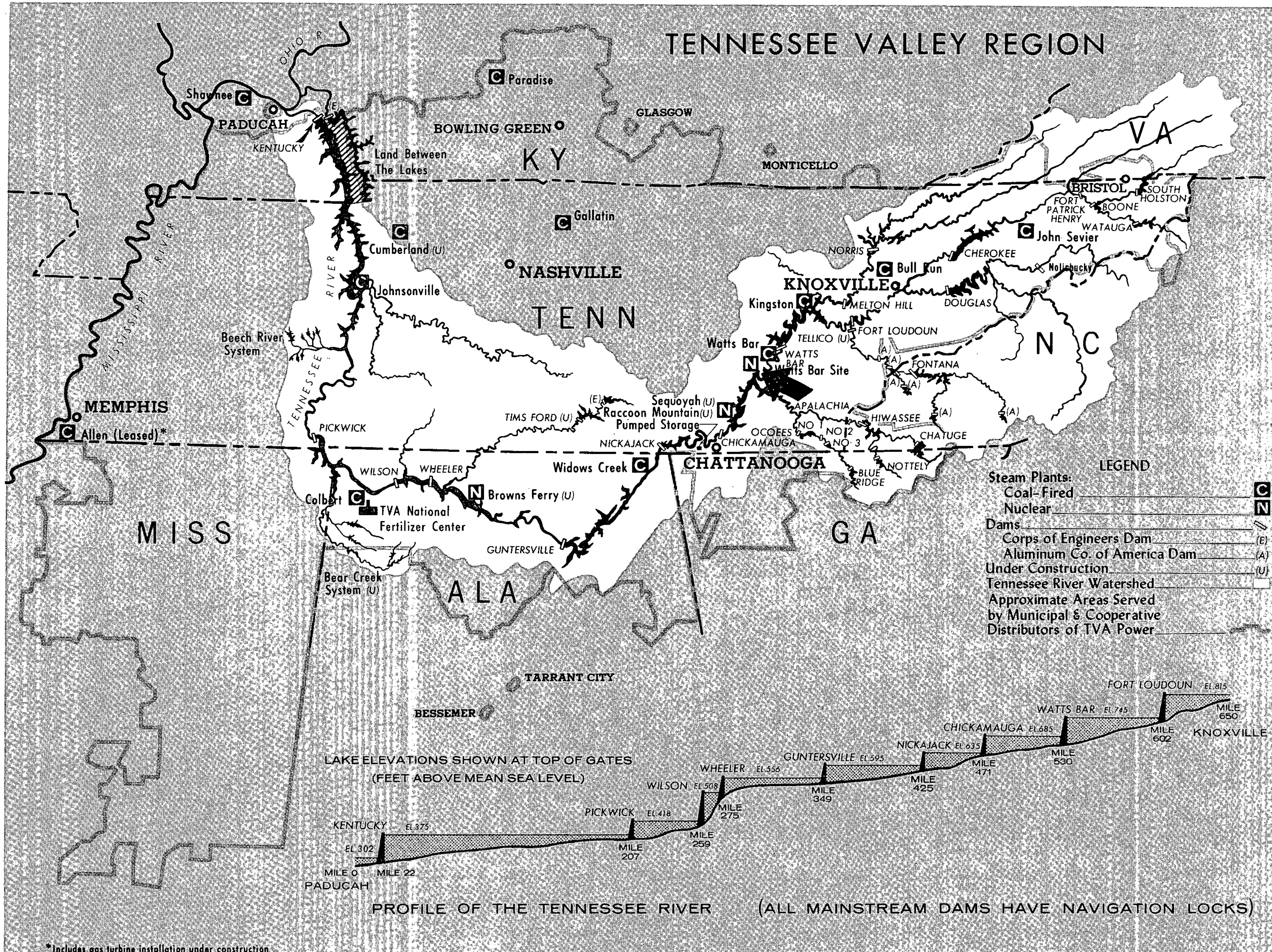
Table 1.2-1
(Continued)

MAJOR TVA SYSTEM CAPACITY ADDITIONS

SINCE CALENDAR YEAR 1949

Plant	Number of Units	Nameplate Capacity-kW Unit	Nameplate Capacity-kW Total	Commercial Operating Date First Unit	Commercial Operating Date Last Unit
Alcoa Hydro					
Bear Creek	1	9,000	9,000	4-14-54	4-14-54
Cedar Cliff	1	6,375	6,375	8-22-52	8-22-52
Chilhowee	3	16,667	50,000	8-28-57	10-18-57
Tennessee Creek	1	10,800	10,800	5-19-55	5-19-55
Corps of Engineers Hydro					
Barkley	4	32,500	130,000	1-20-66	3-30-66
Center Hill	3	45,000	135,000	12-11-50	4-11-51
Cheatham	3	12,000	36,000	11-21-59	11-09-60
Dale Hollow*	1	18,000	18,000	11-17-53	11-17-53
Old Hickory	4	25,000	100,000	4-09-57	12-23-57
J. Percy Priest	1	28,000	28,000	2-03-70	2-03-70
Wolf Creek	6	45,000	270,000	10-06-51	8-22-52

*Other units in this plant installed in period prior to 1950.



TENNESSEE VALLEY REGION
OHIO R.
Paradise
Shawnee
PADUCAH
(E)
KENTUCKY
Land Between The Lakes
BOWLING GREEN
GLASGOW
KY
MONTICELLO
VA
BRISTOL
SOUTH HOLSTON
FORT PATRICK HENRY
BOONE
WATAUGA
John Sevier
Gallatin
Cumberland (U)
CHEROKEE
NORRIS
Bull Run
Nolichucky
NASHVILLE
KNOXVILLE
Johnsonville
Kingston
MELTON HILL
DOUGLAS
TENN
RIVER
MISSISSIPPI RIVER
Beech River System
FORT LOUDOUN
TELLICO (U)
Watts Bar
WATTS BAR
Watts Bar Site
FONTANA
N C
TENNESSEE
MEMPHIS
Allen (Leased)*
Sequoyah (U)
Raccoon Mountain (U)
Pumped Storage
TIMS FORD (U)
APALACHIA
HIWASSEE
PICKWICK
NICKAJACK
OCOEES
NO 1
NO 2
NO 3
CHICKAMAUGA
CHATUGE
CHATTANOOGA
Widows Creek
BLUE RIDGE
NOTTELY
WILSON
WHEELER
Browns Ferry (U)
Colbert
TVA National Fertilizer Center
MISS
GUNTERSVILLE
GA
Bear Creek System (U)
ALA
TARRANT CITY
BESSEMER
LEGEND
Steam Plants:
Coal-Fired
Nuclear
Dams
Corps of Engineers Dam (E)
Aluminum Co. of America Dam (A)
Under Construction (U)
Tennessee River Watershed
Approximate Areas Served by Municipal & Cooperative Distributors of TVA Power
LAKE ELEVATIONS SHOWN AT TOP OF GATES
(FEET ABOVE MEAN SEA LEVEL)
FORT LOUDOUN EL 815
WATTS BAR EL 745
CHICKAMAUGA EL 685
NICKAJACK EL 635
GUNTERSVILLE EL 595
WHEELER EL 556
WILSON EL 508
PICKWICK EL 418
KENTUCKY EL 375
EL 302
MILE 650
KNOXVILLE
MILE 602
MILE 530
MILE 471
MILE 425
MILE 349
MILE 275
MILE 259
MILE 207
MILE 0
PADUCAH
MILE 22
PROFILE OF THE TENNESSEE RIVER
(ALL MAINSTREAM DAMS HAVE NAVIGATION LOCKS)
*Includes gas turbine installation under construction

Figure 1.2-1

1.3 Environmental Approvals and Consultations - AEC is responsible for the issuance of a construction permit and operating license for Watts Bar Nuclear Plant, following a complete review of environmental and licensing considerations. There are also numerous other requirements to insure protection of environmental values in the construction and operation of the plant. In the planning, design, and construction of its generating facilities TVA uses a broad interdisciplinary approach to insure that environmental values are given consideration at appropriate stages, and has adopted procedures and standards which will insure protection of the environment. In addition to its own standards, as a Federal agency TVA 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. § 4321 (1970) (as implemented by Executive Order 11514 (35 Fed. Reg. 4247) and guidelines issued by the Council on Environmental Quality (36 Fed. Reg. 7724)). In addition, TVA is subject to Executive Order 11507 (35 Fed. Reg. 2573) relating to the prevention, control, and abatement of air and water pollution in Federal facilities, as well as the Clean Air Act, 42 U.S.C. § 1857 (1963), the Federal Water Pollution Control Act, 33 U.S.C. § 446 (1965) (as amended by the Federal Water Quality Improvement Act of 1970, 33 U.S.C. § 1152 (1970)), and Office of Management and Budget Circulars A-78 and A-81, all of which require compliance with applicable state or Federal air and water quality standards. In addition, TVA is subject to the inter-governmental coordination requirements of Office of Management and Budget Circular A-95 which insures 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.

By statute, TVA is not subject to the provisions of Section 10 and 13 of the River and Harbors Act of March 3, 1899, 33 U.S.C. Sections 403, 407(1970). TVA has consulted with the Corps of Engineers concerning the Corps' implementation of the Refuse Act Permit Program under Section 13. To assist the Corps in administering the Permit Program, TVA has agreed to provide information concerning the quantity and content of TVA's discharges identical to that which the program is designed to secure from private permit applicants.

The state and regional A-95 clearinghouses have been advised of the Watts Bar Nuclear Plant, and the draft environmental statement and supplements and additions to the draft statement have been submitted for their review.

On August 31, 1970, the project manager for the Watts Bar Nuclear Plant met with the county chairmen of Rhea and Meigs Counties, the mayors of Dayton and Decatur, and the city manager of Dayton to discuss the proposed plant.

In October 1970, one of TVA's regional planners met with the Rhea County Planning Commission in Dayton to discuss the impact of the plant construction on schools and education. He also met with the Spring City Chamber of Commerce to discuss water and sewer problems with the Chamber and with members of the Tennessee Planning Commission, the Rhea County Planning Commission, and the Southeast Development District.

Also in October 1970, TVA education and manpower officials began a continuing discussion of the impact of the proposed plant on education with the superintendents of the Rhea, Roane, and Meigs County school systems, the Dean of Harriman Community College, and a representative of the Tennessee Department of Education.

On November 20, 1970, the project manager and TVA's Board Chairman addressed a meeting of the Spring City Chamber of Commerce which drew 250 persons. On December 21, 1970, the project manager and representatives from TVA's Divisions of Reservoir Properties and Navigation Development and Regional Studies met with city officials of Spring City and Decatur to coordinate water supply needs for the plant.

Throughout the first three months of 1971, meetings were held between local leaders in the area and TVA's Office of Tributary Area Development to identify and help solve community problems.

In February of 1971, staff from the Office of Health and Environmental Science consulted with officials of the Tennessee Department of Public Health concerning TVA's plans for environmental protection at the proposed Watts Bar Nuclear Plant.

On March 2, 1971, the project manager for the plant site discussed the economic and social impact of the plant on the region at a meeting of the Dayton Chamber of Commerce.

TVA's Education and Manpower Development Staff has provided technical assistance and information to the Rhea County Board of Education since March of 1971. Part of this effort involved assisting the Board in preparing an application for a grant to construct a consolidated high school. The application was filed in June 1971, and the notice of funding for $900,000 was received in June 1972.

Another activity of the staff was to work with local education boards, local labor leaders, and state manpower officials to develop a training program for local citizens to qualify them for construction jobs on the project. The state included this program in its State Manpower Plan submitted to the Department of Labor in June 1972.

In October 1971 TVA's Regional Planning Staff arranged for a meeting between the Tennessee State Planning Commission and the Rhea County Quarterly Court to discuss the planning assistance available from TSPC. The plant's imminent construction and accompanying effects provided the catalyst for stimulating local interest in such a program. The Rhea County Planning Commission has been meeting regularly since then and, as a first step in fostering orderly development, has adopted subdivision regulations.

TVA will continue to work with local officials and organizations to minimize impacts on local schools, housing, etc. These expected impacts are discussed in detail in section 2.9.

There is no zoning which would affect the plant site.

1.4 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 will be prepared for the Watts Bar 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.

Each state through which radioactive material from a TVA plant is 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 facility.

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 plan will be incorporated as an annex to the TVA Radiological Emergency Plan.

1. Meetings with outside agencies - Representatives of TVA have met or will meet with representatives of the following states and agencies to discuss and plan for radiological emergencies which might result as a consequence of the operation of the Watts Bar Nuclear Plant.

(1) State of Georgia* - Department of Public Health.

(2) State of South Carolina* - Department of Public Health.

(3) State of Tennessee* - Department of Public Health - October 12, 1971.

(4) State of Kentucky* - Department of Public Health.

(5) State of Illinois* - Department of Public Health.

(6) Environmental Protection Agency* - Eastern Environmental Radiation Laboratory - October 22, 1970, and June 9, 1971.

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 the EPA and the AEC.

---

* Previously consulted on radioactive material shipments from Browns Ferry Nuclear Plant.

2.0 ENVIRONMENTAL IMPACT OF THE PROPOSED FACILITY

The following discussion assesses the probable impact of the construction and operation of the facility on the environment.

Impacts have been evaluated considering the environment of the area as described in Section 1.1, General Information.

The sources of impacts discussed in sections 2.1 through 2.10 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 - About 100 tons of nuclear fuel will be shipped annually to and from the plant, and packaged radioactive waste totaling about 25 tons annually will be shipped 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 is achieved by a combination of limitations on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. These factors are discussed below in regard to the shipment of new fuel, spent fuel, and radioactive waste.

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 0.3659 inch in diameter by 0.6 inch long and are stacked inside zircaloy tubing with a 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. Two hundred and four of these rods are included in a 15 x 15 array to form a fuel assembly. A more detailed description of the fuel assemblies is given in the safety analysis report which was filed in support of the construction permit application.[1]

TVA will apply for a special nuclear material license to provide for receipt, possession, and storage only 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.[2] Fuel will be shipped in shipping containers which will have been demonstrated to assure criticality safety under both normal and accident conditions.

(1) Method and frequency of shipment - Westinghouse is the fabricator of the unit 1 initial core fuel assemblies and is responsible for shipment of these fuel assemblies to the reactor site. Westinghouse presently has fuel fabrication plants at Cheswick, Pennsylvania, and Columbia, South Carolina. Although this fuel can be shipped by either truck, barge, or rail, it will most likely be shipped by truck trailers from the Columbia, South Carolina, fabrication plant in quantities up to seven shipping containers per load, each containing two fuel assemblies, thereby providing a maximum of 14 fuel assemblies per truck shipment. About 10 such shipments by truck will be received at the plant annually (about 14 shipments in the initial core for each unit).

(a) Shipping routes - It is assumed that Westinghouse Electric Corporation will ship the initial core fuel assemblies by truck from its fabrication plant in Columbia, South Carolina, to the plant. The major population centers encountered over the approximately 325-mile route include the following:

City	1970 Population	Density Persons/mile^2
1. Columbia, SC--by way of I-26 to	113,542	6,343
2. Spartanburg, SC--by way of I-26 to	44,546	2,837
3. Asheville, NC--by way of I-40 to	57,681	2,658
4. Knoxville, TN--by way of I-40 to	174,587	2,267
5. Harriman, TN--by way of U.S. 27 and State 68 to	8,734	4,159
6. Watts Bar Plant Site	---	---

As indicated, interstate highways will be used to the maximum extent possible for the shipment of nuclear fuel and radioactive wastes. Alternate parallel routes will be used whenever necessary because of construction or temporary closure of interstate highway segments.

(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 thin layers of metal and self-shielding reduces the cumulative effect, no additional gamma or beta shielding is required in shipping packages for new fuel. The new fuel properties are given below:

- No radioactive fission products.
- No radioactive gases.
- High melting point.
- Insoluble solid.
- Zircaloy clad.
- In the clad form, the fuel assemblies will not disruptively react or decompose under expected or postulated thermal conditions.

(2) Environmental effects - The population exposure resulting from the normal shipment of radioactive material has been evaluated for the people who reside on either side of the transport route as shown on figure A-1 of Appendix A of this document. The radiation dose as a function of distance from a stationary shipping container is shown in figure A-2 of Appendix A. In order to assess the environmental effects of radioactive material shipments, it is assumed that they are made at the regulatory radiation level limit of 10 mrem/h at 6 feet from the nearest surface. The actual dose rate will be below the indicated values. As shown, the radiation exposure rate drops off quite rapidly, and at 240 feet from the container the exposure rate to a resident living at this point is approximately equal to natural background. Because the container will be normally moving, the total exposure from the containers to such an individual will be an insignificant fraction of the exposure from natural background radiation.

(a) Normal shipments - The only exposure to people from the routine shipment of new fuel is for the brief period such a shipment is in direct view and to the individual truck drivers so assigned, because of the estimated low dose rates at the time of shipment (<0.1 mrem/h at 6 feet from the cluster of containers). 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 10 shipments of new fuel would be about 0.0005 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 damage 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 and a determination of whether there had been damage of such significance that it would affect the subsequent 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 - The spent fuel removed from the two reactors during the annual refuelings contains on a weight basis in excess of 99.99 percent of the fission products formed inside the fuel and is temporarily stored in the spent fuel pool at the plant. The water in the pool serves as a radiation shield and coolant while the short-lived fission products decay. At the end of this storage period of about 3 to 4 months, the spent fuel is loaded into ruggedly built shielded containers for shipments to a fuel reprocessing plant where 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) Method and frequency of shipment - All the equipment and services for spent fuel transportation and reprocessings 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 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 is a considerable diversity of shipping methods possible 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 also has the potential to move 5 metric tons of uranium at a time and in special cases may be used as a link to the nearest available railroad.

Truck shipment of spent fuel from Watts Bar would involve about 130 legal weight shipments (73,280 pounds) over a period of about 4 to 6 months each year, or about 65 shipments if a 90,000-pound limit is permitted.

Rail shipments originating from the plant would require about 13 shipments annually. The shipments would be in a special rail cask holding ten fuel assemblies. Fuel assemblies which have identified clad perforations will be placed in a special container as necessary before being loaded into the spent fuel cask.

Since it will not be necessary to ship spent fuel from Watts Bar to a reprocessing plant until approximately 1978, 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 are assumed for purposes of routing and estimating the environmental effects.

(a) Shipping routes - It is assumed that the spent fuel from Watts Bar would be shipped about 325 miles by rail to the closest fuel reprocessing plant which is at Barnwell, South Carolina. The major population centers encountered en route are:

	City	1970 Population	Density Persons/mile^2
1.	Watts Bar Site--by way of CNO&TP and Sou to	---	---
2.	Knoxville, TN--by way of Sou to	174,587	2,267
3.	Asheville, NC--by way of Sou to	57,681	2,658
4.	Spartanburg, SC--by way of SCL to	44,546	2,837
5.	Greenwood, SC--by way of GA and FL and Sou to	21,069	2,926
6.	Barnwell, SC (AGNS site)	4,439	562

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

The inventory of fission product activity and decay heat of spent fuel at the time of shipment is given in Table 2.1-1. However, it should be noted that effectively all of this contained radioactivity, except for about 30 percent of the noble gases and about 3 percent of the iodines, 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 clad fuel were to be breached, there is still no ready mechanism for dispersing any substantial fraction of the total contained radioactivity.

(2) <u>Environmental effects</u> - Prior to shipment, the fuel will be allowed to decay a minimum of about 3 to 4 months with the result that essentially all noble gases with the exception of krypton-85 will be virtually gone and the iodine-131 will have decayed to very low levels. Further, the decay heat which has been generated by the fuel during reactor irradiation will have decreased. Of the iodine isotopes, only iodine-131 is present in significant amounts. Fission products other than noble gases and iodine are strongly held within the uranium dioxide fuel pellets. Hence, only noble gases and iodine would escape through a penetration in fuel clad to the shipping cask cavity. Fuel rods known to have ruptured cladding prior to shipment will be sealed in a container for ruptured fuel rods.

(a) <u>Normal shipment</u> - The principal normal environmental factor from spent fuel shipments would be the direct radiation dose as they move from the reactor to the reprocessing plant. The population exposure resulting from normal shipments of radioactive materials has been evaluated on the basis that there would be about 32,500 people living in an area between 100 feet and 1/2 mile on both sides of the transport route along the estimated 325-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. Figure A-1 of Appendix A shows the location of the shipping container relative to people living adjacent to the transport route that was used to calculate the radiation exposures. The calculation does not include reductions of exposures due to shielding from structures, topographic features, or other radiation-attenuating materials.

For the estimated 13 shipments per year, each moving at only 20 mi/h, the maximum exposure received by any individual along the route would be about 0.0038 mrem per year. The average exposure for these 13 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 32,500 people living within 1/2 mile on either side of the transport route between Watts Bar and the fuel reprocessing plant at Barnwell, South Carolina, these people would receive an annual dose of about 0.007 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 13 shipments during the year is estimated to be about 0.13 man-rem.

Since the exposure to the 32,500 people who reside along the route and to a person who might come within 6 feet of the railcar for a short period is only 0.0001 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 Watts Bar 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. Figure A-3 of Appendix A 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 and 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 the front row of a crowd would be exposed to these low radiation levels.

Calculations for a probable shipping container indicate 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 fission gases 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 dose would be about 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 therefore would be less severe.

The contaminated coolant is basically low specific activity material. In the event the coolant were drained from the container in an accident, the emergency plans restricting access to the localized area of the accident and preventing a radiation hazard to the public and the environment would be initiated.

The principal environmental risk resulting from an accident would be the potential whole-body radiation exposure due to the release of noble gases and from direct radiation and potential thyroid dose due to the release of iodine. 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 can be classified as concentrates from the waste evaporators, spent demineralizer resins, miscellaneous dry solid wastes, irradiated or contaminated equipment components, and tritiated water.

The radwaste packaging facility at Watts Bar is equipped to use standard DOT17H[3] drums. The waste evaporator bottoms and spent demineralizer resins will be solidified by a cement-vermiculite process 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 about 60 to 120 days' decay, the only significant radioactive isotopes present are long-lived corrosion products such as cobalt-60.

Based on the estimated quantities and activities, there will be about 15 shipments of the waste evaporator concentrates and 10 shipments of the spent demineralizer resins each year in approved containers. Waste evaporator concentrates are drummed and placed in an approved all-steel container for shipment to an AEC-licensed disposal areas. The resins may be shipped in specially constructed lead-steel containers similar to the LL-60-150 cask to be used for shipping the higher activity radioactive material from the Browns Ferry Nuclear Plant. Special high strength trailers will be used to transport the LL-60-150 cask and the all-steel container to offsite burial grounds. The casks will be decontaminated if necessary at the disposal area and returned to the plant.

Appropriately packaged compressible wastes will probably be shipped to the disposal area on flatbed trucks. Packages exceeding the regulatory limits permitted will be placed inside containers which will provide shielding. There will be approximately five to ten shipments per year from the plant.

Radioactive equipment components will have a low volume and no shipments are expected during the first years of operation. They will be stored in the spent fuel pit until a sufficient amount is accumulated 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 may have to be disposed of annually which would require use of about 13 tank trucks with each containing about 35 Ci of tritium.

(a) Shipping routes - It is assumed that radwaste shipments from Watts Bar would be by truck about 300 miles to the closest AEC-approved disposal area at Morehead, Kentucky. The nearest major population centers encountered along the route are:

City	1970 Population	Density Persons/mile^2
1. Watts Bar site--by way of U.S. 27 and I-40 to	---	---
2. Knoxville, TN--by way of I-75 to	174,587	2,267
3. Lexington, KY--by way of I-64 to	108,137	4,702
4. Morehead, KY	7,191	4,494

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

Type Waste	Annual Amount	Expected Activity @ Shipment
1. Waste evaporator concentrates	1,050 ft^3	0.5 Ci/ft^3
2. Spent demineralizer resins	350 ft^3	<20 Ci/ft^3*
3. Miscellaneous dry solids	350 ft^3	<<0.5 Ci/ft^3
4. Radioactive equipment components	**	--
5. Tritiated water	50,000 gal***	2.5 μCi/cc

*Shipment in appropriate container with a dose rate 10 mrem/h at 6 feet.
**Low volume, no shipments during first 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 that packaged evaporator concentrates and spent resin radioactive wastes are shipped by truck at the regulatory radiation level limit of 10 mrem/h at 6 feet from the nearest surface. It is also assumed that the exposure

rate to transportation personnel is not greater than the regulatory radiation level limit of 2 mrem/h in occupied positions of vehicles.[4]

(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 container), 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 container 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 waste evaporator concentrates and spent demineralizer resins would be about 0.125 man-rem.

Figure A-1 of Appendix A 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 A-2 of the same appendix. On the basis that there would be a total of about 30,000 people living along the assumed 300-mile transport route between Watts Bar and the waste burial facility at Morehead, Kentucky, these 30,000 people would receive an annual dose of about 0.012 man-rem per year. A summary of these effects is given in Table 2.1-2.

The 5 to 10 shipments annually 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 exposure to the 30,000 people who reside along the route, to each truck driver per shipment, and to a person who might come within 6 feet of the container for a short period is 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 Watts Bar to the disposal facilities.

(b) Accident occurrences - Based on the national truck accident statistics for 1969 and considering the number of waste shipments, a transportation accident may be expected to occur about once every 10 years. It is highly unlikely, however, that a shipment of solid radioactive waste would be involved in a severe accident during the 40-year 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 radioactive material for the Watts Bar plant, truck accidents may be expected to occur about once every 5 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 40-year 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 B or Type A packages as appropriate.[5] 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 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 260 mrem, which is less than the annual dose limit to an individual in the general public as specified in 10 CFR Part 20. This dose decreases rapidly with distance, as shown in figure A-5, and at 600 feet is 10 mrem. If a uniform average population density is assumed, the population dose within 50 miles is less than 0.050 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, the transportation emergency plans 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.[6] 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.[7] 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) materials 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, 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.[8]

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 packaging standards are for accident conditions. The large quantity 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 heating of 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:

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

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

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

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

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

(2) Package design - The following discussion is directed toward relating the new fuel, spent fuel, and radwaste container design to AEC and DOT regulations for both normal and accident conditions. These conditions against which a package designer must evaluate any radioactive material packaging are intended to assure that the package has the requisite integrity to meet all conditions which may be encountered during the course of transportation.

(a) New fuel container description and licensing - Westinghouse is the new fuel fabricator for the initial core fuel assemblies. An AEC special nuclear material license[9] authorizes Westinghouse to deliver special nuclear material to a carrier for transport in the RCC and RCC-1 container packages. Authorization to transport new fuel assemblies has also been obtained by Westinghouse from the Department of Transportation under Special Permit No. 5450.

The new fuel assemblies are enclosed in polyethylene wrappers and placed in a metal container which supports the fuel assembly along its entire length during the course of transportation. This metal container also provides necessary impact protection to meet the drop test requirements of the AEC regulations.[10] The metal container is gasketed and bolted shut and includes provisions for pressurization and for humidity control. The characteristics of the fuel shipping containers (Model Nos. RCC and RCC-1) are given below.

- All metal outer shell (14-gage steel) in form of a reinforced cylinder divided into two parts parallel to its long axis
- Steel beam forms "strong back" to support fuel assemblies
- Capacity - two PWR assemblies
- Weights

  Empty -- 3,000 lb

  Loaded - 6,150 lb
- Type B packaging requirements met (Department of Transportation (DOT) regulations - 49 CFR Section 173.398)
- Package design meets requirements for Fissile Class II and III shipments

(b) Spent fuel container description and licensing - There are several features which are typical of all spent fuel shipping casks which serve to prevent release of radioactive material. These include such things as heavy stainless steel shells on the inside and outside separated by dense shielding material, such as lead or depleted uranium.

The normal shipping conditions require that the package be able to withstand conditions ranging from -40°F to 130°F and to withstand the normal vibrations, shocks, and wetting that would be incident to normal transport. In addition, the packages are required to withstand specified accident conditions with the release of no radioactivity other than slightly contaminated coolant and no more than 1,000 curies of radioactive noble gases. The accident conditions for which the package must be designed include, in sequence, a 30-foot free fall onto a completely unyielding surface, followed by a 40-inch drop onto a 6-inch diameter pin, followed by 30 minutes in a 1,475°F fire, followed by 8 hours' immersion under 3 feet of water. Appendix B[11] of this document relates these 10 CFR Part 71 accident conditions to similar conditions for the container which might be experienced as a result of a transportation accident.

It should be noted that there is a wide margin of safety in container designs.[12] For example, the IF-300 spent fuel shipping cask which will be used at Browns Ferry and may be used at Watts Bar is designed to absorb the total effects of the impact of a 30-foot free fall onto an essentially unyielding surface with deformation of the outer fins only. Because the outer shell has considerable strength 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, 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 in Appendix B, the specified accident conditions are representative of conditions at least as severe as those which would be experienced by containers in transport. Further, since the specified accident conditions are required to be applied to the containers in sequence, the severity of these conditions 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 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	N/A
3 feet from surface of container	N/A	1,000 mrem/h
6 feet from external surface of vehicle	10 mrem/h	N/A
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	N/A
Alpha	220 dpm/100 cm^2	N/A

These levels represent limits which have been established by the regulations and are not to be exceeded. In most cases the containers should exhibit radiation levels and releases somewhat less than those permitted by the regulations. This is because the fuels and materials which will be handled are not expected to be at the maximum activity levels for which the containers have been designed.

TVA has not selected a contractor for the equipment and services related to spent fuel shipments. Therefore, 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 the spent fuel cask become a condition 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 higher level radioactive wastes from the Watts Bar Nuclear Plant has not been determined at this time. However, for purposes of evaluating the envionmental 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 level wastes from Browns Ferry. The LL-60-150 container uses 4 inches of lead sandwiched between an inner shell of 1/4-inch steel and an outer shell of 1-inch steel. It can be used for shipping the higher level encapsulated spent demineralized resins in 30-gallon drums from Watts Bar since the maximum allowable curie content of the 30-gallon drum containing cement and spent resin is 240 curies of Class III radionuclides (32 rem/h at one meter from the unshielded drum). Shielding this container with an approximate amount of lead as for the LL-60-150 container reduces the dose rate at the surface of the shield to about 2.5 mrem/h which is only 1/4 the permitted dose rate at the time of shipment.

The LL-60-150 cask for the higher level solid waste 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.[13] 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 by 49 CFR Section 173.393(j)(3). A shielding analysis was also performed 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°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 in 3 feet of water for more than 24 hours will not cause any detrimental effect since the cask is established in the analysis to be leaktight following the preceding accident conditions.

For the lower level waste (0.5 Ci/ft^3), an all-steel cask holding about 183 ft^3 has also been designed and will be constructed by ATCOR, Inc., for use at Browns Ferry and may be used at Watts Bar.

The low activity compressible waste will be packaged for shipment in appropriate containers. Radioactive equipment components will be shipped by contract with a specialist in the field 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 conditions of transport as well as accident occurrences which might be encountered.

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

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 requirements of applicable regulatory bodies for movement offsite.

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

e. 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) Normal conditions of transport - TVA now has nine nuclear units under construction or planned for operation between 1972 and 1979. Because of these commitments to the use of nuclear power for substantial portions of its generating capacity and the resultant necessity to ship radioactive materials associated with the operation of these and future nuclear plants, an interdisciplinary task force has been established to evaluate the environmental implications, available technology, economics, and other factors related to the consequent shipment of radioactive material to and from these plants.

The task force is investigating the various transportation modes, prevention of accidents, environmental risks and effects and is developing criteria for establishing TVA's policies and procedures relative to the applicable regulations. The findings and recommendations of the task force will be used in formulating the detailed plans for shipment of all radioactive material to and from all of TVA's nuclear plants now under construction or planned for the future.

(d) 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 emergency 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 for containing the contaminated material and preventing a radiation hazard to the public and the environment will be initiated.

Emergency procedures regarding transportation of radioactive material are described in TVA's nuclear plant procedure manual[14] and the TVA Radiological Emergency Plan.[15] Elements of the emergency 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 a 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 on way 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 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. Escorts will be provided where required by regulations and, in addition, where TVA considers them necessary.

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, of spent fuel elements to the fuel reprocessing plant, and of low-level waste to offsite disposal grounds.

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)	13	10	∼ 0.1	0.0017	0.0006	0.006
Waste							
Low Level	Truck	25[a]	10	∼ 0.1	0.003	0.001	0.012
						Total	0.018[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)	13	1,000	9	2	86	0.07	5
Waste								
Low Level	Truck	25[a]	500					

a. Design conditions.
b. This population group receives about 4200 man-rem/yr exposure from natural background radiation (140 mrem/yr).

Table 2.1-3

NOTIFICATION REQUIREMENTS OF STATES

FOR SHIPMENT OF RADIOACTIVE MATERIAL

Alabama

Requirements:

Telephone or telegraph
Route, mode of transportation, time of arrival in state

Notify:

Director
Division of Radiological Health
Room 311, State Office Building
Montgomery, AL 36104
Telephone: 205-269-7634

Georgia

Requirements:

Letter, telephone or telegraph
Approximate route and mode of transportation

Notify:

Chief
Radioactive Materials Control Section
Division of Radiological Health
535 Milam Avenue, SW
Atlanta, GA 30314
Telephone: 404-762-6111

Illinois

Requirements:

Letter, telephone or telegraph
Route, estimated arrival time in state

Notify:

Director
Department of Public Health
535 West Jefferson
Springfield, IL 62706
Telephone: 217-525-6550

Indiana

Requirements:

No notification required

Notify:

Director
Division of Radiological Health
1330 West Michigan
Indianapolis, IN 46206
Telephone: 317-633-6340

Kentucky

Requirements:

Letter, telephone or telegraph
Route, estimated entry and exit times in state

Additional:

Identify carrier and approximate activity of each shipment

Notify:

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 Watts Bar 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 Watts Bar Nuclear Plant.

STEP I

Line Name	Voltage (kV)	Approximate Length of New Construction (Miles)	Approximate Date Required
Bull Run-Sequoyah, Loop Into Watts Bar Nuclear Plant	500	10.0	December 1976
Watts Bar Hydro-Watts Bar Nuclear No. 1	161	1.0	December 1976
Watts Bar Hydro-Watts Bar Nuclear No. 2	161	1.0	December 1976
STEP II			
Watts Bar-Volunteer	500	80.0	September 1977
Watts Bar-Roane	500	33.0	September 1977
Watts Bar-Sequoyah No. 2	500	40.0	September 1977

Under Step I two 500-kV transmission lines will provide system connections for the Watts Bar Nuclear Plant Unit 1. These 500-kV lines will be provided by opening the existing Bull Run-Sequoyah 500-kV line in the vicinity of Watts Bar and extending the resulting line sections approximately 5 miles to the nuclear plant switchyard. This will establish 500-kV transmission line connections to the Sequoyah Nuclear Plant and to the Bull Run Steam Plant.

Station service power to the nuclear plant will be provided by two 161-kV transmission lines from the Watts Bar Hydro Plant. Only one mile of new construction for each line will be required. The remainder of the line will be two existing 161-kV transmission lines from the Watts Bar Hydro Plant to the Watts Bar Steam Plant. Both lines are entirely on the TVA reservation.

Under Step II three additional 500-kV transmission lines will be required when unit 2 is ready for initial operation--some nine months after unit 1 is in service. One of these will be a second line to the Sequoyah Nuclear Plant. Another will be a line to the proposed Volunteer Substation near Knoxville, Tennessee, and a third line to the proposed Roane Substation at Oak Ridge.

A major part of the Watts Bar-Roane 500-kV Transmission Line will be constructed on right of way of an existing transmission line from the Watts Bar Hydro Plant to the Atomic Energy Commission Substation K-27. This transmission line will be retired.

For the tentatively selected routes approximately 165 miles of new transmission line construction and approximately 3,165 acres of easements for new right of way will be required for the Watts Bar Nuclear Plant connections. Approximately 25 percent of the right of way is in woodland, 25 percent is used for farming and pasture, and the remainder is in uncultivated open land.

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 and other development; and areas of historical, scenic, or archaeological significance. Locations on crests of mountains and ridges are avoided to minimize visual impacts.

Route selection is coordinated with municipal, county, and state planning boards and 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.*

Topographic maps frequently are out of date with respect to 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 relocations are required. This policy is being followed in the selection of routes for the lines from the Watts Bar Nuclear Plant, and no family relocations are anticipated. However, in the event families are relocated, assistance will

---

*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.

be provided in accordance with Public Law 92-646, "Uniform Relocation Assistance and Real Property Acquisition."

To the extent possible TVA avoids routing of 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. In selecting a location for such crossings, conflicts with residential, commercial and industrial developments; game sanctuaries; and scenic and recreational areas are avoided. Designs are developed to utilize the natural growth of trees and other vegetation for screening of structures.

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 it is necessary to cross wild or scenic rivers, TVA works closely with private organizations having an interest in preserving such rivers, as well as with Federal, state, and local agencies having jurisdictional responsibilities.

When a navigable stream or reservoir is crossed, the crossing 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 also be closely coordinated with the Tennessee State Planning Commission, the Tennessee Department of Conservation, the Tennessee State Highway Department, the Tennessee Historical Commission, the Southeast Tennessee Development District and Council of Government, the East Tennessee Development District, the Knoxville-Knox County Metropolitan Planning Commission, the Tellico Area Planning Council, and all appropriate county planning commissions.

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

2. Beneficial uses of transmission line right of way -

(1) Shear clearing of right of way - In the construction of new lines through wooded areas, the right 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 right of way is 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" right of way merge.

Power line right of way has great potential as wildlife habitat because of the "edge effect" which it creates and the high food and cover productivity of early vegetation successional stages. Many power lines are good producers of wildlife without special management because of these two factors.

Mechanical maintenance of some type is generally required about every five years for utility line right of way. 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 produces 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 not inconsistent 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 right of way creates long linear forest openings which are indefinitely 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 selective cutting of vegetation along the right 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, 245T and/or Hychlor and are presently 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 right 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. These operations involve only minor environmental impacts.

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) <u>Multiple use of right of way</u> - As a general rule where transmission line right of way crosses 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 interests 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. Right 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 landowner desires to use the right 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. Investigations have been undertaken to utilize transmission line corridors for "Puckerbrush Forestry." For several years now TVA has been conferring with Dr. Harold E. Young at the University of Maine on the use of "Puckerbrush Forestry." This pilot forestry program in the Northeast is an outgrowth of the Sycamore Silage Study considered at the University of Georgia. At present adequate markets have not been developed to fully utilize the harvest from either of them. TVA will continue its interest in this area, and the landowners will not be discouraged from utilizing the right of way in this manner.

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.

At staging or material assembly points, relatively large quantities of the used packing material which accumulates is transported to approved waste disposal or land fill sites. However, in localized areas, smaller quantities of wood and paper are disposed of by controlled burning. Noncombustible waste and residue from burning is buried onsite at a depth of approximately 3 feet and the disturbed area is graded and seeded to prevent soil erosion.

4. Erosion control practices - Construction of the 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 right 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 to settling ponds where the land is exposed, 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 right of way is 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 and drainage ditches. Terracing and ground cover will be provided in order to prevent soil erosion.

5. <u>Miscellaneous impacts</u> -

(1) <u>Ozone</u> - 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 produced 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 C.

(2) <u>Compatibility with communications equipment</u> - 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 Watts Bar Nuclear Plant.

No inductive coordination problems have been experienced on the Bull Run-Sequoyah-Widows Creek 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 Watts Bar Nuclear Plant to form the Watts Bar-Sequoyah and Watts Bar-Bull Run 500-kV lines. For the selected routes, we do not anticipate any inductive coupling problems for the other proposed transmission lines.

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

(4) <u>Impacts on aviation</u> - When transmission line structures exceed certain heights as prescribed by the Federal Aviation Administration, as is frequently the case with crossings of major rivers, structure heights are coordinated with the FAA to conform to air safety regulations. River crossing structures exceeding heights as specified by the FAA are painted and provided with lights to meet Federal Aviation Standards.

(5) <u>General impacts</u> - During normal operations no adverse environmental impact is associated with either 161- or 500-kV transmission lines. Under some atmospheric conditions a light humming may be noticed directly under 500-kV lines, but this noise is rarely heard off the right 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 right 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 activity.

6. Tentative transmission line route selection - Based on the above considerations, the tentative line routes and alternate routes for connecting the Watts Bar Nuclear Plant were investigated. The routes shown on figure 2.2-2 are feasible at present. Changes within the next 3 years may require that these routes be shifted to avoid new developments.

(1) Watts Bar-Volunteer 500-kV Transmission Line - To supply the growing loads in the Knoxville, Tennessee, area, a new 500-kV transmission line will connect Watts Bar Nuclear Plant with the proposed Volunteer Substation, which will be in the vicinity of Strawberry Plains, Tennessee.

A generally straight routing would, of course, be the shortest and most direct method of connecting the nuclear plant with the Volunteer Substation, as indicated schematically as proposed Route A on figure 2.2-1. This would require the least amount of right of way easement and fewer transmission line structures. However, this would not be feasible as this route traverses the heart of Knoxville and the rapidly developing areas in the vicinity of Loudon and Lenoir City. This routing would also create extensive conflict with other existing developments in the area.

A second alternate route shown schematically as proposed Route B on figure 2.2-1 was developed considerably south of the above route. This route would have left the Watts Bar switchyard and traveled in a generally eastward direction for approximately 5 miles. From this point the route would have turned northeast until it intersected with an existing 161-kV TVA transmission line. For approximately 13 miles the new route would have then paralleled the existing transmission line. From this point the route would have proceeded eastward and crossed the Little Tennessee River approximately 8 miles south of Lenoir City, Tennessee. From this point the projected route stayed well south of Maryville, Tennessee. The line would then proceed in a northeastward direction toward Strawberry Plains, Tennessee. As more detailed information was developed, it became obvious that conflicts with existing development plans were numerous. The Watts Bar switchyard arrangement could not be properly adjusted for the lines to leave in an eastward direction. In addition, large deadend towers would have been required adjacent to the switchyard to terminate the line tension from the river crossing spans over the Tennessee River. Residential developments adjacent to the existing 161-kV transmission line in the proposed parallel section would have necessitated the purchase of several houses. This route would cross the proposed Timberlake development project in an area designated as a water-oriented residential subdivision.

Considering the above factors, it became obvious that another route farther south would be required to minimize the conflicts with present developments.

A third alternate as shown schematically as proposed Route C on figure 2.2-2 provided the most feasible route. This route will leave the substation switchyard generally in a southward direction. This will allow coordination with the switchyard arrangement and provide a perpendicular crossing of the Tennessee River. The route will then proceed to a point in the vicinity of Highway 58, crossing it at approximately 90 degrees in a wooded area. This provides a very satisfactory crossing and is in keeping with the Environmental Criteria for Electric Transmission Systems published by the Department of the Interior. The route will then traverse in an eastward direction north of Niota, Tennessee, placing it approximately midway between the cities of Athens and Sweetwater, Tennessee, thereby avoiding these more populated areas. Proposed Interstate Highway 75 will be constructed in this vicinity. The transmission crossing over the interstate will be closely coordinated with the Tennessee State Highway Department. After crossing U.S. Highway 11 north of Niota, the route will turn northward to avoid Christiansburg and the "Lost Sea" tourist attraction. From this point a location through the proposed Timberland development will be used which will minimize the conflict with this development. The planners for this project concur with this location as it places the line adjacent to an industrial development. After crossing the Little Tennessee River, the route will turn eastward and cross the U.S. Highway 411 at approximately 90 degrees. It will then turn in a northeastward direction and will follow the lower slopes of Black Sulfur Knobs at the foothills of the Chilhowee Mountain. The location will avoid the more populated areas in the vicinity of Springview, Forest Hills, and Blockhouse. The line will cross U.S. Highway 73 and U.S. Highway 441 in areas of marginal development minimizing the environmental impact. The route will then head northwestward to the Volunteer Substation site.

This proposed route will be approximately 80 miles in length with approximately 72.5 miles being built on a 200-foot right of way easement. Five miles at the Watts Bar Nuclear Plant will parallel the Bull Run-Sequoyah 500-kV Transmission Line loop to Watts Bar, and 2.5 miles will parallel the Watts Bar-Sequoyah 500-kV Transmission Line No. 2 (see figure 2.2-2). Approximately 1,800 acres of new right of way easement will be required for proposed Route C as shown on figure 2.2-2. The route traverses primarily rural areas and partially wooded rolling hills.

(2) Watts Bar-Bull Run and Watts Bar-Sequoyah No. 1 500-kV Transmission Lines - The existing Bull Run-Sequoyah 500-kV Transmission Lines, which was constructed in 1967, will be looped into the new switchyard by constructing two single-circuit lines, each approximately 5 miles in length. This will create the Watts Bar-Bull Run 500-kV line and the Watts Bar-Sequoyah 500-kV Transmission

Line No. 1 which is shown schematically as Routes E and F respectively on figure 2.2-2.

In keeping with the switchyard arrangement at Watts Bar Nuclear Plant and also to provide a perpendicular crossing of the Tennessee River, these lines will be constructed parallel to the proposed Watts Bar Nuclear-Volunteer 500-kV Transmission Line on right of way approximately 650 feet wide. This 5-mile section of wide right of way will require approximately 400 acres of easements. The use of common right of way reduces the environmental impact along the route in that 18.75 percent less acreage is required in parallel construction than for four transmission lines on separate rights of way.

(3) <u>Watts Bar-Roane 500-kV Transmission Line</u> - To supply the increased AEC loads in the Oak Ridge, Tennessee, area, a new 500-kV transmission line will connect the Watts Bar Nuclear Plant with the proposed Roane, Tennessee, 500-kV Substation. A site for this substation has tentatively been located approximately 10.5 miles southwest of Oak Ridge, Tennessee.

In 1933 a 220-kV transmission line was constructed from Wheeler Reservoir in north central Alabama to Norris Hydro Plant approximately 20 miles northwest of Knoxville, Tennessee. In 1964 approximately 30 miles of this line was utilized at 161-kV to connect Watts Bar Hydro Plant with the Atomic Energy plant at Oak Ridge. The construction of a 500-kV line, due to its large current-carrying capabilities, will eliminate the need for this lower voltage transmission line connection. Approximately 27 miles of this transmission line easement, which was purchased in 1933, will be utilized for the 500-kV line to Roane 500-kV Substation as shown schematically as proposed Route D on figure 2.2-2. Approximately 6 miles of new 200-foot-wide right of way easement at the Watts Bar Nuclear Plant end of this connection will be required.

The connection to Roane will leave the Watts Bar Steam Plant switchyard generally in a southward direction for approximately two spans and then turn southeastward and cross the Tennessee River. Approximately 0.75 miles east of the river, the route will head generally northward following as much as possible the Watts Bar Reservation boundary until the proposed route intersects with the existing right of way of the 161-kV line which is to be utilized for the 500-kV line.

As much as possible, the new 500-kV towers on the Watts Bar-Roane 500-kV Transmission Line will be installed at the location of the retired towers, thereby reducing the land use impact along the existing right of way. The 500-kV towers will be comparable in height and appearance with the existing towers and will therefore not create any additional visual impact. By utilizing existing right of way for this proposed route, new land easements are reduced from 800 to 145 acres.

(4) <u>Watts Bar-Sequoyah No. 2 500-kV Transmission Line</u> - To provide backup transmission facilities for transmission system stability, a second 500-kV transmission line connection will be required from Watts Bar Nuclear Plant to the Sequoyah Nuclear Plant. A straight line routing would be the shortest, most

direct method of connecting the two nuclear plants. This would require the least amount of right of way easement and fewer transmission line structures. However, this would not be practical, as the route would have crossed the Tennessee River eight times and the Hiwassee River once.

A second alternate route that was given consideration was to construct the second 500-kV line parallel to the proposed Watts Bar-Sequoyah 500-kV Transmission Line No. 1 which is shown as Route F on figure 2.2-2. Field investigations revealed that developments adjacent to the existing right of way in the vicinity of Tennessee State Highway 58 were quite extensive. Several houses would have to be purchased and several families relocated. Also, to reduce the possibility of a natural disaster causing an outage on both ties to Sequoyah, separation of the lines as much as possible is desirable.

Considering the above factors, it became obvious that a search for another alternate route would be desirable. Further field investigation revealed that the location shown schematically as Route G on figure 2.2-2 provided the best routing at the present time. In keeping with the switchyard arrangement at Watts Bar Nuclear Plant and also to provide the desirable perpendicular crossing of the Tennessee River, this route will be parallel to three of the 500-kV lines out of Watts Bar for about 5 miles and will then be parallel to the proposed Watts Bar-Volunteer 500-kV line for an additional 2.5 miles. The developments on the land adjacent to the Tennessee River, the communities of Forest Grove and Fairview, and the Highway 58 area dictated the use of common right of way. The use of right of way easement common with the Volunteer 500-kV line reduces the amount of easement required and also provides greater separation between the two lines to Volunteer. From this point the route will proceed southeastward for about 2 miles, then turn south-southwestward for about 17 miles. This will locate the line route in the low-lying area adjacent to Rogers Creek and to the east of the more developed areas along the Hiwassee River. The route will then proceed westward, avoiding the more developed areas adjacent to Candies Creek and cross Tennessee State Highways 58 and 60. The crossings over Highways 58 and 60 both will be at about 90 degrees and in the low-lying area adjacent to Gunstocker Creek. The route will then turn southwestward and intersect with the existing Watts Bar-Sequoyah 500-kV Transmission Line No. 1. The remaining 2 miles and the crossing over the Tennessee River will be constructed on 350-foot-wide right of way common with Watts Bar-Sequoyah 500-kV Transmission Line No. 1. One hundred and fifty feet of this easement will be new.

Route location G as shown on figure 2.2-2 will be approximately 40 miles long, of which about 30.0 miles will be constructed on easement 200 feet wide. The remaining 10.0 miles will be on right of way common with other lines. Approximately 820 acres of new easement will be required for this line route.

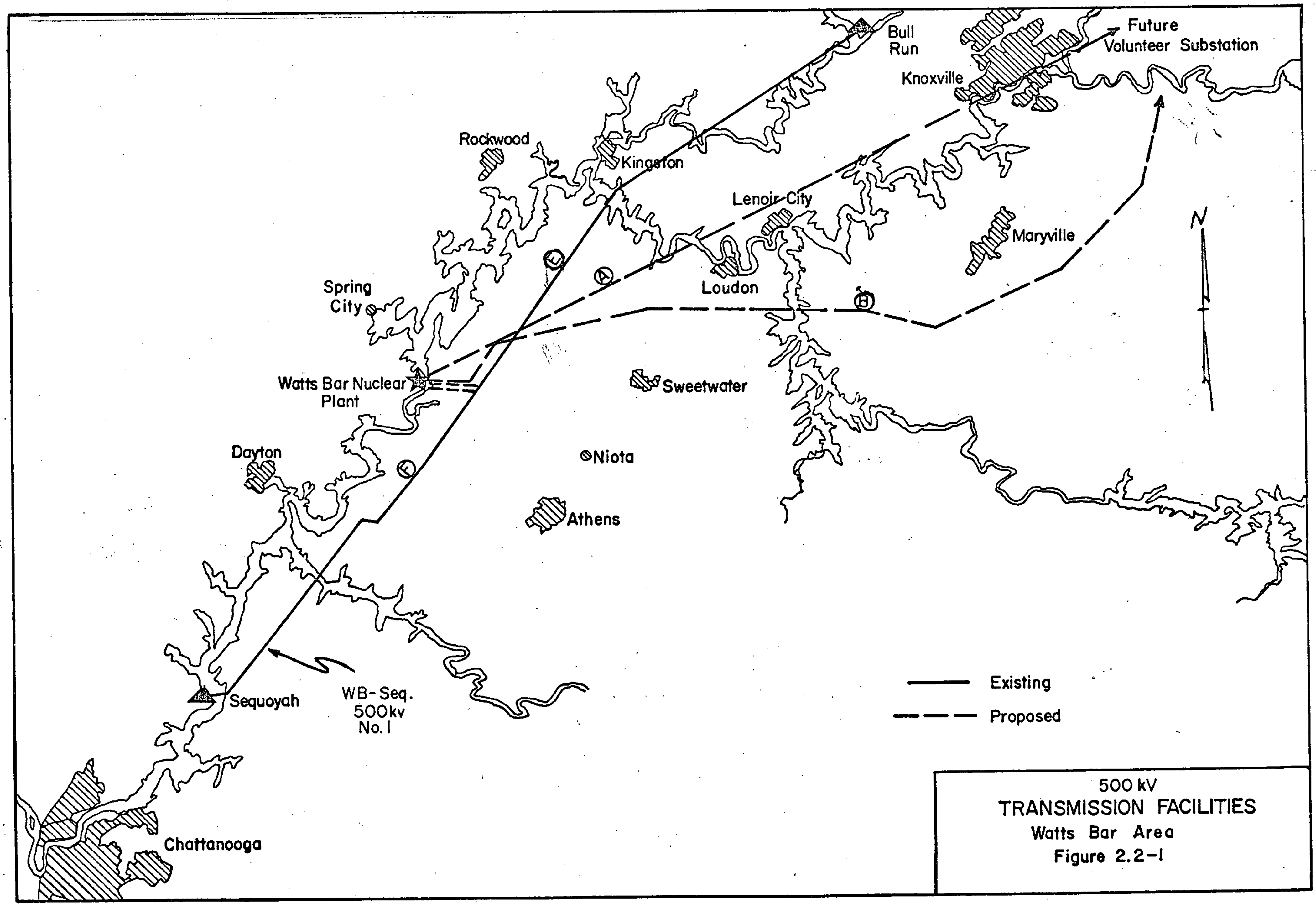
(5) <u>161-kV transmission lines for station service</u> - Station service power for the Watts Bar Nuclear Plant will be supplied from the Watts Bar Hydro Plant over two separate 161-kV transmission lines. These lines will be on separate structures, and the separation of the lines will be sufficient to insure that the

failure of any tower will not endanger the other lines in order to comply with safety criteria set forth by the Atomic Energy Commission. These lines will be created by utilizing the two existing 0.6-mile 161-kV transmission lines from the Watts Bar Hydro Plant to the Watts Bar Steam Plant. From the Watts Bar Steam Plant approximately 1 mile of new construction will connect the two single-circuit 161-kV transmission lines to the Watts Bar Nuclear Plant. Both the existing and new construction for the 161-kV transmission line connections will be entirely on the TVA Watts Bar Reservation.

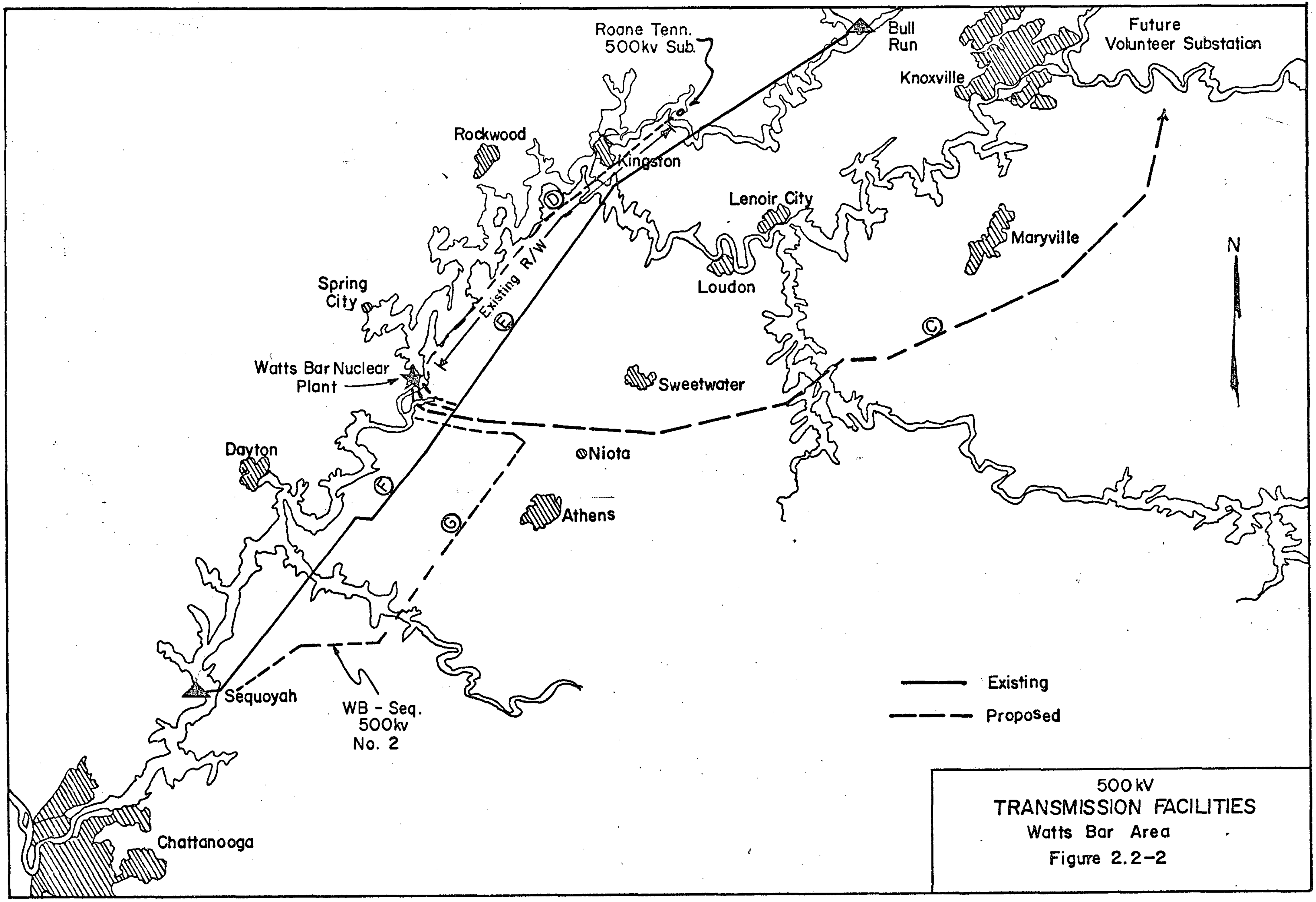
7. Conclusion - No long-term environmental goals appear to be jeopardized by the transmission lines, and no significant adverse cumulative impact on the environment is foreseen. The transmission lines involve the commitment of the resources used in the construction of the facilities and will cause some minor limitations in land use. No significant permanent alterations in topography are involved. The cumulative impact of the project will be to help maintain reliable electric service to consumers receiving TVA power.

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 Watts Bar 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. The replacement of a lower voltage line with a higher voltage line on existing right of way easement also reduced the impact on land use.

No 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.



500 kV
TRANSMISSION FACILITIES
Watts Bar Area
Figure 2.2-1



500 kV
TRANSMISSION FACILITIES
Watts Bar 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 Watts Bar 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 has submitted 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. The analyses presented in this safety analysis report 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 D 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, 4.0, and 5.0 are not expected to occur during 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 D 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), atmospheric dispersion values are those given in AEC Safety Guide No. 4[2], and fuel element fission product inventories are calculated using the model given in TID-14844[3]. Doses to hypothetical individuals at the minimum exclusion distance (1,200 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 D. 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 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials within the yearly dose limits of 10 CFR Part 20. Table 2.3-2 also shows that the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 145,000 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.

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	0.016	9.6
3.2	Release of waste gas storage tank contents	0.064	38
3.3	Release of liquid waste storage tank contents	0.013	0.900
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	0.005	0.43
5.3	Steam generator tube rupture	0.26	17
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.008	0.52
6.2	Heavy object drop onto fuel in core	0.17	11

*Evaluated as routine release in section 2.4.

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)
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	0.008	0.52
7.2	Heavy object drop onto fuel rack	0.0089	0.62
7.3	Fuel cask drop	0.0027	0.18
8.0	Accident initiation events considered in design basis evaluation in safety analyis report		
8.1	Small loss-of-coolant	0.00053	0.086
8.1	Large loss-of-coolant	0.48	89.0
8.1a	Instrument line break	NA	NA
8.2(a)	Rod ejection accident	0.052	9.0
8.3(a)	Small MSLR	0.003	0.053
8.3(a)	Large MSLR	0.003	0.53

2.4 Radioactive Discharges - It is TVA's policy 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.

To implement this policy, treatment of radioactive wastes provided by the original Watts Bar plant design has been augmented to provide additional margins against environmental impacts resulting from releases of radioactive materials. All equipment installed by TVA to reduce radioactive effluents to the minimum practicable level will be maintained in good operating order and will be operated to the maximum extent practicable. Basically, the design modifications were made to increase the holdup time of gaseous wastes, reduce releases of iodine in condenser offgas, and reduce releases of radioactive products in water. The latter is achieved by using Ag-In-Cd control rod absorber instead of B_4C to reduce tritium generation, by recycling tritiated liquid, and by treating steam generator blowdown during periods of steam generator leaks. The waste treatment facilities can be modified or supplemented if a higher degree of treatment should be required in the future.

The original design provided 45-day holdup of radioactive gases to reduce their activity and provided for tritiated water to be released to the environment under controlled conditions to avoid significant buildup of tritium in the primary coolant. Studies to further reduce these discharges resulted in adoption of the present design which provides 60-day holdup of gases, significantly reduces releases of tritium by recycling and reduces the amount of iodine in the condenser offgas by processing the gaseous effluents through high efficiency particulate (HEPA) and charcoal filters during periods of significant primary-to-secondary leakage.

Recycling minimizes the release of tritium and other radioactive material that would have been released with the original system. The following table compares expected radwaste system releases during normal operation of the original design and of the design adopted, based on an annual average operation at 100 percent of full power and 0.25 percent failed fuel.*

Radioactive Releases, Ci/yr

	Gases	Liquids
Original Design (45-day holdup no tritium recycle, B_4C control rods)	3,400	1,590 tritium 4.5 other
Present Design (60-day holdup tritium recycle, Ag-In-Cd control rods)	2,900	140 tritium[a,b] 0.46 other

a. Tritium vapor releases are about 380 ci/yr.
b. Does not include releases (0.46 Ci) due to primary-to-secondary leakage.

1. Basis for evaluation of radioactive discharges - The principal routes of release or removal of radioactivity from the Watts Bar Nuclear Plant are:

1. liquid discharges
2. gaseous discharges
3. solid radwaste disposal

*0.25 percent failed fuel is defined as defects in fuel pins which produce 0.25 percent of the core power.

TVA has investigated the predicted level of failed fuel for the Watts Bar plant and has concluded (based on operating experience and predictions of fuel failure rates) that the assumption that the presence of clad defects in fuel pins which produce 0.25 percent of the core power is a reasonable and obtainable level of fuel performance over the life of the plant. Good fuel performance is ensured by proper fuel design, good fabrication techniques, and a comprehensive quality assurance program.

The fuel pins are zircaloy tube containing UO_2 pellets. 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 Watts Bar fuel will be similar to that in plants presently 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. The evaluation of radioactive releases is based on 0.25 percent failed fuel in both units. Conservative assumptions are made regarding power level, load changes, and shutdown releases.

Reactor coolant is continuously purified of fission and corrosion products in a sidestream system (Chemical and Volume Control System) which includes demineralizers and filters. Normally, this stream is returned to the reactor coolant system. From time to time, however, this stream is diverted to a holdup tank in the Boron Recovery System. This is done in connection with chemical shim control adjustment, load changing, and degassing of the coolant at shutdown. A portion of the dissolved gas in the coolant, which includes hydrogen plus krypton and xenon, is released in the holdup tank and is transferred to the gas decay tanks. The liquid is passed through demineralizers for additional purification, and is fed to a boric acid evaporator. In the gas stripper portion of the evaporator, the remaining dissolved gas is removed from the coolant and is transferred to the gas decay tanks. The liquid, a boric acid solution, is concentrated to about 12 percent boric acid. The concentrate is transferred to the boric acid tanks for reuse in the reactor coolant system. The distillate is transferred to the primary makeup water tanks for reuse. No liquid release occurs as a result of this processing.

Most leakage from radioactive systems is collected in closed drains and recycled thereby resulting in essentially no liquid releases. However, a small amount of leakage from some valves and seals is not recoverable and must eventually be processed by the radioactive waste disposal system for release to the environment. Estimated releases from the Watts Bar plant are based in part on the liquid radwaste produced by a nonrecyclable leakage of 20 gallons of primary coolant per day per unit, excluding primary-to-secondary leakage. An extended treatment system has been included in the plant design to process the steam generator blowdown in the event of significant primary-to-secondary leakage. The condenser offgas system is equipped with HEPA and charcoal filters to limit iodine and particulate releases. Releases from this system are estimated assuming a continuous 20-gallon per day primary-to-secondary leak in each unit. The releases of radioactivity due to leakage of liquid from the secondary system are estimated based on an assumed leak rate of 20 gallons per day per unit and a carryover of 0.1 percent in the steam generator. The resulting release due to secondary system leakage is only 0.05 Ci and is not considered further. Parameters used in estimating releases of radionuclides in gaseous and liquid effluents are based on operating experience and experimental data, where available, and effort is made to select realistic parameters.

Dilution of liquid releases to the reservoir is based on an average cooling tower blowdown flow of 28,000 gallons per minute.

(1) Liquid discharges -

(a) Liquid treatment systems - Radioactive liquid wastes will be evaporated as required and the residues packaged for offsite disposal. Processed water whose tritium concentration is 10 percent or more of the primary coolant tritium concentration will be returned for reuse as reactor makeup. Miscellaneous low-level liquid wastes containing less tritium are collected, analyzed, filtered, and discharged.

Small quantities of radioactive wastes will be released to the discharge pipe for dilution with the plant water discharges. Table 2.4-1 summarizes the estimated annual quantities of liquid discharges from the various sources within the plant. Estimated releases of radionuclides in liquid effluents are shown in Table E-1 of Appendix E. Radioactive liquid waste in passing from the tanks to the discharge pipe goes through a valve which is locked closed when not in service, a valve controlled by a radiation monitor, and a valve that is interlocked with a flowmeter so that it cannot be opened unless a dilution flow of at least 28,000 gal/min exists. These controls assure that the liquid waste will be diluted and that concentration limits will not be exceeded.

The treatment of radioactive detergent or laundry waste in the sewage treatment facility has been considered and rejected. The quantity of radionuclides expected to be released from these sources is small. Contamination of the sewage treatment facility would be small but is not considered warranted.

Since the Watts Bar Nuclear Plant is located immediately downstream from the Watts Bar Hydro Plant and Dam, when the hydro units are not operating there may be insufficient water available to provide proper dilution of the cooling tower blowdown from the nuclear plant. Steam generator blowdown is not released during the time the hydro plant is not in operation. Instead it is collected in a 150,000-gallon storage tank until hydro plant operation is resumed. All radioactive liquid effluents from the nuclear plant are interlocked so that discharges to the river cannot occur while the hydro plant is not operating. Design of the routing of radioactive liquid waste discharges has been changed so that they do not empty into the holding pond. The liquid radioactive wastes will be diluted with the cooling tower blowdown and released to the river through a diffuser in order to provide rapid dilution with the riverflow.

Watts Bar Nuclear Plant facilities are believed to be fully adequate to process radioactive liquid waste to a level which can be considered as low as practicable. The bases for tank sizes for storing reactor coolant and liquid radwaste are:

Chemical Volume Control System holdup tank (224,000-gallon capacity) - The size of these tanks is based on a cold shutdown and startup of both units simultaneously, with one unit at 80 percent of core life and the other at 70 percent of core life. It is assumed that both 30 gal/min evaporators are in service at 75 percent capacity while the tanks are being filled. No other operational condition is likely to impose a greater load on the tanks. The reason the Watts Bar holdup tank capacity is smaller than that of some earlier plants is that credit had not been taken for the evaporators being in operation at those plants.

Monitor tanks (18,000-gallon capacity) - Tests of the prototype Westinghouse boric acid evaporator showed that boric acid carryover in the distillate was very low (<10 ppm boron). For this reason it was decided that the distillate could be sent directly to the primary makeup water storage tank rather than sending it to a monitor tank first. The single monitor tank can be used for distillate from the boric acid evaporators and/or the waste evaporators.

Laundry and hot shower tank (1,200-gallon capacity) - The two 600-gallon tanks are sized to receive the expected maximum daily input of laundry and hot shower drains. Larger tanks would permit less frequent discharges, but would not appreciably decrease the amount of radioactivity released.

Waste condensate tanks (5,000-gallon capacity) - Two 1,500-gallon tanks were provided initially. A third 2,000-gallon tank has been added. Waste condensate can also be routed to the 15,000-gallon cask decontamination tank. This should be sufficient to handle the waste condensate liquid effluent.

Primary makeup water storage tanks (374,000-gallon capacity) - Watts Bar will have two 187,000-gallon tanks. This will be adequate to handle the storage of the primary makeup water.

(b) Tritium recycle - The only feasible alternative to the recycle of tritiated water is to permit its controlled release to unrestricted areas. Tritium recycle was selected because it is consistent with TVA's policy regarding radioactive discharges, and it has been determined that retention of tritiated water at an AEC-approved disposal area is feasible. This permits a minimal liquid radioactive release. Figures 2.4-1 and 2.4-2 show the original liquid radwaste system and the system as modified, respectively.

To minimize discharge of tritium, tritiated water from expected sources will be recycled by segregating drains which contain tritium from those which do not. Any liquid which shows a tritium concentration which is higher than 10 percent of the concentration of the primary coolant will be recycled and not released. This effectively recycles more than 90 percent of the tritium collected as liquid. Plant operating procedures will be implemented to assure that during all periods tritium levels in the condenser vacuum pump effluent, steam generator blowdown distillate, and any other effluents are within acceptable limits.

The intended method for avoiding tritium release is to recycle tritiated water back into the primary system until the primary coolant tritium concentration reaches a maximum desirable level from an operating personnel dose standpoint. 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 μCi/ml for analysis purposes, and based on the assumptions used for estimating routine releases, this level would be reached about

8 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 6, the tritium concentration in the refueling volume (not including the spent fuel pool) is 0.9 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 1.9 μCi/ml and increases to 2.4 μCi/ml during the subsequent fuel cycle.

At any time except during refueling, the volume of water in the primary system is approximately 280,000 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 350,000 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 9,100 Ci (both units). Note that without tritium recycle (maximum tritium concentration of 2.42 μCi/ml) the total would be 9,000 Ci.

Tritiated water bled from the primary system will be shipped offsite as necessary as low specific activity liquid waste for retention at an AEC-approved disposal site. A connection has been provided in the rail car 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. A major source of this type of tritiated discharge will be steam generator blowdown during periods of primary-to-secondary leakage in the steam generator. Other 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.

Secondary system blowdown, even though it contains tritium due to a leak, must be discharged.

It is not practical to recycle the water for primary system makeup because a prohibitive amount of storage capacity would be needed. Recycling the processed blowdown liquid as secondary system makeup is of no benefit since the tritium would be discharged when normal blowdown was resumed.

The amount of tritium discharged will vary depending on the concentration of tritium in the primary coolant, the primary-to-secondary leakage rate, the steam generator blowdown 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 would be about 140 curies.

(c) <u>Extended treatment of steam-generator leaks</u> - Radioactive discharges which would occur as a result of release of steam generator blowdown during periods of steam generator primary-to-secondary leaks are held to the lowest practicable level by modification of the original plant design to allow processing of blowdown when it contains radioactive products.

An auxiliary blowdown system is provided for the four steam generators of a unit when one or more of the steam generators has a primary-to-secondary leak. Blowdown is diverted from the normal blowdown and passed through a heat exchanger where the temperature is reduced to about 150°F, thus eliminating vapor effluent. The liquid is then sent to the floor drain collector tank in the waste disposal system. From the tank, the liquid is processed through the auxiliary evaporator. Condensate is collected, analyzed, treated as necessary, and released to the plant discharge pipe.

When the blowdown liquid monitor senses an activity of 6×10^{-6} µCi/ml, an alarm will occur and blowdown valves will be closed automatically. At this level, with a 100 gal/min blowdown rate, the radioactivity level in the plant discharge flow (28,000 gal/min) would be 2×10^{-8} µCi/ml. The condenser offgas monitor will be set to alarm at 6×10^{-5} µCi/ml.

The monitoring system will be backed up by periodic laboratory analysis of blowdown liquid. Laboratory analysis will permit detection of leaks too small to be detected by the monitors and will also show the presence of tritium which the monitors will not detect. In any case, if a large leak is detected, unit shutdown will be initiated. In most cases, however, unit operation will be continued while the situation is being evaluated. If the leak is small enough that radioactivity releases are below the limits in the proposed Appendix I to 10 CFR Part 50, operation will continue with the normal blowdown system or with the radwaste system not including the auxiliary waste evaporator. If Appendix I limits for liquid discharges would be exceeded, the auxiliary system including the auxiliary waste evaporator will be used to process blowdown. The length of time that operation in this mode is continued will depend on a variety of factors, including the offsite doses due to releases of radioactivity in the condenser offgas and processed blowdown liquid, the degree of contamination of the secondary system, and the ability of the blowdown processing system to handle the blowdown flow.

During a primary-to-secondary leak, the secondary system becomes contaminated with radioactive material and chemicals from the primary system. This continues until the unit is shut down and the leak is repaired. After repairs have been made, blowdown processing will be continued until the radioactivity content is low enough that no releases resulting in significant doses will occur.

If, for example, a 1 gal/min leak of primary fluid containing 2.5 μCi/ml of tritium were to continue for 10 days, a total of 137 Ci would be transferred to the secondary system. Assuming a 12-gal/min blowdown rate during the 10-day leak period, 37 Ci would be processed through the blowdown treatment system and be released to the reservoir as liquid waste. At the end of the 10-day leak period, the secondary coolant system would still contain radioactive materials in addition to tritium. Therefore, the normal practice would be to continue processing the blowdown liquid through the radwaste system for some time after the leak has been repaired.

The auxiliary evaporator provided will handle a continuous contaminated blowdown flow rate of 12 gal/min with margin for downtime for minor repairs. The floor drain collector tank can accumulate blowdown while the evaporator is shut down. If the processing system is unable to keep up with the blowdown flow, the unit will be shut down. The process for treating steam generator blowdown liquid is the same whether a primary-to-secondary leak exists in one or both units. In either event, the total blowdown flow rate for treatment is limited to about 12 gal/min.

In normal operation, the blowdown rate is set to maintain a maximum dissolved solids content of 125 ppm in the secondary side of the steam generator. The rate is determined primarily by the amount of condenser cooling water inleakage. In the event of a primary-to-secondary leak, the dissolved solids concentration would be allowed to increase to 600 ppm. The required blowdown rate under these conditions would depend primarily on the amount of boric acid leaking into the secondary system. Sodium phosphate must be added to neutralize the boric acid. With a limit of 600 ppm total dissolved solids, there is room for about 50 ppm of boron. A 12-gal/min blowdown rate would accommodate a leak rate of 0.6 gal/min with 1,000 ppm boron in the primary coolant, 1.2 gal/min at 500 ppm, and 6 gal/min at 100 ppm. Any combination of condenser inleakage with primary-to-secondary steam generator leakage which necessitated a blowdown rate above the capacity of the auxiliary evaporator would require shutdown of the unit.

(d) Conclusion - It is concluded that the decisions to recycle tritium and to provide for extended treatment of steam generator blowdown have resulted in a design which will hold releases of radioactive liquids to the lowest level practicable.

(2) Gaseous discharges -

(a) Gaseous treatment systems - The gaseous radwaste system collects and processes gaseous radioactive wastes originating from degassing of reactor coolant, displacement of cover gases as liquids accumulate in various tanks, miscellaneous equipment vents and relief valves, and sampling operations and automatic gas analysis for hydrogen and oxygen in cover gas. These waste gases are collected, compressed and dehumidified, and stored in gas decay tanks for at least 60 days to allow for radioactive decay (figure 2.4-4). Compressed gas is recycled as a cover gas for the various tanks to minimize the volume of gaseous wastes released and to maximize the time for radioactive decay. After decay, the only significant radioisotopes released to the environment are Kr-85, Xe-133, and Xe-131m. The estimated annual releases of these isotopes are shown in Table F-1 of Appendix F. Each gaseous decay tank has provisions for sampling the tank contents before beginning a release. During normal operations, gases are discharged intermittently at a controlled rate from these tanks through one of the two monitored shield building vent pipes which discharge near the top of each reactor building. The gas from the decay tank is passed through a HEPA filter and two charcoal iodine filters. The shield building vent gas monitor sample is continuously collected during venting through an isokinetic probe in the vent pipe. The sample is monitored by three separate systems which continuously measure and record gaseous, particulate, and radioiodine discharges. An annunciator and alarm system are provided in the control room which actuate during high activity levels in the vent pipe. A trip valve in the discharge line is closed automatically by a high activity level indication in the plant vent.

Waste gases are released from the gaseous decay tanks through either of two monitored shield building vent pipes. One release point is through and near the base of the unit 1 shield building dome and the other is through and near the base of the unit 2 shield building dome. The dome release points are considerably higher than the other plant building roofs. The shield buildings are located on an east-west axis. The other plant buildings lie between the shield buildings and to the south of the shielding building axis. The vents are located in the northwest and northeast sectors, respectively, of the unit 1 and unit 2 shield building domes. Waste gas from the gas decay tanks can be discharged through either of the two vents. Thus, regardless of wind direction, it will usually be possible to select one of the two release points such that waste gas flow is not toward the other plant buildings. Even in the event gases are being released from one of the two vents under atmospheric conditions when air flow is from the north, the released gases must pass around or over the shield building dome. If these radioactive gases should enter plant buildings, they would be detected by inplant radiation monitors, and the release could be terminated if necessary.

The auxiliary building ventilation systems provide ventilation for all areas of the auxiliary building including the refueling area, the waste packaging area, and the cask loading area. Radioactive liquid wastes that originate in the reactor coolant system contain dissolved radioactive gases. If such liquids should be exposed to the building atmosphere, as in a spill, dissolved gas is released and is picked up in the building ventilation exhaust system. Most of the liquid wastes, however, remain confined in closed-piping systems and equipment. Sumps, tanks, and evaporators in the liquid waste system have vent connections that lead directly to the auxiliary building ventilation exhaust ducts. The ventilation systems normally discharge air through the auxiliary building vent which is filtered with HEPA filters. The auxiliary building exhaust vent is fitted with a monitor identical to those installed in the shield building vent pipes so that gaseous, particulate, and radio-iodine discharges are continuously monitored and recorded. An excessive activity level in this vent is alarmed in the control room. Upon detection of high vent activity, the normal auxiliary building ventilation system is automatically isolated and the auxiliary building gas treatment system placed into operation. This system provides for filtration and charcoal adsorption of the effluent from the auxiliary building. Exhaust air from this ventilation system is discharged through one of the two shield building vent pipes. The releases from the auxiliary building ventilation system are evaluated on the basis of 10 gallons per day released to the auxiliary building from the makeup and purification system. Iodine releases are based on 0.01 percent of the iodine in the leak being released to the environment.

If the secondary coolant system becomes contaminated due to primary-to-secondary leakage, radioactive iodine and noble gases would be released to the atmosphere through the condenser mechanical vacuum pump exhaust. Radiation dose due to these releases will be an important factor in determining how long operation can continue with such leakage. Calculated releases for this situation are based on a continuous primary-to-secondary leakage rate of 20 gallons per day in each unit. To minimize the amount of iodines (and particulates) released via this route, high-efficiency particulate and charcoal filters have been included in the plant design. A continuous sample is drawn from the condenser vacuum pump exhaust and monitored by a scintillation crystal-photomultiplier detector for gaseous activity indicative of a primary-to-secondary system leak. Filters in the condenser offgas lines, which are normally on bypass, will be placed online whenever the installed monitors indicate the presence of radioactivity in the offgas.

If reactor coolant leaks into the containment exist and are not collected in closed systems, then releases of radioactive material result when the containment atmosphere is purged. This release route is evaluated assuming 50 pounds of primary coolant leakage per day and purging of each primary containment twice a year. Prior to purging, the containment cleanup system may be actuated to reduce the particulate and iodine inventory by circulating the containment air through HEPA and charcoal filters. The purge exhaust also passes through charcoal filters, further reducing the iodine concentration. Tritium in containment atmosphere released at each purge is expected to be about 4.3 curies. This assumes that the containment is saturated at 100°F, and that the water vapor contains 2.5 μCi of tritium per gram. Tritium in containment ventilation exhaust air at each refueling is estimated to be about 190 curies. It is assumed that the release period is 13 days.

If there is steam leakage or leakage from the feedwater system concurrently with primary-to-secondary leakage, some iodine would be released to the turbine building atmosphere and would be exhausted to the atmosphere by the turbine building ventilation system. This is not an important route of release of noble gases, since all noble gases released to the secondary system are assumed to be released via the condenser offgas without holdup. Calculated releases for this situation are based on a continuous primary-to-secondary leakage rate of 20 gallons per day in each unit and steam leakage of 835 pounds per day.

The continuous monitoring systems for the building vents have the following sensitivities:

Type of Emission	Minimum Detectable Discharge Rate (Ci/s) Shield Building	Auxiliary Building	Service Building
Noble Gases	1.3 (-5)	1.0 (-4)	5.7 (-6)
Particulates	1.3 (-8)	1.0 (-7)	5.7 (-9)
Iodines	1.3 (-8)	1.0 (-7)	5.7 (-9)

The monitor on the condenser offgas system will detect noble gases with a sensitivity of 4.7×10^{-10} Ci/sec. Set points for alarm and actuation functions will be established for the monitors to alert operating personnel to increases in radionuclide concentrations in gaseous effluents. More sensitive laboratory analyses will also be performed for particulates and iodines.

(b) Alternative gaseous radwaste systems - The original design of systems used for treatment of gaseous radioactive discharges and the extended treatment system adopted were described in the Watts Bar draft environmental statement dated May 14, 1971. These designs provided for 45-day and 60-day holdup of gases, respectively, and are shown schematically in figure 2.4-4. While the effectiveness of the design adopted is sufficient for environmental protection, other alternatives for this purpose have been considered so as not to foreclose prematurely any options which might further reduce releases to the environment. These include cryogenic distillation of gases, absorption of gases, and recombination of hydrogen with oxygen. All of these systems are designed to reduce the plant's gaseous radioactive effluents.

Estimated releases of radionuclides for all systems considered are shown in Table F-1 of Appendix F.

In order to assess the adequacy of the chosen extended treatment system when compared to the other alternatives, each system will be evaluated in terms of cost, feasibility, adaptability to the Watts Bar plant, and environmental benefits.

Cryogenic distillation - In this system, radioactive gases are removed by liquefying them at low temperatures and are stored onsite. The system (figure 2.4-5) would be installed in the vent line downstream of the gas decay holdup tanks. Its main advantage when compared to the 60-day gas decay tank system is that it removes more than 99 percent of the radioactivity remaining in the tank at the time of release.

Cryogenic systems for producing industrial oxygen were developed 30 to 40 years ago. However, the application of a cryogenic system at a nuclear power plant could have performance problems unrelated to those encountered in other industries. The problems associated with krypton-85 storage onsite and its eventual disposal must also be considered.

In the cryogenic extended radwaste treatment system, krypton and xenon are removed from the vent gases and stored in tanks. The holdup of krypton-85 would increase the potential for the accidental release of the concentrated waste to the environment and would require long-term storage (greater than 60 days) and ultimate disposal of gaseous radioactive waste.

While the future potential of the cryogenic system may offer advantages, it has not been used for the treatment of radioactive gaseous wastes in large commercial nuclear power plants. As compared to simple gas decay holdup tanks, the cryogenic system is a rather complicated mechanical system utilizing pumps, compressors, refrigeration systems, piping, and tanks. Because of the lack of experience with this type of service, some question exists as to the reliability of the cryogenic system. Its reliability would not be as high as that of the gas decay tanks which is essentially a passive system and has been used in radioactive gas treatment for nuclear plants similar in design to Watts Bar. The cryogenic distillation system is estimated to cost $600,000.

Absorption by solvent (ORDGP system) - This system (figure 2.4-6) shows promise for removing krypton and xenon from a gas stream by selective absorption in a fluorocarbon solvent. The performance and reliability of this type system has not been proven in nuclear plant service. The only experience to date has been with bench and pilot plant size systems. While this system shows promise for future application to nuclear plants, it was decided that further development would have to be done before it could become an acceptable alternative for large-scale applications such as Watts Bar. The estimated cost of the ORGDP system is $400,000.

Hydrogen recombiner - The recombiner (figure 2.4-7) would be integrated into the present gaseous waste disposal system. Removal of hydrogen by combining it with oxygen reduces the gas volume to be stored in the gas decay tanks and the effective holdup time is extended to a year or more. Due to the long half-life of krypton-85, the additional holdup time has little effect on the releases of this isotope. Because krypton-85 is the predominant isotope present after 60-day holdup, the use of a hydrogen recombiner would have little effect on the total release. The estimated cost of the hydrogen recombiner system is $400,000.

(c) Conclusion - Both the cryogenic and ORGDP systems have the potential when perfected of removing more than 99 percent of the noble gases from the gas released from the decay tanks. With the recombiner, all of the noble gas isotopes except krypton-85 would be reduced to negligible levels. With the cryogenic or ORGDP system, the noble gases could be collected in a small volume and placed in long-term storage. Equipment for the ORGDP system is not commercially available at present since the process is still undergoing development. It is possible that at least one firm would be in a position to offer the equipment in the near future.

TVA has concluded that the 60-day holdup alternative represents the best balance of economic cost, reduction in environmental impact, and feasibility. Therefore, the benefits to be gained by further reducing the radioactive gaseous

releases are not commensurate with the cost associated with the reduction. To implement this conclusion, TVA is proceeding with the design and procurement for the 60-day gas decay tank alternative.

(3) Solid radwaste disposal - The solid radwaste system collects, processes, stores, packages, and prepares for shipment solid radioactive waste materials produced through operation of the two reactor units.

The waste disposal system is designed to package all solid wastes in standard 30- or 55-gallon drums for removal to disposal facilities. Concentrates from the waste evaporator and spent ion exchange resins are packaged in drums previously filled with a mixture of cement and vermiculite.

Dry solid wastes, such as contaminated rags, paper, clothing, spent filter elements, laboratory apparatus, small parts and equipment, and tools, are collected in suitable containers placed throughout the plant. Compressible wastes are packed into 55-gallon drums with a baling machine. Large-sized contaminated items are encapsulated in steel containers or encased in concrete.

The wet solids and dry solids are packaged and shipped from the plant in accordance with applicable AEC requirements, U.S. Department of Transportation 49 CFR Part 189 requirements, and the regulations of those states through which the wastes pass en route to the disposal area. Transportation of the solid radwaste is discussed in section 2.1.

2. 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 Watts Bar Nuclear Plant will be so low as to be indistinguishable from natural background radiation. 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 to biota including man 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 internal retention of radionuclides with a single exponential model. This model is used for estimating the doses to 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.

Internal doses to man are calculated for the bone, G.I. tract, thyroid, and total body.

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 E.

(2) Radionuclides in gaseous effluents - The following doses to humans living in the vicinity of the Watts Bar 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 sector-averaged diffusion equations and meteorological data collected at the Watts Bar 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.

The principal potential for iodine releases is from the condenser vacuum pump, from containment purging, and from the plant ventilation systems. The gaseous effluents from the condenser vacuum pump, from containment purging, and from the auxiliary building ventilation systems can be filtered with charcoal filters to remove iodine if necessary. TVA has concluded that it is not practicable to treat iodine releases from the turbine building ventilation system because of the large flow rates and small concentrations involved. The estimated releases of iodine are based on numerous assumptions related to operating conditions as well as physical and chemical characteristics of iodines. Action will be taken to ensure that actual iodine releases are kept as low as practicable.

A more detailed description of the analytical methods used in calculating these doses and a detailed listing of results are given in Appendix F. As is discussed in Appendix F, it is believed that the meteorological data used in the calculations in this report will lead to the prediction of air concentrations and radiation doses which are higher than would be experienced during reactor operation.

(3) Summary of radiological impact - Table 2.4-2 summarizes the radiation doses calculated for releases of radionuclides in gaseous and liquid effluents during normal operation of the Watts Bar Nuclear Plant. The external radiation dose from outside liquid storage tanks is also shown and is discussed in Appendix G. The increases in radioactivity and potential radiation doses shown include only those resulting from operation of the Watts Bar Nuclear Plant. The cumulative increases in radioactivity and potential radiation doses from operation of Watts Bar Nuclear Plant and Sequoyah Nuclear Plant are discussed in Appendix H.

A comparison of doses resulting from the operation of Watts Bar Nuclear Plant to those occurring from natural radioactivity assists in placing the doses from Watts Bar in perspective. Near the plant site the average annual dose from naturally occurring external sources of radiation is 125 mrem (Table 2.4-3). 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 Watts Bar 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 variances 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 10 mrem from the normal operation of the Watts Bar Nuclear Plant. For this individual to receive the maximum dose he would have to stand 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 7 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 Watts Bar from naturally occurring radioactivity is estimated to be approximately 145,000 man-rems in the year 2000 (Table 2.4-3). The population dose in the year 2000 due to normal operation of the Watts Bar Nuclear Plant is calculated to be 31 man-rems (Table 2.4-2), which is only 0.02 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 Watts Bar Nuclear Plant is actually less than 0.02 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 Watts Bar Nuclear Plant will operate with no signficant risk to the health and safety of the public.

3. 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, what impact the power plant is having on the environment.

Field staffs in TVA's Division of Environmental Research and Development and the Division of Forestry, Fisheries, and Wildlife Development will carry out the sampling program outlined in Tables 2.4-4, 2.4-5, and 2.4-6. Sampling locations are shown in figures 2.4-8 and 2.4-9. 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 two 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 upon 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 Tennessee.

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 Watts Bar Nuclear Plant. Two of these monitors are 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 are located at perimeter areas out to 10 miles. These stations are instrumented and telemeter data into the control room. Generally these stations are located in or near the more densely populated areas within 10 miles of the plant in those quadrants having the greatest wind frequency on an annual basis (see figure 2.4-8).

Two other monitors are located at distances out to 17 miles. These remote monitors are used as control or baseline stations. Samples of air, rainwater, and heavy particle fallout will be collected routinely as indicated in Table 2.4-4.

Atmospheric tritium will be sampled at the Watts Bar 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 16-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 air monitoring station.

Milk is sampled from dairy farms near the plant on a monthly basis. Locally processed milk is also 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) Reservoir monitoring - Sampling will be carried out quarterly along eight river cross sections in Watts Bar and Chickamauga Reservoirs. These will be located as indicated in figure 2.4-9 at Tennessee River miles (TRM) 532.1, 527.4, 518.0, 506.6, and 496.5; at Hiwassee River miles (HRM) 24.3 and 2.3; and at station X (approximate location TRM 528.0) which will be located 500 feet below the point of discharge of radioactive wastes, the location of which has not been determined. In addition, a single-point station is located in the tailrace at Watts Bar Dam (TRM 529.9) upstream of the nuclear power plant site. Samples collected for radiological analyses include fish from five cross sections and plankton from six. Bottom fauna will be sampled at six cross sections and bottom sediment from eight. Further sampling information can be noted in Tables 2.4-5 and 2.4-6 and figure 2.4-9. Locations of these cross sections conform to sediment ranges established and surveyed by TVA.

Cross section 496.5 is 31.5 miles downstream from the Watts Bar Nuclear Plant site and 12.7 miles upstream from the Sequoyah Nuclear Plant diffuser and was originally selected as a control station for the Sequoyah monitoring program. The stations established for the Sequoyah plant monitoring program extend downstream to TRM 425.5 (in Nickajack Reservoir) and will supplement the Watts Bar monitoring program. The beginning date for the Watts Bar monitoring program is later than that for the Sequoyah program. However, the Watts Bar monitoring program will be initiated before the Sequoyah plant begins operating, and thereafter both programs will be conducted concurrently.

Samples of water, net plankton, sediment, 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, sediment, shells and flesh of clams, flesh of two commercial and one game fish species, and the whole body of one commercial fish species. 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 ten gamma emitting radionuclides will be determined with a multichannel gamma spectrometer.

At present TVA feels that it is 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 southeast Tennessee 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 Watts Bar Nuclear Plant. Therefore, it seems more logical to sample other vectors in the environment which the waterfowl might inhabit for short periods of time.

(a) Water - A total of 27 water samples will be collected for determination of suspended and dissolved radioactivity from the eight cross sections and the tailrace of Watts Bar Dam.

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 Chickamauga 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 from collections at five sampling stations--TRM 532.1, 527.4, 506.6, 496.5, and HRM 2.4. One composite will consist of one pound of flesh from six white crappie, 8 inches or longer; one from the flesh of six smallmouth buffalo, 14 inches or longer; one from six whole smallmouth buffalo, 14 inches or longer; and one from the flesh of six channel catfish, 12 inches or longer. 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, 13 net plankton samples will be collected at six stations by horizontal tows with a one-half meter, 100-150 micron mesh net. 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-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 dredge hauls made for bottom fauna. Gamma, gross alpha, and gross beta activity, and Sr^{89} and Sr^{90} content will be determined in 13 samples collected from points in eight cross sections. Each sample will be a composite obtained by combining equal volumes of sediment from at least three dredge hauls at a point in the cross section.

(e) Bottom fauna - Eleven samples of Asiatic clams will be collected with a Peterson or Ekman dredge from six 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 at Spring City, at the Watts Bar Reservation, at Dayton, and at the Savannah Valley Utility District will be analyzed monthly. Englewood public water supply, taken from Middle Creek, a tributary of the Hiwassee River, will be analyzed quarterly. Specific isotopic

analyses will be performed and averaged for each station for a 6-month period.

(6) Quality control - A quality control program will be established with the Tennessee Department of Public Health Radiological Laboratory and the Eastern Environmental Laboratory, Environmental Protection Agency, Montgomery, Alabama, 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.

Table 2.4-1

ESTIMATED ANNUAL LIQUID DISCHARGE TO WASTE DISPOSAL

Two Units

Source	Total Annual Discharge, gal
Laundry, shower, handwashes	240,000
Laboratory	32,000
Equipment drains, leaks	173,000
Decontamination	30,000
Spent Fuel Cask Decontamination	350,000
Resin regeneration, Boric Acid Evaporator Condensate	150,000
Total Waste Disposal System	975,000

Table 2.4-2

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

	Normal Operation	Proposed 10 CFR 50 Appendix I Guides
A. Liquid Effluents		
Activity released	0.92 Ci	10 Ci
Average concentration before dilution in the Tennessee River	1.7 (-8)[c] $\mu Ci/cm^3$	2.0 (-8) $\mu Ci/cm^3$
Maximum human organ doses		
1. bone	2.9 (-2) mrem	5 mrem
2. G.I. tract	1.8 (-2) mrem	5 mrem
3. thyroid	5.5 (-2) mrem	5 mrem
4. skin	1.7 (-2) mrem	5 mrem
5. total body	1.7 (-2) mrem	5 mrem
Human population doses within the Tennessee Valley Region		
1. bone	7.3 man-rem	
2. G.I. tract	4.4 man-rem	
3. thyroid	12 man-rem	
4. skin	4.1 man-rem	
5. total body	4.1 man-rem	
Maximum dose to terrestrial vertebrates	1.1 mrad	
Maximum doses to aquatic organisms		
1. plants	.093 mrad	
2. invertebrates	130 mrad	
3. fish	0.25 mrad	

a. Table excludes tritium. Doses due to releases of tritium in liquid effluents are 1.7×10^{-3} mrem and 0.32 man-rem. Doses due to releases of tritium in gaseous effluents are 0.27 mrem and 0.81 man-rem.
b. Releases for two units operating at full power with 0.25 percent failed fuel.
c. 1.7×10^{-8}

Table 2.4-2 (continued)

	Normal Operation	Proposed 10 CFR 50 Appendix I Guides
B. Gaseous Effluents		
I-131 concentration at site boundary	3.8 (-15) $\frac{\mu Ci}{cc}$	1.0 (-15) $\frac{\mu Ci}{cc}$
Maximum individual doses		
1. inhalation at site boundary (thyroid)	1.3 (-1) mrem	5 mrem
2. consumption of milk from nearest dairy farm (thyroid)	3.3 mrem	5 mrem
3. external exposure at site boundary (β&γ)	6.6 mrem	10 mrem
Population doses within a 50-mile radius		
1. inhalation (thyroid)	1.3 (-1) man-rem	
2. consumption of milk (thyroid)	5.4 man-rem	
3. external exposure (β&γ)	1.3 (+1) man-rem	
C. Direct Gamma Radiation from Liquid Storage Tanks	5.0 (-2) mrem	
D. Maximum Annual Dose to Any Individual[d]	1.0 (+1) mrem	
E. Maximum Population Dose[d]	3.1 (+1) man-rem	

d. Thyroid. Assumes external exposure also contributes to thyroid dose.

Table 2.4-3

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 1,000,000[c] people = 145,000 man-rem

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 Watts Bar Nuclear Plant in the year 2000.

Table 2.4-4

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			
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 is 3.5 liters of sample for analysis after necessary preparation.
f. G - grap sample at time of collection

Table 2.4-5

SAMPLING SCHEDULE FOR WATTS BAR AND CHICKAMAUGA RESERVOIRS

Station River and Mile	Horizontal Location[a]	Depths for Water Samples[b]	Depths for Zooplankton, Chlorophyll, and Phyto-Plankton Cell Counts[b]	Benthos[c]	Sediment[c]	Fish[d]
Tennessee	LM	S,M,B	S,M	3	3	
532.1	RR	S,B	S,M	3	3	T
Tennessee 529.9 (Tailrace)	R	S				
Station X[e]	M	S,M,B				
Tennessee	LM	S,B		3	3	
527.4	RM	S,B	S,M			G
	RR			3	3	
Tennessee	LM	S,B		3	3	
518.0	RM	S,B	S,M	3	3	
Tennessee	L	S				
506.6	R	S,B	S,M	3	3	G
Hiwassee	C	S,B				
24.3	RR				1	
Tennessee	L			3	3	G,T
496.5	M	S,B	S,B	3	3	

a. Horizontal location looking downstream; L, C, and R (left, middle, and right) are approximate quarter points across the entire reservoir width; LL, LM, RM, and RR represent approximately 1/8, 3/8, 5/8, and 7/8 of the distance across the reservoir.
b. Sample depth designations: S = surface (one meter depth); M = mid-depth; B = near the bottom.
c. Minimum number of dredge hauls.
d. G = gill net; T = trap net.
e. Station X will be located 500 feet below the point of discharge of radioactive wastes.

Table 2.4-6

RESERVOIR MONITORING RADIOLOGICAL ANALYSES

Type Sample	Analyses*
Fish	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90}**
Sediment	Gamma scan, gross alpha, gross beta, Sr^{89} and Sr^{90}
Water	Gamma scan, gross alpha, gross beta, Sr^{89}, Sr^{90}, and tritium
Plankton	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.

*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.

**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.

***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.

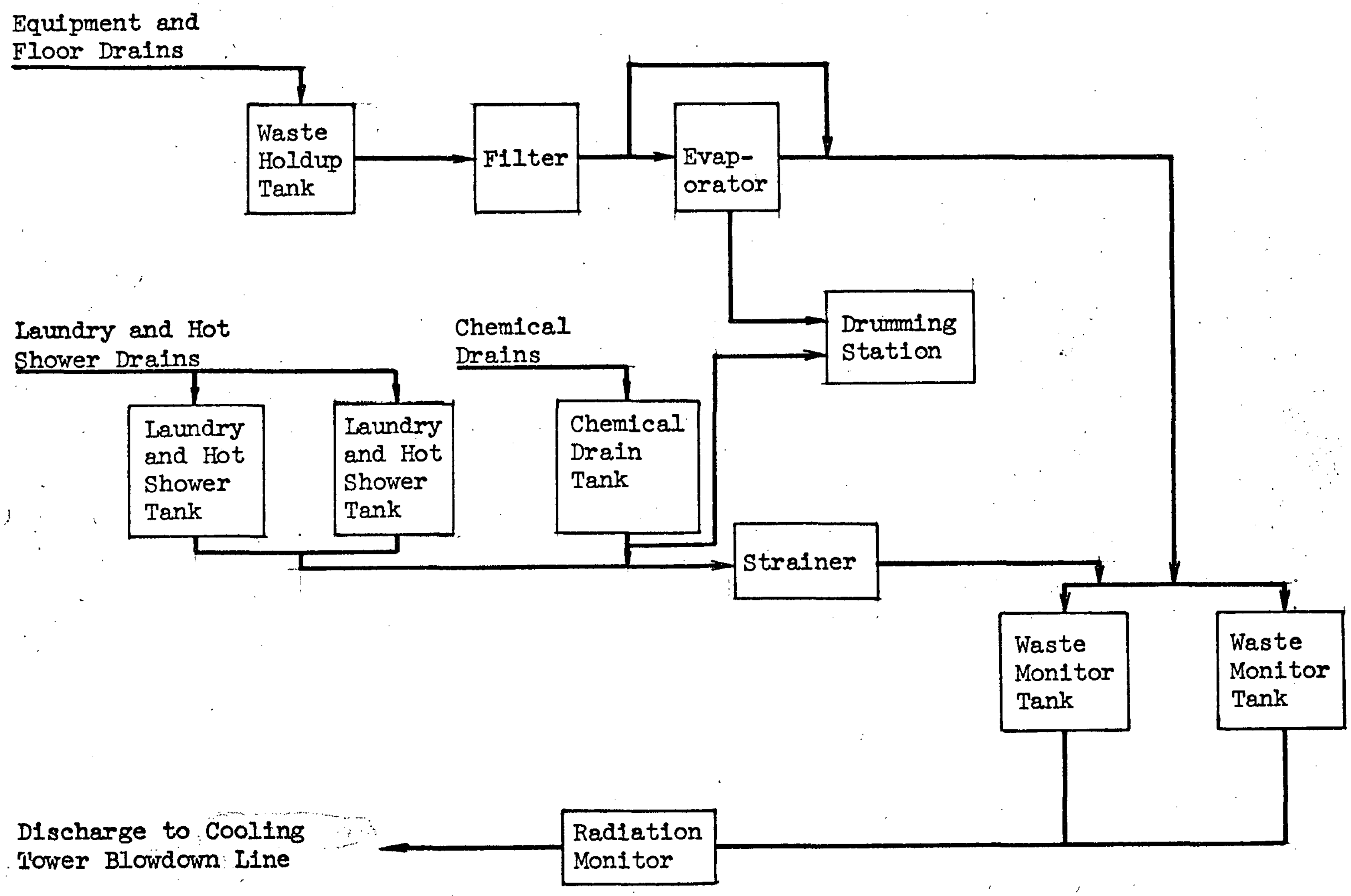


Figure 2.4-1
LIQUID RADWASTE
ORIGINAL SYSTEM

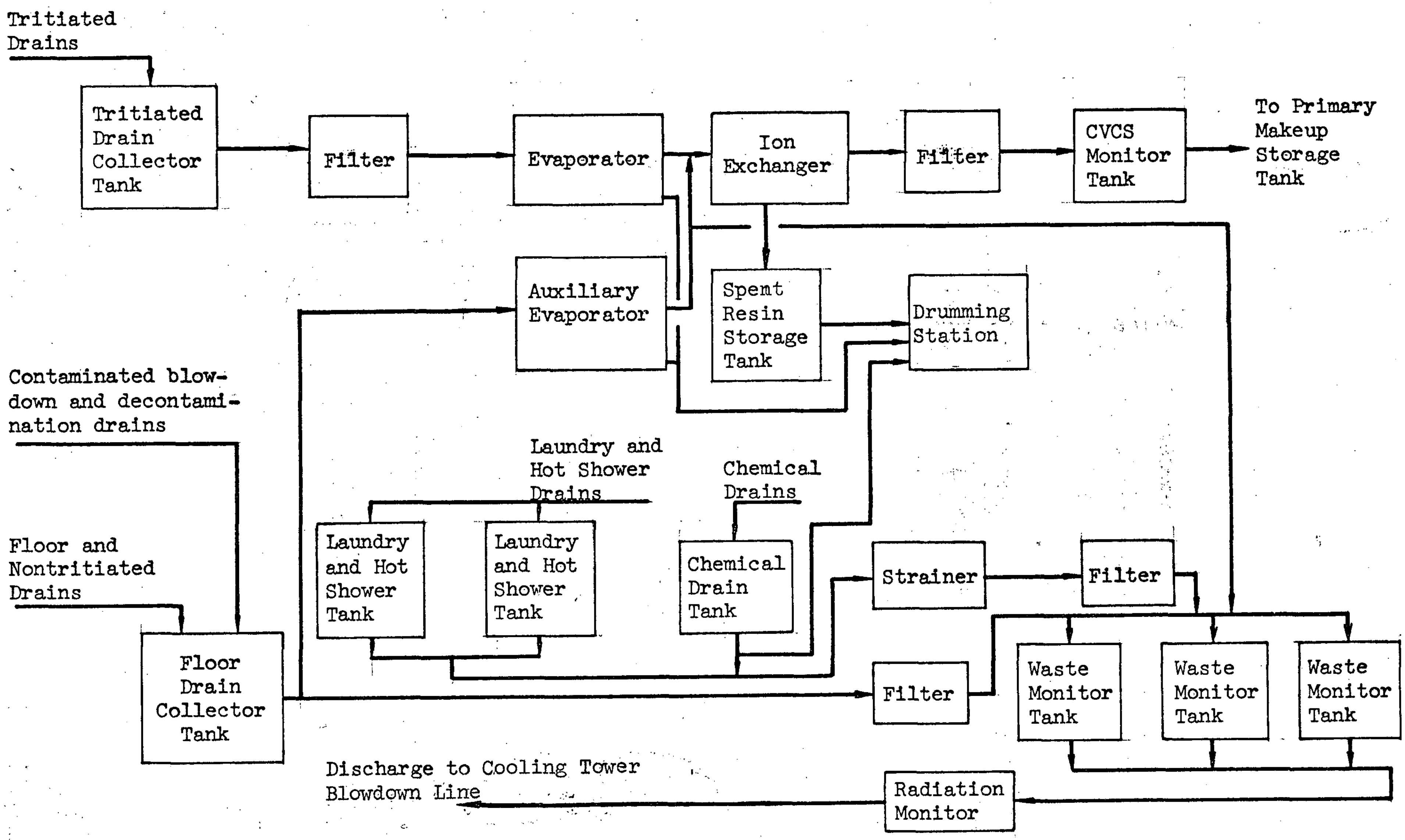
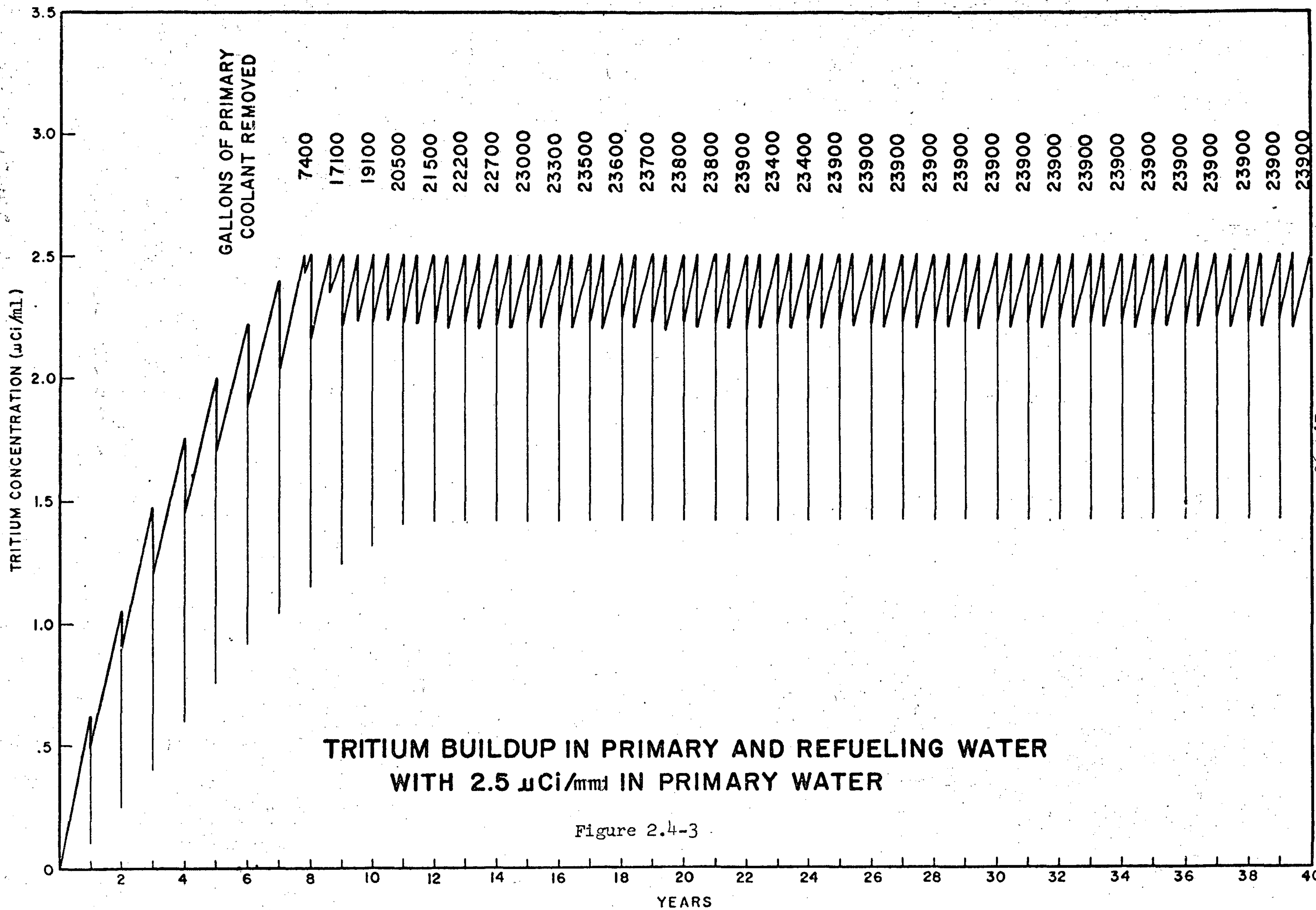


Figure 2.4-2
LIQUID RADWASTE
TRITIUM RECYCLE AND
BLOWDOWN PROCESSING



TRITIUM BUILDUP IN PRIMARY AND REFUELING WATER
WITH 2.5 µCi/mml IN PRIMARY WATER

Figure 2.4-3

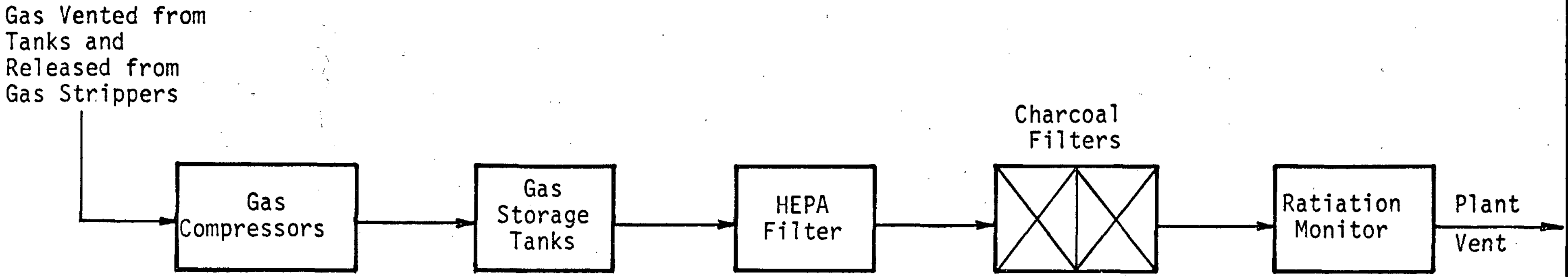


Figure 2.4-4
Gaseous Radwaste Original 45-day Holdup (Six Storgae Tanks)
Alternate 1, 60-day Holdup (Nine Storage Tanks)

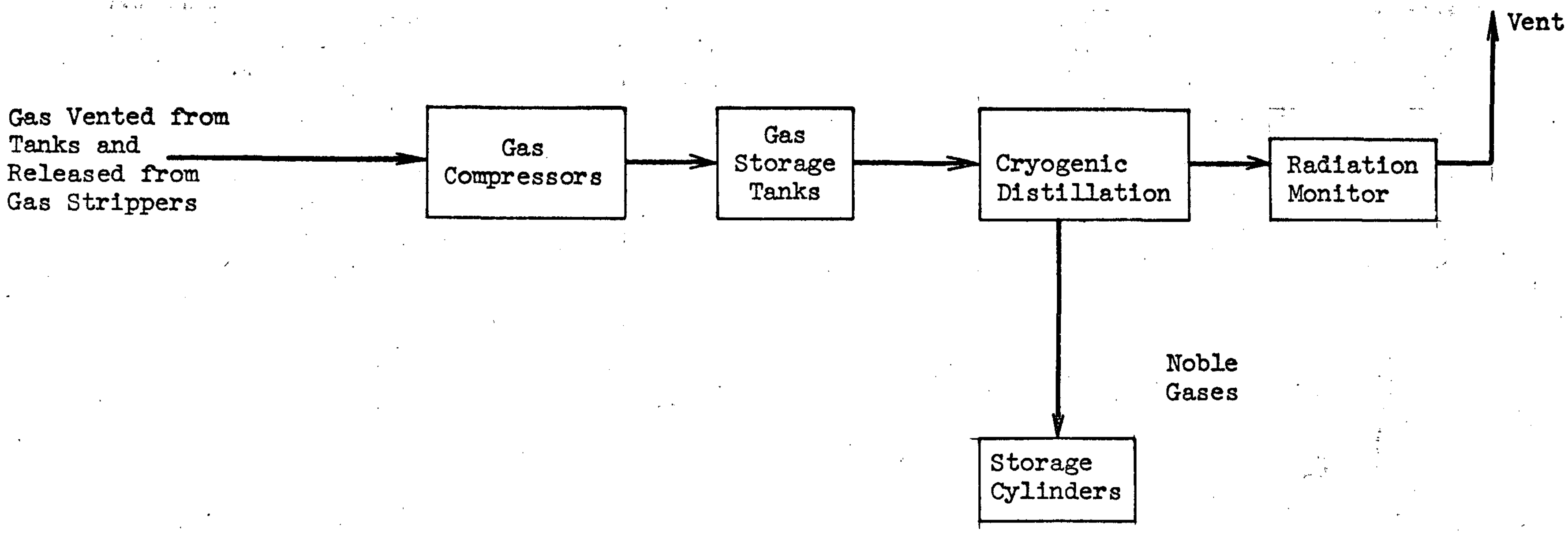


Figure 2.4-5
GASEOUS RADWASTE
ALTERNATIVE 2
ADDITION OF
CRYOGENIC DISTILLATION

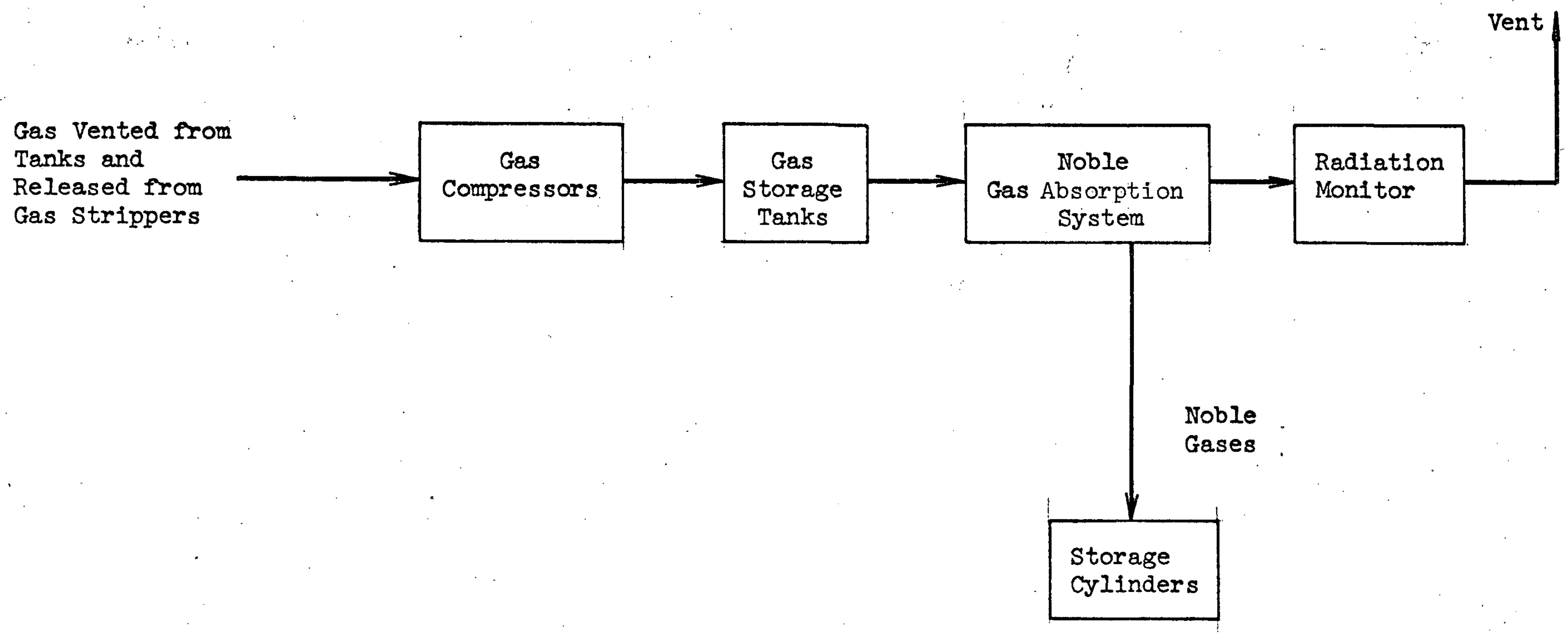


Figure 2.4-6
GASEOUS RADWASTE
ALTERNATE 3
NOBLE GAS ABSORPTION SYSTEM

B-7

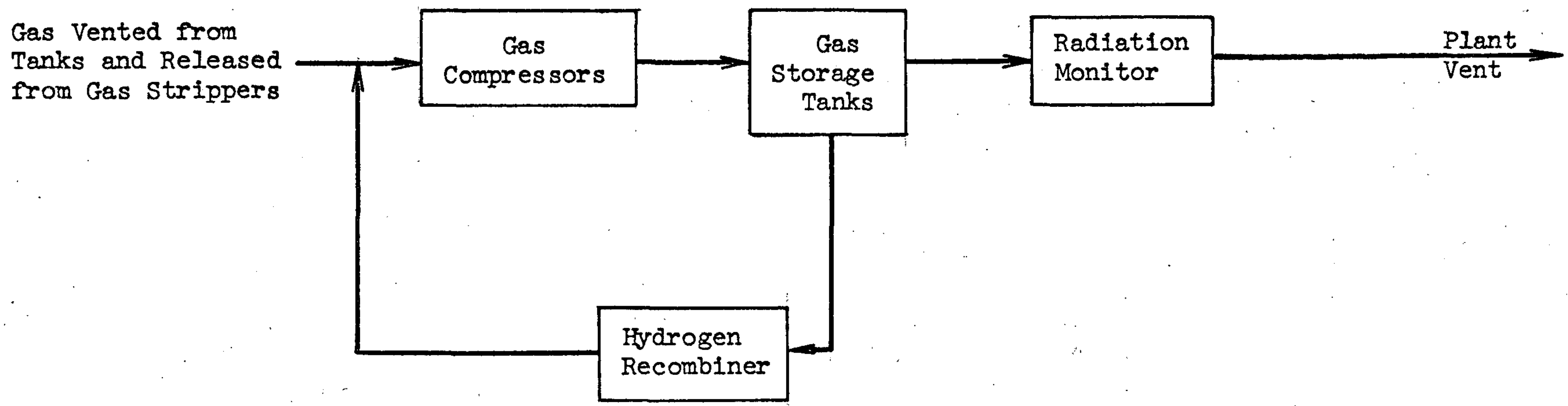


Figure 2.4-7
GASEOUS RADWASTE
ALTERNATIVE 4
ADDITION OF A
HYDROGEN RECOMBINER

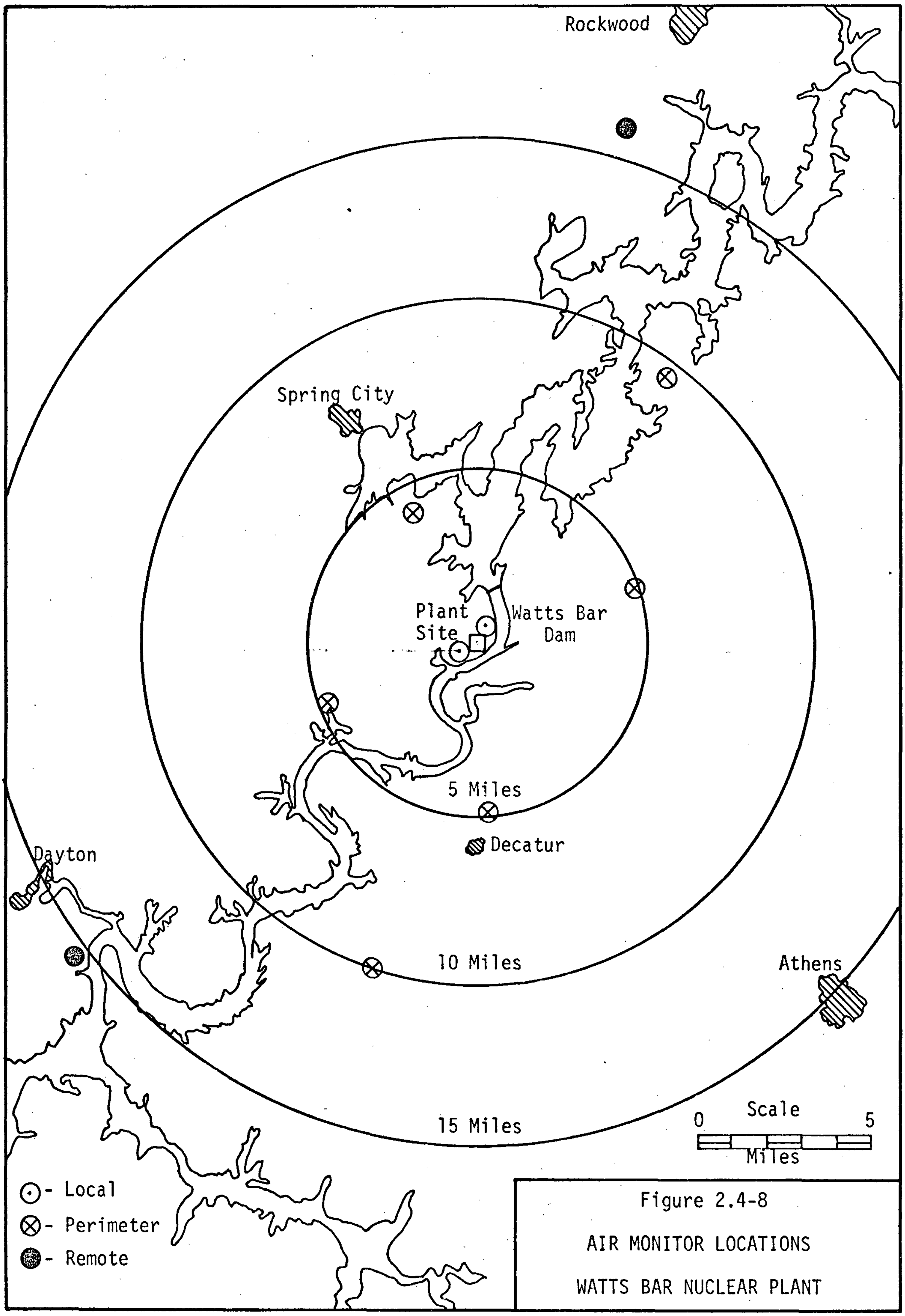


Figure 2.4-8

AIR MONITOR LOCATIONS

WATTS BAR NUCLEAR PLANT

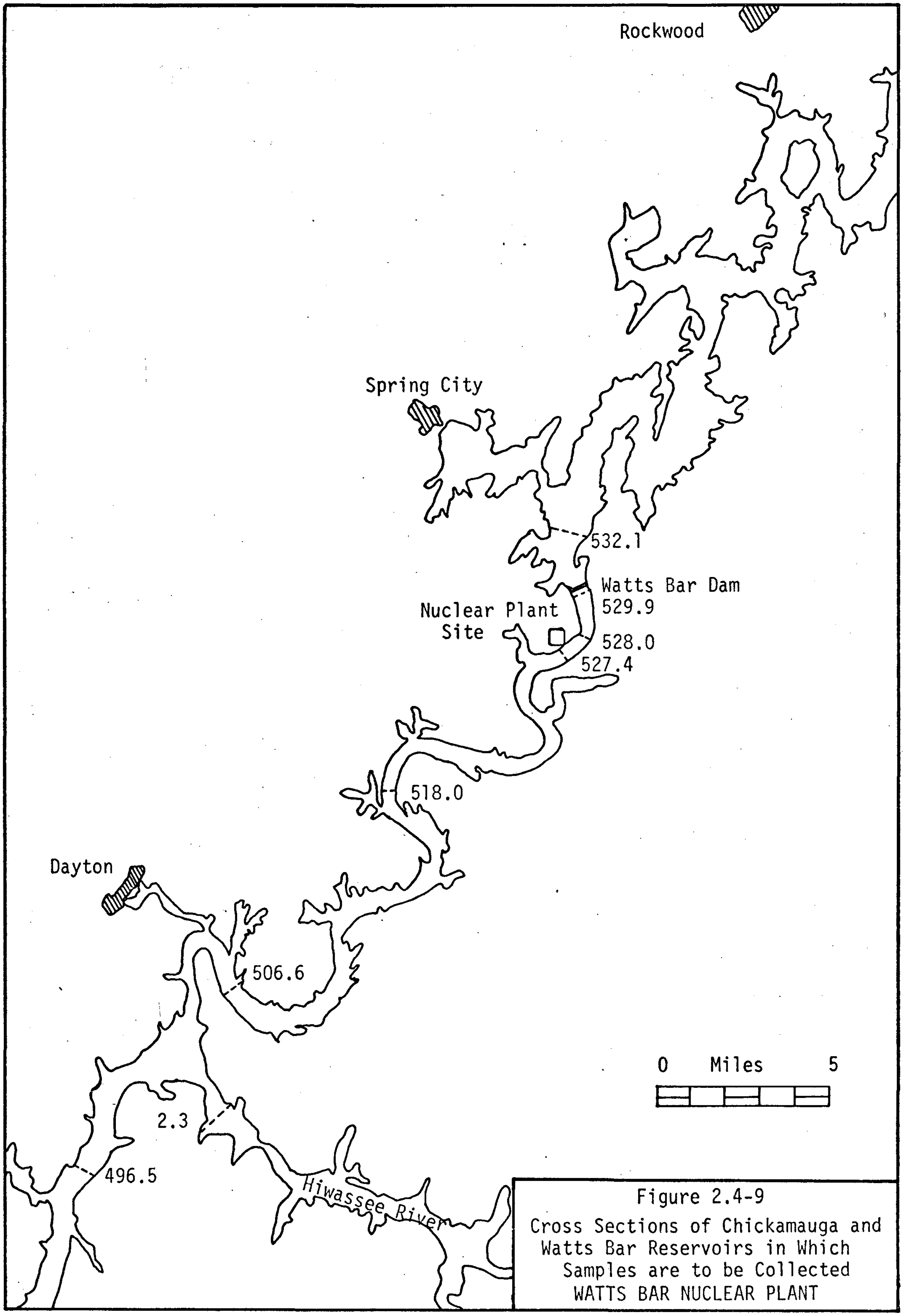


Figure 2.4-9
Cross Sections of Chickamauga and Watts Bar Reservoirs in Which Samples are to be Collected
WATTS BAR NUCLEAR PLANT

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 under existing technology, within reasonable economic limits.

A description of the potential sources and amounts of non-radioactive 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 - TVA has altered the originally proposed design for handling plant effluents including the chemical discharges at the Watts Bar Nuclear Plant. These alterations in handling the plant chemical discharges are included in the present plant design for handling the plant effluents as shown schematically in figure 2.5-1. This section describes the modified design and discusses the control and treatment of chemical wastes and the probable environmental impact of chemical releases.

The sources of these chemicals and the maximum expected quantity of chemical end products that could be discharged are summarized in Table 2.5-1. The average and the maximum expected total chemical concentrations in the discharge pipe and in the reservoir after intial 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. These computations show that even under adverse conditions and using conservative assumptions, impacts to the environment due to chemical discharges from the Watts Bar Nuclear Plant will be very small.

(1) Cooling tower blowdown and drift - Operation of the two natural draft cooling towers for the condenser circulating water system will evaporate approximately 62 ft^3/s of the flow to the towers during periods of high evaporation. Drift will also be carried from the towers but is not expected to exceed about 0.1 ft^3/s per tower. To control the dissolved solids concentrations in the condenser cooling water, a certain amount of blowdown from the towers and makeup to the towers must be provided.

Normal blowdown rate will be approximately 62 ft^3/s during periods of high evaporation. This will maintain a condenser cooling system solids concentration about twice the reservoir solids concentration. Blowdown will be returned to the river through a diffuser system designed to provide the best diffusion possible with the streamflow available and minimize environmental impacts due to disturbances of aquatic life during construction and operation of the plant.

Chemical additives other than intermittent chlorination for biological control should not be required for cooling water concentration factors normally held to about 2. The water in Chickamauga Reservoir at the Watts Bar site normally shows a scaling rather than a corrosive nature and use of corrosion inhibitors is not necessary. No significant discharge of corrosion products is anticipated.

As described in Section 2.6, Heat Dissipation, cooling tower blowdown will be discontinued when the releases from the Watts Bar Dam are less than 3,500 ft^3/s. During normal operation of Watts Bar Dam these periods seldom exceed 12 hours in duration on any given day. During a 12-hour period, dissolved solids concentrations in the cooling water circuit will normally rise to between three and four times their reservoir concentrations and, depending on fluctuations of dissolved solids concentrations in the river, will occasionally exceed four concentrations.

The major potential impact of discharging cooling tower blowdown could result from increasing trace metal concentrations above those existing in the reservoir. As shown in Section 2.6, Heat Dissipation, impacts associated with dissipating the relatively small quantity of heat in the cooling tower blowdown are insignificant even under the most adverse conditions anticipated, and Section 2.4, Radioactive Discharges, shows that doses due to radioactive discharges are less than those allowed by the proposed Appendix I to 10 CFR Part 50.

To assess the effect of concentrating within the cooling system the trace metals contained in the cooling system makeup water as withdrawn from the river, concentrations existing at the Fort Loudoun discharge were assumed to exist at Watts Bar and no credit was taken for dilution by the Little Tennessee and Clinch Rivers. In addition, calculations of metal concentrations in the cooling tower blowdown were made assuming that maximum observed trace metal concentrations in the reservoir occurred during a period when blowdown had been discontinued for about 12 hours.

Discontinuing blowdown for about 12 hours would result in increasing the concentration factor of the cooling system from 2 to 4. The resulting maximum trace metal concentrations that were calculated to occur in the cooling system, in the diffusers as discharged, and in Chickamauga Reservoir after a dilution of 9:1 with reservoir flow when blowdown was resumed are included in Table 2.5-3. Also shown in the table are the applicable effluent and stream guidelines recognized by the Tennessee Water Quality Control Board.

Under these conditions, the effluent guidelines would be met for all identified parameters except selenium, cadmium, mercury, and possibly silver. At the edge of the jet mixing zone the stream guidelines would be met for all parameters except iron, zinc, manganese, cadmium, and possibly silver and arsenic. The maximum observed concentrations for iron, zinc, cadmium, manganese, and possibly silver and arsenic in the makeup water as it would have been withdrawn from the reservoir exceeded the stream guidelines. Since the minimum detectable concentration of the laboratory analytical procedures used for the silver and arsenic analyses exceeded the stream guidelines for these metals, effluent and stream concentrations cannot be reliably compared with the guidelines.

Although the stream guidelines might be exceeded for some parameters after initial jet mixing, these concentrations would not be expected to have a significant environmental impact. Additional mixing, which will occur in the reservoir as the water moves downstream, would further reduce the trace metal concentrations to levels approaching those occurring in the river at the time.

If the condenser cooling water system were operated normally at concentration factors of 5 and 6, concentration factors of 7 and 8 would result during periods when blowdown was discontinued. The discharge of cooling tower blowdown under these conditions could result in high trace metal concentrations which may adversely affect the aquatic life.

Because of the relatively large variations in concentrations of solids in the condenser cooling water which will be experienced during periods of reservoir flow fluctuations, it is not deemed advisable to operate during normal blowdown periods with cooling water concentration factors much above 2. (See Section 2.6, Heat Dissipation.) These considerations will be closely observed during the early operation of the plant, and the best balance of cooling system concentration factors and heat dissipation will be adopted to minimize environmental impacts and operating costs.

During periods when blowdown is discontinued, the raw cooling waterflow in excess of that required to make up for evaporation will be diverted to the holding pool. This water will be stored in the pool until flow is restored from Watts Bar Hydro Plant and cooling tower blowdown is resumed, at which time a valved outlet from the holding pool will be used to discharge excess water stored in the holding pool through the blowdown discharge system until the holding pool is returned to its normal storage capacity. Concurrent with discharges from the holding pool, cooling tower blowdown may be increased to lower solids concentrations in the condenser cooling water back to the normal level of about twice the reservoir concentration.

The discharge flow rates from the holding pool and the cooling tower blowdown may be individually adjusted to take advantage of the holding pool discharge with its low solids concentrations and relatively low temperature for dilution of the blowdown stream.

Chlorination of the condenser circulating water may be necessary for biological control and, if used, will be fed for 1 hour a day to maintain a maximum of 0.5 mg/l residual at the condenser outlet during feed periods. Data collected at Paradise Steam Plant, where the chlorinated condenser circulating water discharges to a natural draft tower, indicated about 0.1 mg/l residual chlorine at the inlet to the tower and zero to a trace of chlorine in the tower basin during the injection period, when the chlorine residual was 0.7 mg/l in the condenser inlet and 0.4 mg/l at the condenser outlet.

It is anticipated that the Watts Bar cooling water will have a similar chlorine demand and that only trace amounts of residual chlorine would be discharged in the cooling tower blowdown.

Cooling tower drift is not expected to exceed 0.2 ft^3/s. This amount of drift would result in an average discharge of solids of less than 300 lb/d. The drift is expected to fall out in the immediate vicinity of the tower. No significant environmental impacts will occur since no area outside the immediate vicinity of the towers will receive significant concentrations of solids.

(2) <u>Raw cooling water and essential raw cooling water systems</u> - Acrolein, an unsaturated aldehyde, will be fed to both the raw cooling water and essential raw cooling water systems for the control of Asiatic clams. It is not expected that its use will be required more than 120 days per year. When required, it will be fed into the systems 1/2 hour each day to maintain a concentration within

the cooling systems of approximately 0.2 to 0.3 mg/l during feed periods. The two cooling system flows will be added as makeup water to the main condenser cooling system upstream of the condensers. Acrolein will not be used when the cooling tower blowdown is being withheld. Assuming the acrolein demand of the main condenser cooling water to be 0.1 mg/l in 1 hour,[1] the acrolein demand of the water within this system is sufficient to deplete all the residual acrolein contained in raw cooling and essential raw cooling systems. Laboratory tests[2] of water collected at the Watts Bar Steam Plant by an acrolein supplier indicate a demand of 0.15 mg/l in 15 minutes. Since acrolein is volatile, much of it would also be readily scrubbed from the cooling system water during its first pass over the cooling tower fill.

Taking no credit for acrolein demand or tower scrubbing and considering only dilution, the maximum concentration that would be expected in the main condenser system during periods when acrolein is simultaneously fed to both the raw and essential systems would be about 0.038 mg/l. Discharge through the diffusers of cooling tower blowdown having this concentration would result in an acrolein concentration in the river at the edge of the jet mixing zone of 0.0038 mg/l. The 96-hour TLM for fathead minnows is reported to be 0.06 mg/l.[1] The concentration in the river resulting from dilution alone (within the main condenser cooling system and by the diffusers) is about 6 percent of the 96-hour TLM.

Because of the acrolein demand of the main condenser cooling water and the acrolein scrubbing in the cooling towers in addition to the dilution, the use of acrolein will not have any significant adverse impact on the environment.

(3) Makeup water filter plant - Operation of the makeup water filter plant will require the use of lime, alum, and chlorine. Residual chlorine in the treated water will be removed by the makeup water treatment demineralizers and will be released 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 lagoon area which will contain two basins for use at alternate times. Each basin will be approximately 6 feet deep, 12 feet wide, and 130 feet long and will be located as shown on figure 1.1-2. The supernatant water from the lagoons will be decanted and returned to the cooling tower blowdown stream for discharge through the jet diffusers. As necessary, the sludge will be removed and disposed of by burial on the plant site or on other TVA grounds. This method of sludge disposal results in minimal environmental impacts.

The addition of a coagulation aid may be necessary for proper operation of the filter plant. The coagulation aid which will be used in the event that it is necessary or advantageous will be chosen from those approved by the Environmental Protection Agency[3] and will be used in accordance with the manufacturer's recommendations.

(4) Water treatment plant demineralizers - 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 pH is neutralized the waste

is discharged from the plant. At Watts Bar 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 condenser circulating water 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:

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

Reactions with alkali:

$$RH + NaOH \longrightarrow RNa + HOH$$

The unit is therefore self-regenerating as long as the process is in balance. Only backwashing is required. Backwash will be diverted to the filter plant backwash lagoon.

It is anticipated that the quality of raw cooling water to be treated for reactor makeup will be such that not over 231,000 pounds of 93 percent sulfuric acid and 431,000 pounds of 50 percent solution of sodium hydroxide will be expended annually if the demineralizers are operated at full capacity. After plant cleanup and startup makeup water requirements will be less than the rated capacity of the makeup water filter plant and demineralizers. Under these conditions the chemical usage and resulting waste product chemical discharges will be reduced correspondingly. The contributions to increases in concentrations in the plant discharge during release are included in Table 2.5-2. These increases in concentrations will cause no significant impact on the environment.

(5) Steam generator blowdown - Hydrazine, ammonia, and sodium phosphate will be used in treatment of the secondary system. Of these, only hydrazine will be fed continuously. Ammonia will be supplied as needed to maintain the desired pH in the steam generators, and sodium phosphate will be fed to maintain a residual PO_4 concentration of 10 mg/l in the secondary system. In the steam generators, hydrazine decomposes to form ammonia which will be discharged as vapor through the condenser vacuum pumps. The steam generator blowdown containing both ammonia and sodium phosphate will be released to the cooling tower blowdown discharge stream. The estimated annual releases of ammonia, sodium, and phosphate from this source are shown in Table 2.5-1 and contribution to increases in the discharge are included in Table 2.5-2. The increased chemical concentrations in the plant effluent resulting from treatment of secondary system water will have no significant environmental impact.

The steam generator blowdown rate will normally be much less than 50 gal/min for two units. The blowdown will be discharged to the cooling tower blowdown except at times of a primary to secondary leak in the steam generator, at which time it is diverted to radioactive waste treatment. Steam generator blowdown will be interlocked with the cooling tower blowdown and will only be discharged from the plant during periods of cooling tower blowdown. The steam generator blowdown will be stored during the times when it cannot be released from the plant. Storage capacity of 150,000 gallons is sufficient for approximately two days at a blowdown rate of 50 gal/min from the plant.

(6) Component cooling water system - Sodium chromate will be used as a corrosion inhibitor in the closed component cooling water system. When necessary for maintenance purposes, the chromate-containing water will be drained from portions of the closed system. Whenever possible, the water will be returned to the system. If not, it will be routed to the radwaste system and processed by evaporation. No chromate will be released to the river.

(7) 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.

(8) Auxiliary steam generator blowdown - Two 40,000-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 ug/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 2,000 to 4,400 gallons per day total for both steam generators and will result in an annual discharge of ammonia of only about 13 pounds. The blowdown, which

will have a residual ammonia concentration of about 0.3 mg/l, will be discharged to the condenser circulating water system. As shown in Table 2.5-2, contribution to the increases in the cooling water blowdown stream will not cause ammonia discharge concentrations to be significant.

(9) 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 concentrations substantially below harmful levels. These procedures are described in Section 2.8, Construction Effects.

(10) Miscellaneous - Most equipment cleaning and decontamination operations will be performed with high-pressure water and with detergent solutions. These liquids will be treated in the radwaste system by filtration and will be released to the cooling tower blowdown discharge line.

Some decontamination operations will involve the use of chemicals such as sodium phosphate, sodium permanganate, ammonium citrate, alkaline potassium permanganate, and nitric, citric, 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 consist of laboratory drains and decontamination wastes. The principal chemical reagents used in the laboratory include sodium and ammonium hydroxides; hydrochloric, nitric, and sulfuric acids; ammonium acetate; and sodium carbonate.

Before the chemical drain tank is emptied, its contents are analyzed. If the liquid does not contain chemicals that would be harmful to the evaporator (principally, chlorides and sulfides) it will be processed in the auxiliary evaporator. The concentrates are drummed and the distillate is released to the reservoir in the usual manner. If the chemical drain tank contains chemicals that would be harmful to the evaporator, the contents are drummed without further processing. The contents of the tank are released to the reservoir only when analysis shows that no environmentally harmful concentrations of chemicals are present and the radioacitivty level is within acceptable limits. It is expected that release would be an infrequent event.

Usage of detergents will be minimized for laundry and similar uses. Benefits gained by treatment of the small amount of detergent wastes are not great enough to justify radioactively contaminating a normally uncontaminated system such as the sewage treatment system. The detergent solutions will be filtered and discharged. Treatment and discharge of these detergent solutions in this manner are not anticipated to result in any significant environmental impacts.

It is anticipated that the cooling tower basins will be drained infrequently for maintenance purposes. When this operation is necessary, the contents of the tower basin will be routed to a settling area, and after a suitable settling period, the water will be discharged to the reservoir via the cooling tower blowdown line. Discharges will be regulated so that water quality standards are not violated. Sludge removed from the tower basins will be buried onsite or on other TVA grounds. No significant environmental impacts are expected to occur from this operation.

The building drainage system (roof and high floor drains) drains into the storm drainage system and thence to the holding pool. These drains will handle only innocuous materials and present no hazard to the environment.

The station sump also discharges to the holding pool and would not normally handle any substances potentially detrimental to the environment. It may occasionally contain some oil which has leaked from some indoor machinery. Oil reaching the holding pool via this route will be reclaimed for disposal as described below for the yard drainage system.

2. Yard drainage system - An area of approximately 30 acres will be diked to provide a yard drainage holding pool. Any debris or oil which may be spilled and enter the yard drainage system will flow to this pool. A skimming type outflow will be provided so that floating debris and oil cannot escape from the pool. This material will be periodically removed from the pool for disposal. It will be disposed of in a manner to minimize environmental impact, dependent on the character of the wastes, such as 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 disposal by the most environmentally suitable method. Possible disposal methods include transporting the oil to one of TVA's conventional coal-fired plants and blending it with the fossil fuels used there.

3. <u>Transformers and electrical machinery</u> - 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 drummed for ultimate 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 holding pool. At the holding pool the oil will be reclaimed for reuse 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 run-off 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 for indoor installations, either Askarel-filled or dry-type transformers will be used. When the former is used, the transformer will be located within a concrete curb to prevent the possibility of spillage of this liquid, which contains polychlorinated biphenyls, from entering the common floor drainage system. A floor drain in the confined area will carry any spillage to a separate storage sump or else the curb will be made high enough to hold the entire liquid content of the transformer. In either case, the liquid will be drummed for proper disposal if not suitable for reuse. Tentative plans are to return the liquid to the manufacturer for ultimate disposal.

4. Sanitary wastes - Extended aeration sewage treatment facilities will be provided during the construction period to treat the domestic wastes from a peak construction force of approximately 2,000 persons. Effluent from the plant will be chlorinated before entering 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 to storage, surplus, or new construction.

Secondary treatment facilities with provision for chlorination will be provided for the permanent plant. It is estimated that the ultimate operating force will number 170 permanent employees. The treatment facility will be designed to handle approximately 300 persons including permanent and temporary employees and visitors. During periods when a large temporary maintenance force is working at the plant, the permanent waste treatment will be supplemented by portable-type chemical toilets.

Both construction and permanent systems will be operated to prevent untreated effluents from entering the river. The design will be in accordance with approved sanitation standards applicable to TVA facilities and will meet Tennessee Pollution Control Board requirements.

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

5. Gaseous emissions - Each oil-fired auxiliary steam generator is expected to operate at an average of about 75 percent capacity, which will result in both units burning 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 40,000 lb/h steamflow with an input rating of about 55×10^6 Btu/h.

Emissions resulting from this 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 727 gallons/h of fuel.

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

Particulates	5.84 lb/h
Sulfur Oxides	5.74 lb/h
Carbon Monoxide	0.029 lb/h
Hydrocarbons	1.47 lb/h
Nitrogen Oxides	251.98 ton/yr

The emissions will be released through a stack which is approximately 127 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	0.23 ug/m^3	150 ug/m^3
Sulfur Oxides	24-hour	8.78×10^{-5} ppm	0.14 ppm
Carbon Monoxide	1-hour	5.08×10^{-6} ppm	35 ppm
Hydrocarbons	3-hour	2.93×10^{-4} ppm	0.24 ppm
Nitrogen Oxides	1-year	7.07×10^{-5} ppm	0.05 ppm

For this evaluation of the emissions from the auxiliary boilers, it can be seen that the emissions will have a negligible environmental impact.

6. Normal solid waste disposal - Normal solid waste disposal during plant operations will be accomplished by burying the waste either on the plant site or on other TVA grounds. This method of disposal is considered to minimize environmental impacts from solid waste.

Disposal of solid wastes during construction of the plant proper and transmission facilities is discussed in Section 2.8, Construction Effects, and Section 2.2, Environmental Aspects of Transmission Lines, respectively.

Table 2.5-1

SUMMARY OF ADDED CHEMICALS AND RESULTING END PRODUCT CHEMICALS

Watts Bar Nuclear Plant

System	Chemical Added Source Chemical	Maximum Annual Use lbs [a]	Waste End Product Chemical	Maximum Resulting End Product [a] Annual lbs	Mean Daily lbs
Makeup Water Filter Plant	Alum $Al_2(SO_4)_3 \cdot 18\ H_2O$	70,800	$Al(OH)_3$ [b]	16,510	45
	Soda Ash Na_2CO_3	23,685	Na^+	10,300	28
			SO_4^{--}	30,600	84
			Settled Solids[b,c]	70,800	194
	Chlorine CL_2	7,900	OCL^- and CL^-	7,900	22
Makeup Water Demineralizer	Sulfuric Acid H_2SO_4 (96%)	231,000	SO_4^{--}	217,000	595
	Sodium Hydroxide NaOH (50%)	431,000	Na^+	124,000	340
Natural Minerals Removed by Demineralizers					
	Sodium Na^+	10,120	Na^+	10,120	28
	Chloride Cl^-	19,700	Cl^-	19,700	54
	Sulfate SO_4^{--}	21,750	SO_4^{--}	21,750	60
	Total Dissolved Solids	117,500	Dissolved Soilds	117,500	322

Table 2.5-1 (cont.)

SUMMARY OF ADDED CHEMICALS AND RESULTING END PRODUCT CHEMICALS

Watts Bar Nuclear Plant

System	Chemical Added Source Chemical	Maximum[a] Annual Use lbs	Waste End Product Chemical	Maximum Resulting End Product[a] Annual lbs	Maximum Resulting End Product[a] Mean Daily lbs
Steam Generator Blowdown	Sodium Phosphate $Na_3PO_4 \cdot 12\ H_2O$	8,750[d]	Na^+ PO_4^{---}	1,590 2,190	4 6
	Ammonia NH_3	65[e]	NH_3	65	0.2
	Hydrazine H_2NNH_2	4,380[f]	NH_3	g	g
Auxiliary Steam Generator Blowdown	Ammonia NH_3	3[e]	NH_3	3	NIL
	Hydrazine H_2NNH_2	10[f]	NH_3	10	NIL
Raw Cooling Water System[h]	Acrolein $CH_2 = CHCHO$	205	Acrolein	--	--
Essential Reactor Cooling Water[h]	Acrolein $CH_2 = CHCHO$	251	Acrolein	--	--
Main Condenser Cooling System[i]	Chlorine Cl_2	146,000	OCL^- and CL^-	146,000	400

a. Based on 24-hour operation 365 days/y at rated capacity.
b. Precipitated material that will make up the water treatment sludge on a dry weight basis.
c. Estimates based on maximum suspended solids data observed at TRM 529.9.
d. Sodium Phosphate will be added to maintain 10 mg/l PO_4 within the system.
e. Ammonia will be added as needed to maintain pH of 9.0 in the system.
f. Hydrazine will be added as needed as a DO scavenger. Hydrazine conservatively assumed to decompose to ammonia.
g. Ammonia will be released to the atmosphere through the air vapor outlet.
h. Acrolein will be added to the system on 120 days for one-half hour each day. The acrolein demand of main condenser water system and cooling tower stripping will prevent any acrolein from being discharged to the aquatic environment.
i. Chlorine will be added to maintain 0.5 mg/l chlorine residual at condenser outlet for one-half hour each day.

Table 2.5-2

SUMMARY OF CHEMICAL DISCHARGES

Watts Bar Nuclear Plant

Waste Product Chemical	Maximum[a] Annual Discharge of Product Chemical lbs	Operating[b] Mode Normal (N) Increased Blowdown (I)	Waste[c] Product Chemical Contribution to Discharge Concentrations mg/l	Observed Concentrations in River At TRM 529.9 mg/l		Concentrations[d] in Effluent N(CF) = 2 I(CF) = 3 mg/l		Concentrations[e] in River at Edge of Jet Mixing Zone mg/l		Maximum[f] Allowable Concentrations mg/l	
				Average	Maximum	Average	Maximum	Average	Maximum	Effluent	River
Sulfates SO_4^{--}	269,350	N	2.204	16.6	27.9	35.404	58.004	18.48	30.91	1,400	250
		I	0.804	16.6	27.9	50.604	84.504	20.000	33.560		
Sodium Na^+	146,010	N	1.195	7.7	11.0	16.595	23.195	8.589	12.219	g	100
		I	0.436	7.7	11.0	23.536	33.436	9.284	13.244		
Chlorides Cl^-[h]	173,600	N	1.421	15.0	23.0	31.421	47.421	16.642	25.442	g	250
		I	0.518	15.0	23.0	45.518	69.518	18.052	27.652		
Ammonia NH_3	78	N	0.000638	0.087[i]	0.170[i]	0.1746	0.3406	0.096	0.187	6.1	0.6
		I	0.000233			0.2612	.5102	0.104	0.204		
Phosphate $PO_4^{\equiv}$	2,190	N	0.018	0.20[i]	0.29[i]	0.418	0.598	0.222	0.321	j	j
		I	0.007			0.607	0.877	0.241	0.349		
Dissolved Solids	657,148	N	5.378	89.8	127	184.978	259.378	99.32	140.24	g	500
		I	1.961			271.361	382.961	107.96	152.60		

a. Based on 24-hour operation, 365 days/y at rated capacity of equipment and maximum chemical requirements.
b. N-Normal Operation: Blowdown = 62 ft^3/s, I-Increased Blowdown after periods when blowdown was discontinued = 170 ft^3/s (62 ft^3/s normal blowdown, 48 ft^3/s extra blowdown to reduce concentration factor and 60 ft^3/s discharge from holding pond).
c. Equivalent concentration of added chemical end products in blowdown.
d. Concentration factor of blowdown = 2 during periods of normal blowdown, net concentration factor of blowdown = 3 during periods of increased blowdown (110 ft^3/s at CF = 4, 60 ft^3/s at CF = 1).
e. Based on jet diffuser designed to mix 9 volumes of river water with one volume of blowdown.
f. Tennessee Water Quality Control Board Guidelines.
g. No specific guideline identified.
h. Computation is for chlorides since the chlorine demand of the cooling water is such that no residual chlorine will be discharged.
i. Data observed at Fort Loudoun Dam tailrace TRM 602.3.
j. No effluent should contain more than 1.0 mg/l phosphates as P (3.2 mg/l as PO_4). The suggested stream limit is 0.01 mg/l as P (0.03 as PO_4) or background whichever is higher.

Table 2.5-3

SUMMARY OF OBSERVED TRACE METAL CONCENTRATIONS AND EXPECTED MAXIMUM TRACE METAL CONCENTRATIONS IN THE CONDENSER COOLING SYSTEM, DIFFUSER SYSTEM, AND AT THE EDGE OF THE JET MIXING ZONE

Parameter Total	Observed Concentrations at TRM 602.3 January-December 1971 μg/l			Maximum Expected Trace Metal Concentrations - μg/l[a]			Tennessee Water Quality Control Board[d] Guidelines - μg/l	
	Max.	Min.	Mean	Condenser Cooling[a] System CF = 4.0	Diffuser[b] Discharge Net CF = 3.0	At Edge of[c] Jet Mixing Zone 9:1 Mixing	Effluent	Stream
Iron	690	270	475	2,760	2,070	828	10,000	1,500 300[e]
Copper	10	<10	<10	40	30	12	1,000	20
Zinc	150	20	58	600	450	180	2,000	100
Barium	300	<100	<118	1,200	900	360	5,000	5,000 1,000[e]
Beryllium	<10	<10	<10	<40	<30	<12	f	f
Silver	<20	<10	<12.5	<80	<60	<24	50	5
Aluminum	130	<10	<38	520	390	156	250,000	1,000
Selenium	7	1	4	28	21	8	10	10
Arsenic	<30	<10	<25	<120	<90	<36	1,000	1,000 10[e]
Manganese	210	70	119.2	840	630	252	10,000	1,000 50[e]
Lead[g]	20	10	14	80	60	24	100	50

Table 2.5-3 (cont.)

SUMMARY OF OBSERVED TRACE METAL CONCENTRATIONS AND EXPECTED MAXIMUM TRACE METAL CONCENTRATIONS IN THE CONDENSER COOLING SYSTEM, DIFFUSER SYSTEM, AND AT THE EDGE OF THE JET MIXING ZONE

Parameter	Observed Concentrations at TRM 602.3 January-December 1971 µg/l			Maximum Expected Trace Metal Concentrations - µg/l[a]			Tennessee Water Quality Control Board[d] Guidelines - µg/l	
Total	Max.	Min.	Mean	Condenser Cooling[a] System CF = 4.0	Diffuser[b] Discharge Net CF = 3.0	At Edge of[c] Jet Mixing Zone 9:1 Mixing	Effluent	Stream
Chromium[g]	<20	<5	<11	<80	<60	<24	3,000	50
Nickel[g]	<50	<50	<50	<200	<150	<60	3,000	100
Cadium[g]	30	<1	<9	120	90	36	10	10
Mercury[g]	4	<1	<1	16	12	4.8	5	5

a. Assumes maximum observed concentrations occur simultaneous with periods when blowdown has been discontinued for 12 hours and the concentration factor in the condenser cooling system has increased from two to four.
b. When blowdown is resumed after periods of no blowdown the diffuser discharge is assumed to be as follows: Regular blowdown of 62 ft^3/s, cf = 4; Increased blowdown to reduce concentration factor = 48 ft^3/s, cf = 4; and holding pond discharge = 60 ft^3/s, cf = 1; therefore net cf = 3 (blowdown and holding pond discharges are variable).
c. Based on jet diffuser designed to mix 9 volumes of river water with one volume of plant discharge.
d. Tennessee Water Quality Control Board Guidelines obtained by letter dated July 19, 1972.
e. Guideline for streams classified for domestic water supply.
f. No guideline established.
g. Observed data from TRM 645.1.

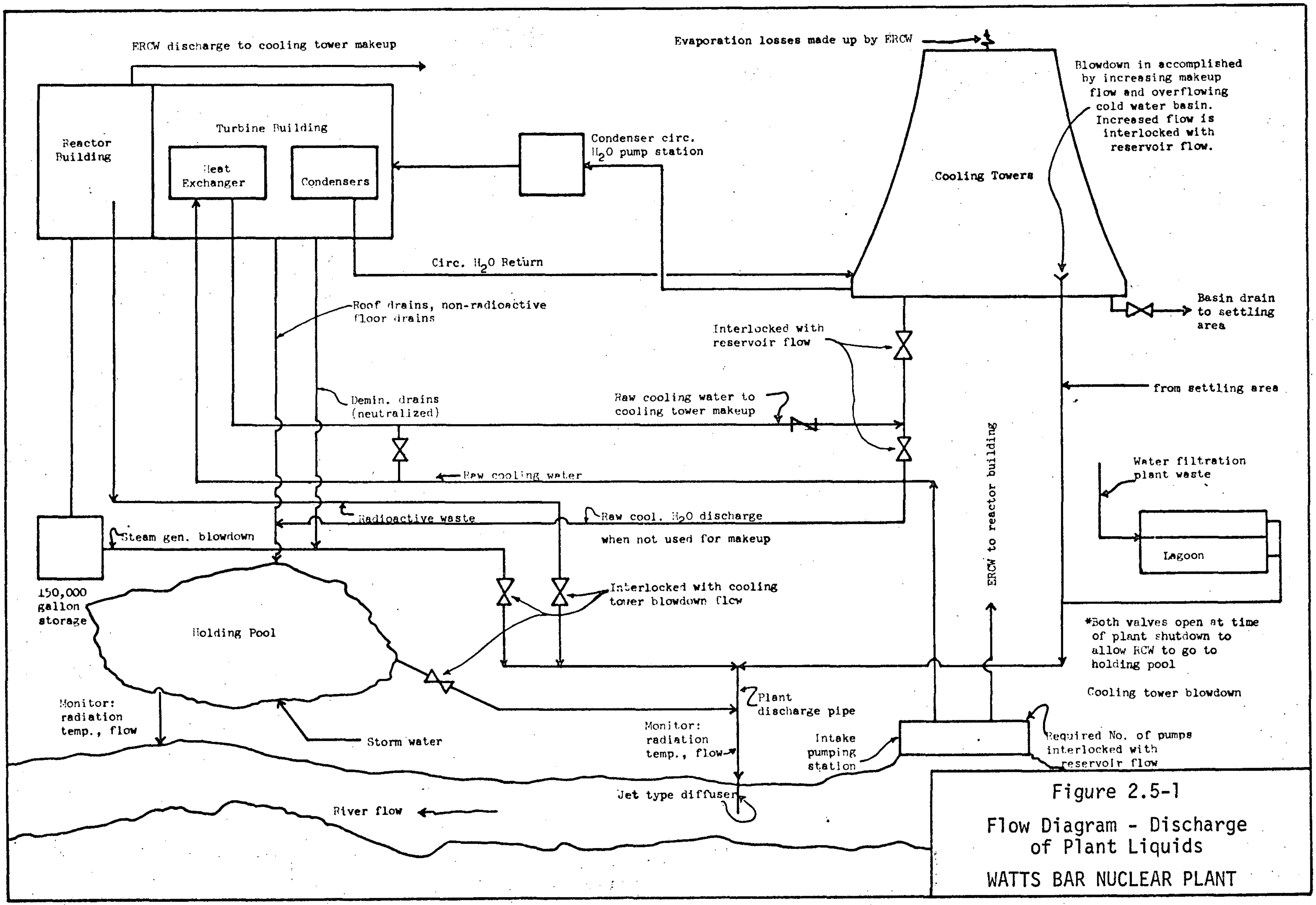


Figure 2.5-1

Flow Diagram - Discharge of Plant Liquids

WATTS BAR NUCLEAR PLANT

2.6 Heat Dissipation - All steam-electric generating plants must release heat to the environment as a consequence of producing electricity. 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 must be released to the environment.

The 2-unit Watts Bar Nuclear Plant will be located on the west shore of Chickamauga Lake near Tennessee River mile 528. The waters of the Chickamauga Reservoir must be of satisfactory quality for the following uses: municipal, industrial, and agricultural water supply; propagation of warmwater fish and other aquatic life; water-contact recreation; navigation; and the final disposal of treated municipal and industrial wastes. Of these uses, the propagation of warmwater fish and other aquatic life was judged to be the one requiring the highest degree of protection from thermal effects.

The temperature criteria of the State of Tennessee in effect at the time Watts Bar Nuclear Plant was originally proposed were as follows:

Water Use	Temperature Specifications
Public Water Supply Water-Contact Recreation Fish and Wildlife Industrial Water Supply	The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour. (The maximum temperature of recognized trout streams shall not exceed 68°F.) In no case shall the maximum temperature rise be more than 10°F above the stream temperature which shall be measured at an upstream control point.
Agricultural Water Supply	The temperature of the water shall not be raised nor lowered to such an extent as to interfere with its use.

These proposed criteria were excepted from approval by the Federal Water Pollution Control Administration (now the Water Quality Office of the Environmental Protection Agency). On July 27, 1971, the Tennessee Water Quality Control Board held a public hearing in Nashville, Tennessee, for the purpose of hearing testimony relating to the establishment of new temperature standards for all waters within the State of Tennessee. At this hearing, both the EPA and the Tennessee Game and Fish Commission recommended that in the main stream of the Tennessee River the rise above natural temperatures should not exceed 5°F and the maximum temperature should not exceed 86°F. The maximum temperature was to be measured at a depth of 5 feet in waters over 10 feet in depth, and at middepth in waters less than 10 feet.

At the October 26, 1971, meeting of the State of Tennessee Water Quality Control Board, revised temperature standards were adopted. The revised temperature standards applicable to all waters of the State of Tennessee were as follows: maximum temperature for warmwater fisheries, 31°C (87.8°F); maximum temperature for recognized trout streams, 20°C (68°F); maximum allowable rise above upstream natural temperature, 3°C (5.4°F); and maximum allowable rate of change, 2°C per hour (3.6°F). The temperature was to be measured outside the mixing zone at middepth in free-flowing streams and at a depth of 10 feet in lakes or impoundments.

On December 14, 1971, these proposed temperature standards were revised and, as amended, were officially adopted by the Tennessee Water Quality Control Board as a guide in determining the permissible conditions of water with respect to pollution. These revised standards are as follows: maximum temperature for warmwater fisheries, 30.5°C

(86.9°F); maximum temperature for recognized trout waters, 20°C (68°F); maximum allowable water temperature change, 3°C (5.4°F); and maximum allowable rate of change, 2°C per hour (3.6°F). The temperature of impoundments where stratification occurs will be measured at a depth of 5 feet or middepth, whichever is less, and the temperature in flowing streams shall be measured at middepth.

TVA received a letter from the Region IV office of EPA dated December 17, 1971, stating that that office was intensely pursuing the immediate adoption of thermal standards for the State of Tennessee. The Region IV office informed TVA that the Agency would not accept any maximums for the Tennessee River other than the following: "Temperature shall not be increased more than 3°C (5.4°F) above the natural prevailing background temperatures, nor exceed a maximum of 30.5°C (86.9°F)."

Since these maximums were the same as those adopted by the State of Tennessee on December 14, 1971, alternative cooling facilities for the Watts Bar Nuclear Plant were analyzed which would meet these limits.

In June of 1972 the State of Tennessee was notified by EPA that the amended standards as proposed on December 14, 1971, by the Tennessee Water Quality Control Board were approved.

1. <u>Description of the cooling system</u> - The engineering aspects of heat disposal from power generating facilities frequently are concerned with the transport of waste heat to the atmosphere by first discharging the heat to the natural water environment. However, it was recognized early in the site investigation studies for

the Watts Bar site that it was not practical to consider a once-through cooling system of river cooling for this plant. To meet cooling requirements at Watts Bar Nuclear Plant and at the same time provide environmental protection for the waters of Chickamauga Reservoir, closed-cycle natural draft cooling towers will be provided. This type of condenser cooling water system will enable the plant to operate with a minimal 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.

Hyperbolic cooling towers will use the natural draft created by warm water cascading over the fill section in the lower portion of the towers for cooling primarily by evaporation. The plant has been designed for two towers which will be 354 feet in diameter and 478 feet high. Figure 2.6-1 shows the tower arrangement.

For each unit approximately 410,000 gal/min of cooling water from the cooling towers is circulated through the condensers. The temperature of the water flowing through the condensers will be raised by approximately 38°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 77,500 gal/min, or 172 ft^3/s, will be withdrawn at the head of a channel feeding from the Chickamauga Reservoir at TRM 528. A maximum of about 51,000 gal/min, or 113 ft^3/s, of this withdrawal will supply water for the raw cooling water system and 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 the circulating water pumps for the towers with the water required for use as cooling tower makeup. Since the 2-unit maximum flow from these two raw cooling water systems will be approximately 113 ft^3/s, it will not meet makeup requirements in all cases, which at a maximum are about 172 ft^3/s. Therefore, additional (supplemental) intake pumps will be provided.

Normal water surface of the Chickamauga Reservoir varies between elevations about 683 (summer) and 675 (winter). The water intake pump structure is located at the end of a trapezoidal cross section intake channel in which the maximum water velocity of the cross section will be less than 0.1 foot per second even for a water surface elevation of 675. The intake structure will have four openings slightly over 5 feet wide and 22 feet high. The top of the opening is at elevation 674 and the bottom is at elevation 652. The maximum velocity of flow will be less than 0.4 foot per second through each of the openings. The openings are followed by traveling screens which have 3/8-inch opening mesh. The maximum screen velocity varies from about 0.5 foot per second during summer high-water level to about 1.0 foot per second during winter low-water level.

The depth of water in the intake channel which connects the intake structure to the reservoir will vary from 15 feet to 23 feet. The intake channel will have a bottom width of 50 feet with side slopes 4 feet horizontally to 1 foot vertically. The intake structure will be located about 850 feet from the existing shoreline (at elevation 683).

Normal blowdown from the natural draft towers will be discharged into Chickamauga Reservoir at a rate of 62 ft^3/s. The maximum rate at which heated water will be discharged into the reservoir will be 170 ft^3/s. Studies are being made to determine the proper type and the best location for the diffuser to provide the best dilution possible with the streamflow, consistent with the need to protect the aquatic biota of the reservoir. At the present time it is believed that the best diffuser design for the Watts Bar site and for this relatively wide range of discharges will be a multiple-nozzle jet-type diffuser.

At the Watts Bar site the reservoir is shallow, with depths ranging up to 25 feet at normal pool elevations. The reach of the river at the plant site has been designated a mussel sanctuary by the State of Tennessee. Better design data to take these factors into account are needed than are presently available; therefore, the final determination of the nozzle diameter, number of nozzles, nozzle angle, and whether to place the nozzles so as to discharge parallel to or perpendicular to the reservoir flow will have to be determined by laboratory tests.

Preliminary analysis shows that multiple nozzles can be used to mix the blowdown with the receiving water to meet the State of Tennessee temperature criteria, which limits the temperature change to 5.4°F and the maximum temperature to 86.9°F. The studies further indicate that the nozzles can be aligned parallel to or perpendicular to the reservoir flow. 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. This alternative was originally planned and discussed in the draft environmental statement for Watts Bar Nuclear Plant. However, the open pipe discharge and the buoyant jet would not achieve the required degree of mixing to meet the State water quality standards. Use of these alternatives could result in the formation of a large strata of heated water and some local fogging under certain conditions. For these reasons TVA decided 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.

2. Impact of heat dissipation facilities - After considering several alternative heat dissipation systems, 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 2.6.4), TVA decided to install closed-system natural draft hyperbolic cooling towers. This section describes the minimal environmental impacts which are anticipated as a result of installing and operating this system.

(1) Physical and chemical characteristics of the tower effluent - Normally, tower makeup will be taken from the discharge of the plant raw cooling water systems which will be obtained 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 172 ft^3/s.

Operation of the two natural draft cooling towers of the condenser circulating water system will evaporate approximately 31 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 dissolved solids content in the source river water, and the effluent standards imposed. This blowdown will be removed from the tower effluent (cold-water side) and normally will be discharged into Chickamauga Reservoir at a rate of 62 ft^3/s. The dissolved solids in the river for 1960-61 averaged approximately 100 mg/l with a peak of 153 mg/l. With a concentration factor of 2 (see section 2.5.1(1)), the blowdown flow would be well below the applicable stream standards of 500 mg/l for dissolved solids.

Since the plant site is located immediately downstream from the Watts Bar Hydro Plant and Dam, there will be insufficient water available to provide proper dilution of the cooling tower blowdown when hydro releases are not being made. At times of no release from the hydro plant all cooling tower blowdown will be stopped. An electric interlock of diversion valves and pumps will be provided to allow cooling tower blowdown only when flow is being released from the dam. During periods of no release from Watts Bar Hydro Plant, the excess raw cooling water (about 51 ft^3/s) which is not needed to replace evaporation and drift will be stored in the holding pool. Periods of no flow below Watts Bar Dam occur frequently but seldom last longer than 12 hours. Historical data show that from 1950 to 1970 there were only 5 full days of zero release from Watts Bar Hydro Plant. The longest period of shutdown was just over 2 days and was to aid in the treatment of Eurasian watermilfoil in Chickamauga Reservoir. Other periods of shutdown were to permit the surcharging of Watts Bar Reservoir to strand drift and provide a clean shoreline. These shutdowns were controlled by TVA and were planned operations. Therefore, after Watts Bar Nuclear Plant becomes operational the blowdown requirements of Watts Bar Nuclear Plant will be considered before the releases of the hydro project are restricted.

When streamflows are restored following shutdowns, the maximum rate at which heated water will be discharged into Chickamauga Reservoir will be 170 ft^3/s, consisting of flow from the holding pool (about 60 ft^3/s) and an increased cooling tower blowdown (about 110 ft^3/s) to lower the solids concentrations to normal levels. After the excess storage in the holding pool has been discharged and the blowdown has reduced the solids concentration to normal, the discharge to Chickamauga Reservoir will be reduced to the normal 62 ft^3/s rate.

Water temperature records for releases from Watts Bar Hydro Plant for 1967-71 are shown in Table 2.6-1 and show a maximum water temperature of 80.6°F. Therefore, with a maximum allowable temperature of 86.9°F for Tennessee, the controlling criteria will be the temperature change of 5.4°F in the receiving waters.

The temperature of this blowdown water will be approximately 85°F under average summer conditions. A peak summer condition might produce temperatures near 95°F. Based on water temperature data collected over a 10-year period and using meteorological data for Knoxville and Chattanooga to estimate the wet-bulb temperature and relative humidity for the Watts Bar site, the maximum temperature differential between the blowdown and the receiving water was determined to be 49°F. Under more normal conditions the blowdown will be about 16°F warmer than the receiving waters. It has been determined that the minimum operating level for one of the hydro units at Watts Bar is at a minimum release of 3,500 ft^3/s. Normally, releases from the hydro plant are much greater than 3,500 ft^3/s and average over 20,000 ft^3/s on an annual basis. The diffuser system will be designed for a discharge capability of 170 ft^3/s, of which some 60 ft^3/s will be from the holding pool and will not be as warm as the tower blowdown. Nevertheless, for design purposes the full 170 ft^3/s is assumed to be at the temperature of the tower effluent. It is within the current state of the art to design a jet diffuser with the capability of achieving a dilution of 10. Therefore, with a minimum hydro plant release of 3,500 ft^3/s, a maximum blowdown discharge of 170 ft^3/s, and a maximum temperature difference between the blowdown and the receiving waters of 49°F, the maximum temperature rise to which the river will be subjected will be less than 5.4°F even for this worst condition. For more normal temperature differences between the blowdown and the receiving water but still for a riverflow of only 3,500 ft^3/s, the mixed temperature of the reservoir will be less than

$2^{\circ}F$ above the temperature of the receiving water. A final determination of the thermal monitoring program for the Watts Bar Nuclear Plant has not been made. However, proposed thermal monitor locations will be determined to insure adequate documentation of compliance with the thermal standards.

During periods when blowdown is being withheld, the water used for cooling the raw water systems in excess of that required for tower makeup will be diverted to the holding pool with a temperature approximately $13^{\circ}F$ above river temperature. The normal level of the holding pool will provide 190 acre-feet of storage. The holding pool will receive all discharges from storm drains, roof and nonradioactive floor drains and when blowdown is being withheld, the raw cooling water. This water will be stored in the pool until flow is restored from Watts Bar Hydro Plant. Three dikes will be constructed to form the holding pool. The tops of two of the dikes will be set at elevation 714 with the top of the third dike set at elevation 707 and designed as an overflow weir. A concrete skimmer will be located inside the holding pool adjacent to this overflow dike to retain oil and floating debris. The top of the dikes and overflow weir will be located above the maximum flood of record (regulated) in order to retain oil and debris for all flood conditions except those which are highly improbable. The bottom of the skimmer wall will be below the top of the outlet level. While some cooling of the warmed water may occur in the holding pool, the surface area (a maximum of about 30 acres) would not be sufficient to provide cooling of any consequence. A valved outlet from the holding pool to the cooling tower blowdown line capable of carrying

60 ft^3/s will be provided. When flow is restored at the hydro plant and cooling tower blowdown is resumed, the valved outlet will be used to discharge flow from the holding pool through the blowdown discharge system until the holding pool is returned to its normal storage capacity. Overflow of the holding pool may occur when large storm waterflows enter the pool at the same time that heated water is being stored from the raw cooling water system. No impact to the reservoir is expected since the 13°F discharge to the pool will mix with the storm water before spillage over the overflow.

If for some unforeseen reason the condenser circulating water should spill from the towers, a considerable portion of the heated water could flow to the reservoir. However, the structural design of the cooling towers will be by a domestic engineering firm, using conservative design techniques based on modern design of existing natural draft towers and the risk of failure is considered small. Of course, if the tower structures should fail, operation would cease until the necessary cooling facilities could be reconstructed.

The estimated amount of drift will be approximately 50 gal/min for each tower, or about 0.2 ft^3/s total.

(2) <u>Local fogging and icing</u> - Potential environmental effects from natural draft cooling tower operation 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 of nearby objects when surface temperatures are below freezing.

Meteorological data indicate that naturally occurring heavy fog (visibility 1/4 mile or less) may occur in the Watts Bar area about 35 days per year. This compares to about 25 days per year at the Browns Ferry Nuclear Plant area in north Alabama or to the maximum occurrence in the United States of 60 days in some valley areas of the central Appalachians.

Fogs occurring in the Watts Bar 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. Heavy fogs normally occur during late evening through midmorning hours when weak wind and optimum radiational cooling conditions prevail. Naturally occurring heavy fogs in the Watts Bar area have the highest frequency during late fall through winter. The lowest frequency occurs during late spring through late summer.

The evaluation of the potential environmental effects from operation of the natural draft and mechanical draft cooling tower alternatives was based on field observations from August 1, 1970, to August 31, 1971, at the TVA Paradise Steam Plant in Kentucky. During this period one or more of the three natural draft cooling towers 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 the Paradise meteorological station and Nashville rawinsonde data. All data were reduced for analysis and extrapolated to the Watts Bar area.

Since the length of the visible cooling tower plume depends primarily on the moisture content of the ambient air, observed plume lengths at the Paradise Steam Plant cooling towers were correlated with the absolute humidity deficit or the amount of moisture a parcel of air can contain at saturation for a specific dry-bulb temperature, less the actual amount of moisture present. This correlation has been acknowledged by other investigators[1,2] but to our knowledge has not been confirmed with actual field data such as those collected (and continuing to be collected) at the Paradise power plant. Observed plume lengths and humidity deficits were fitted by the least squares method. Observed plume lengths determined in this way were correlated to wind direction by extrapolation of 12 months (August 1970 to July 1971) of early morning Nashville rawinsonde data to the Watts Bar area. The rawinsonde data were tabulated for two layers, 0 to 1,000 feet and 500 to 3,000 feet, for identifying mean meteorological conditions applicable for the lower mechanical draft towers (height

60 feet) and the higher natural draft towers (height 478 feet). Also, a correctional factor was applied for the larger cooling tower evaporation rate at Watts Bar.

The data analysis was then used to construct radial graphs giving the directional frequency by compass point sector of the expected plume lengths for both the mechanical and natural draft cooling towers and for periods of above and below freezing temperatures. The plume length data from which the graphs were drawn were separated into the sixteen 22-1/2 degree compass point sectors. Radial distances on each graph represent plume lengths up to 5 miles; plotted contours represent percentages of occurrence of plumes equal to or greater than the indicated length for each of the sixteen compass point sectors.

No significant environmental effects are anticipated from the natural draft cooling tower operation at the Watts Bar Nuclear Plant. With the average plume rise ranging from 500 to 1,000 feet above the 478-foot towers, the visible portion of the elevated plume would seldom, if ever, reach the level terrain of the valley floor and cause localized fogging. Therefore, the natural draft cooling towers are not expected to have any effect on ground transportation. On rare occasions the plume could strike the 1,500- to 1,800-foot high Walden Ridge which flanks the valley to the northwest at distances of 5 to 7 miles from the plant site and cause some local fogging and light icing during periods of freezing temperatures.

No increased density or frequency of ground fog resulting from the cooling tower plumes is expected in the valley area. During periods of heavy natural fog, the air within the lower 1,500 feet, including the cooling tower plumes, will be moderately stable; therefore, no mixing of the plume to ground level and resulting intensification of the lower fog layer will likely occur.

The most noticeable environmental effect of natural draft cooling tower operation would be one involving aesthetics. The elevated plumes have dimensions that could be visible within 5 to 10 miles from the plant site. The estimated width of the combined plumes from the two cooling towers would be 0.44, 0.56, 0.67, 0.75, and 0.91 mile at respective distances of 1, 2, 3, 4, and 5 miles from the plant.

Assuming continuous full load cooling tower operation for a 1-year period, the visible plumes should move northeast 10 percent and east 10 percent of the time with lengths equal to or greater than 0.5 mile during the early morning hours as indicated in figure 2.6-2. One percent of the time (about 4 days per year) the plume should extend about 4 miles in each of the sectors north-northeast through southeast.

The data suggest that an icing potential does exist on 60 to 70 days (300 to 350 hours) per year during the 5-month period, November through March, when freezing temperatures are normally expected. The majority of these potential icing conditions would occur within about 5 miles (figure 2.6-3) from the plant and primarily in the southerly sectors.

However, observations at the Paradise Steam Plant during the winter seasons of 1969 and 1970 indicated no occurrence of significant icing attributable to the operation of the three natural draft cooling towers, although fallout of ice crystals from the plume was observed on one occasion. Therefore, based on these observations, the icing at the Watts Bar site should not be significant.

Because of the height of the natural draft cooling towers, direct contact icing, if any, will be limited. On rare occasions some icing could occur in the Walden Ridge area northwest of the plant. Light fallout of freezing precipitation from the bottom of the plume should occur rarely.

When cooling tower plumes are moving to the north-northeast and northeast directions, they could merge with the plumes from the Watts Bar coal-fired steam plant 3,000 feet downwind. The coal-fired plant has operated less than 2,500 hours in the last 15 years and is equipped with electrostatic precipitators designed for 95 percent efficiency. Figure 2.6-2 indicates that visible cooling tower plumes could move over the power plant area about 14 percent of the time (northeast, 10 percent; north-northeast, 4 percent). However, due to the 278-foot higher elevation of the 478-foot cooling towers relative to the top of the stacks at the Watts Bar Steam Plant and the predominantly neutral or unstable dispersion conditions with the upvalley winds, the vapor plume would normally be higher than the plume from the steam plant which only operates part time. Therefore, there would usually be no mergence of the plumes for some distance downwind of the steam plant. At this point both plumes would be well dispersed. With the more stable downvalley wind when the Watts Bar Steam Plant plumes would move toward the cooling towers (southwest, 2 percent; south-southwest, 4 percent) with relatively little rise, there could be some mergence effects in the immediate area of the cooling towers.

Based on observations at the Paradise power plant, the only effects of this type of mergence have been identified with acid fly ash fallout, particularly during plant unit startup and shutdown when the electrostatic precipitators are not operating at design efficiency. Under such conditions, some significant acid mist and acid fly ash fallout could occur. Such effects would be confined to within one-half to one mile of the plant and, in most cases, would be in the form of slight staining on metal objects and slight markings on vegetation. Steps will be taken which could include a change in fuel, plant operation limitations, or temporary shutdown of the coal-fired units whenever the nuclear and coal-fired units are operating simultaneously and the potential for plume mergence is likely to occur. However, since the anticipated future operation of the Watts Bar Steam Plant is expected to be limited to system peak conditions, and because of the low-sulfur content of the fuel, the effects of plume mergence should be minimal.

(3) Aesthetics - The hyperbolic form and concrete materials will be compatible with the architecture of the main plant and would not require any special aesthetic treatment.

The natural draft cooling towers being 478 feet high would most certainly become a landmark on the surrounding terrain. The extensive plumes would increase this effect.

(4) Noise - 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.

3. Applicability of Section 21(b) permit - Under the provisions of Section 21(b)(6) of the Water Quality Improvement Act of 1970, TVA as a Federal agency is not required to obtain the certificate of compliance with applicable state water quality standards required by Section 21(b) of that Act. TVA is, however, obligated by Section 21(a) of that Act and by Executive Order 11507, "Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities," to meet all state water quality standards in the operation of its facilities.

The thermal discharge will not affect the quality of the waters of any other state.

4. 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, mechanical draft cooling towers, natural draft cooling towers, 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. This resulted in a complete analysis of only the cooling tower alternatives.

(1) Once-through cooling - The Watts Bar Nuclear Plant will be located approximately 2 miles downstream from the Watts Bar Dam, and the flow past the site is therefore dependent on releases

from the dam. Figure 2.6-4 shows a duration curve of the hourly releases from the dam for the 1959-68 time period. Assuming 100 percent mixing of the condenser cooling water over 75 percent of channel width with the river, a flow of approximately 17,200 ft^3/s would be required to assure that the temperature rise in the river would not exceed 3°C. As indicated by this figure, there would be insufficient flow about 35 percent of the time and no flow about 10 percent of the time. While it might be possible to alter the operation of the hydro plants, it would not be feasible to provide a continuous release of 17,200 ft^3/s during sustained dry periods or during certain portions of the year when upstream reservoirs are being filled. For example, an examination of the hourly flow duration curves for the month of April based on 1959-68 records indicated that no flow existed about 17 percent of the time and flows are less than 17,200 ft^3/s about 50 percent of the time in April. For the month of May similar data showed no flow 16 percent of the time and flows less than 17,200 ft^3/s over 50 percent of the time.

Therefore, while at other TVA plant sites it has been practical to consider the use of once-through river cooling as a heat dissipation method, it was recognized early in the investigation that a once-through cooling system using a diffuser at the Watts Bar site is not a feasible alternative for heat dissipation.

The combined-cycle system of alternatively operating the auxiliary cooling facilities in closed, open, or helper modes is not readily adaptable to the Watts Bar Nuclear Plant since mode changes would be required twice daily during the frequently occurring daily flow variations. Therefore, the facilities would be designed for closed-cycle operation only.

(2) Mechanical draft cooling towers - The use of cross flow mechanical draft cooling towers as an alternate cooling method would require six cooling towers, each 55 feet wide by 60 feet high by 375 feet long.

Normally, tower makeup water would be taken from the discharge of the plant auxiliary and essential raw cooling water system. The main circulating water pumps would circulate water to the condenser and to the towers. In mechanical draft towers, the water is broken into drops by falling through the tower fill. Heat from the drops is transferred to the airflow which is induced by large fans. The water returning from the towers flows by gravity back to the condenser intake where the circulating water pumps are located.

(a) Feasibility - Closed-cycle mechanical draft cooling towers are suitable for application to the Watts Bar Nuclear Plant. Figure 2.6-5 shows a possible location and arrangement of the six mechanical draft towers on the plant site.

(b) Land requirements - The use of mechanical draft towers as an alternative means of cooling would not require the purchase of additional land beyond that already owned.

(c) Environmental considerations -

Physical and chemical characteristics of tower effluent - Water necessary for continuous operation of the system would be obtained from the Tennessee River at the plant site. The blowdown required to prevent the buildup of dissolved solids which would otherwise interfere with operation is estimated to be 3.8 percent of the circulating waterflow, or about 70 ft^3/s. The temperature of this blowdown water for the mechanical draft towers would be approximately 83°F under average summer conditions. Peak summer conditions can produce temperatures near 95°F a few hours a day on the hottest summer days. The blowdown diffuser system to discharge the blowdown from the mechanical draft cooling tower to the reservoir would be of about the same design as for the natural draft towers. Discharges through the blowdown diffuser for this system would also be made only when Watts Bar Hydro Plant is discharging at least 3,500 ft^3/s. With this minimum flow of 3,500 ft^3/s, a maximum temperature rise for the blowdown which would be slightly less than for the natural draft system and assuming a dilution of 10, the maximum temperature change to which the river will be subjected is less than the 5.4°F standard even for the worst situation.

Evaporative water losses for the mechanical draft towers are estimated to be about 4 percent of the circulating waterflow, or 74 ft^3/s.

Drift, which is water that is blown out of the tower, has been estimated by the cooling tower manufacturers to involve quantities from 0.03 percent to 0.2 percent of the circulating waterflow, or 0.6 to 4.0 ft^3/s for the plant.

With a blowdown concentration factor of 2, the total makeup required would be approximately 8 percent of the circulating flow, or 148 ft^3/s.

Local fogging and icing - Potential environmental effects from mechanical draft cooling tower operation 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 objects when surface temperatures are below freezing.

The general discussion of the local atmospheric conditions and methods of analysis described under section 2.6.2(2) for the natural draft towers is applicable to the mechanical draft towers.

Environmental effects from the operation of the mechanical draft cooling towers at the Watts Bar Nuclear Plant will include considerable fogging and possibly icing within about 5 miles of the cooling towers. The effects will be more significant than the potential effects from the higher plumes of the 478-foot natural draft cooling towers.

In some cases the visible plumes from the mechanical draft towers could 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 the most likely conditions occurring between 3 and 8 a.m.

Most fogging would probably occur southwest of the plant in the direction of the highest frequency of plume occurrence, as indicated in figure 2.6-6. About 13 percent (47 days) of the total days the plume would be transported in this sector with lengths equal to or greater than 0.5 mile. These plumes could aggravate natural fogging conditions. Therefore, the frequency of fog immediately southwest of the plant would be increased.

Periods of potential icing conditions, when the ambient temperature is below freezing, could cause some hazard to traffic in the local area. The data indicate that cooling tower induced icing could occur on 70 days (about 350 hours) per year during the 5-month period, November-March, with the highest frequency expected in January and February. Duration of heaviest icing would depend on the persistence of the below-freezing temperatures with the most likely occurrence from midnight to 7 a.m. The directions with the maximum frequency of plume travel during icing conditions are southeast and south-southeast as shown in figure 2.6-7. These conditions could extend to 4 or more miles less than 1 percent of the time in these sectors. On such occasions some light to moderate icing could be encountered by traffic on nearby paved roads and possibly by river traffic.

When cooling tower plumes are moving to the north-northeast and northeast directions, they could merge with the plumes from the Watts Bar coal-fired steam plant 3,000 feet downwind. Plumes from mechanical draft cooling towers with lengths of about 0.5 mile or greater could occur in these two sectors about 16 percent of the time. Plume mergence could also occur when the plumes from the coal-fired plant move south-southwest and southwest toward the cooling towers about 23 percent of the time. As discussed in section 2.6.2(2) for natural draft towers, such effects at Watts Bar are expected to be confined to within one mile of the plant site, and steps to reduce the effect will be taken whenever the nuclear and coal-fired units are operating simultaneously and the potential for plume mergence is likely to occur. The potential effects of plume mergence would be in the form of slight staining of metal objects and slight markings on vegetation.

Aesthetics - The materials of mechanical draft towers are not compatible with the architecture of the powerhouse; therefore, design features would be incorporated to achieve all possible 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 cooling towers would increase noise levels at the plant site by a small increment. This increase would be due to the fans and the falling water. Predicted sound pressure levels from one major manufacturer of cooling towers are 76 dB at 250 Hz, 63 dB at

2,000 Hz, and 59 dB at 8,000 Hz--all 50 feet from the louvered face (re 0.0002 microbar).

(d) Economic considerations - The economic comparison will be made using the natural draft tower system as a base for operation and maintenance cost.

Initial investment - The initial investment required to install mechanical draft towers is estimated to be $36.6 million.

Capability - The mechanical draft cooling tower system has an optimum economic selection point at a lower tower approach than that for a natural draft system. For this reason the turbine backpressure is more favorable and the plant efficiency correspondingly greater. This higher efficiency results in greater output for the plant as compared with the base system. The effect is as follows:

Capacity gained over base - 5,192 kW

Added plant value, present worth in terms of 1972 dollars - 1,300,000

Operation and maintenance - The use of mechanical draft cooling towers instead of natural draft cooling towers would have the effect of increasing the efficiency and the offsetting effect of added fan power and tower maintenance costs. These effects are as follows:

Heat rate, percent decrease	0.2
Heat rate, Btu/kWh decrease	21

Present-Value Evaluation (Dollars)

Efficiency gain	(-)700,000
Fan power cost	5,500,000
Total operation cost	4,800,000
Maintenance cost	2,500,000
Total operation and maintenance cost	7,300,000

(e) Construction schedule - It is expected that the design, construction, and placement into operation of mechanical draft cooling towers would take approximately 19 to 25 months.

(3) Natural draft cooling towers - The plant has been designed for the use of two natural draft cooling towers in a closed-cycle system. The towers will be 354 feet in diameter and 478 feet high.

Makeup will be taken from the discharge of the auxiliary and essential raw cooling water supplies, and tower blowdown will be taken from the tower basins. The main circulating water pumps circulate water to the condensers and to the towers. Water falls through the fill and heat from the water is transferred to the air. Airflow is created in the tall hyperbolic shells. The cooled water then flows by gravity back to the condenser intake.

(a) Feasibility - Natural draft cooling towers have been used for many years. The first unit in the United States, at the Big Sandy plant, was built and put into operation in 1962. The largest tower in operation, to our knowledge, is

320 feet in diameter and 452 feet high. The following large counter-flow towers are now under construction:

American Electric Power - Amos Plant - 400 feet diameter x 492 feet high

Portland General Electric - Trojan Plant - 385 feet diameter x 492 feet high

Toledo Edison and Cleveland Electric - Davis-Besse Plant - 411 feet diameter x 492 feet high

Cincinnati Gas & Electric - Zimmer Plant - 383 feet diameter x 479 feet high

Figure 2.6-1 shows the tentative location and arrangement of the two natural draft towers on the plant site.

(b) Land requirements - The use of natural draft cooling towers will not require the purchase of any additional land beyond that already owned.

(c) Environmental considerations - The environmental considerations for natural draft towers are discussed in section 2.6.2.

(d) Economic considerations - The initial investment required for the installation of the natural draft tower system is approximately 41.6 million dollars. This system is used as a base for comparing operation and maintenance costs with a mechanical draft tower system.

(e) Construction schedule - It is expected that the design, construction, and placement into operation of natural draft cooling towers would take approximately 36 to 42 months.

(4) Spray canal system - The investigation showed the only location available for a spray canal locates it in an area which is restricted by the reservoir on one side and a high ridge on the other side of the plant, as shown in figure 2.6-8.

The high ridge along the west side of the plant would have a serious effect on the performance of the spray canal when the prevailing wind is from the west through the south-southwest quadrants (about 21 percent of the time).

Because of this adverse effect on the performance of the spray canal, it was concluded that a spray canal could only be effectively utilized in conjunction with a cooling lake. Therefore, the spray canal was not considered to be a feasible alternative except for use to augment a cooling lake.

(5) Cooling lake system - Preliminary investigations indicate that the use of a cooling lake system would require approximately 3,500 acres of exposed water surface. At the Watts Bar site the only area available within several miles is the valley lying to the west of the plant site beyond the ridge line (figure 2.6-9). This valley contains a natural drainage area of about 2,100 acres bounded by ridge lines on the west, north, and east and by a natural saddle in the valley floor on the south side. The elevation of this saddle suggests a lake surface elevation of approximately 740 feet. From this saddle the valley floor drops progressively to the Chickamauga Reservoir elevation of 683 feet in a distance of about 2 miles. In order to increase the lake size to the required 3,500 acres it would be necessary to construct a dam across the valley about 1.5 miles south of the saddle. This dam would be more than 2 miles long and at

least 80 feet high in several locations. The construction of a dam to increase the lake size does not appear to be a practicable alternative.

In order to construct a 2,100-acre cooling lake in this area, it would be necessary to displace the Yellow Creek fish hatchery to some other location or dispense with it altogether. In addition, the railroad and highway leading westward from the Watts Bar Dam site would have to be relocated for a distance of approximately a mile. Approximately 40 residences would have to be removed as well as two churches and a few other buildings. There is a large spring in the area that would be covered. This spring would have to be carefully sealed to prevent the possibility of a contamination of the underground water system by the lake water.

In addition to the several dikes that would have to be built, it would be necessary to extend a tunnel from the plant site to the northwest approximately 2,000 feet to reach elevation 740 in order that the system would not require more than one pumping station. Spray modules could be placed in the lower lake connecting the plant discharge to the pumping station. These spray modules would be needed to augment the cooling capacity of the 2,100-acre lake.

The combination of inadequate lake area (making spray modules necessary), the necessary relocation of the highway and railroad, the loss to users of 2,100 acres of farmland, the necessity to move or destroy the Yellow Creek fish hatchery, and the construction of several dikes and a 2,000-foot-long tunnel makes the environmental consequences of this alternative unacceptable.

(6) Evaluation of alternative heat dissipation facilities - To minimize the thermal effects on Chickamauga Reservoir, TVA has decided upon a closed system utilizing counterflow natural draft cooling towers to dissipate the waste heat. TVA has concluded as discussed above that the installation of the diffuser system or the spray canal is not a feasible alternative for heat dissipation and that the cooling lake is environmentally unacceptable.

Since cooling towers were the only alternatives which were both feasible and environmentally acceptable, the extensive considerations and detailed analyses were limited to mechanical draft and natural draft cooling towers.

As an alternative to the presently proposed water intake requirements and design, TVA considered a scheme which would reduce the amount of water intake by utilizing the natural draft cooling towers to also cool the heat exchanges in the secondary steam section of the generating plant. However, to do so would require larger and more expensive heat exchangers with a resultant decrease in overall plant efficiency. As discussed, the intake channel velocities for the proposed system are very low and no significant environmental impacts are expected (see section 2.7). TVA does not believe the expense and associated problems of this alternate scheme are justifiable.

Operational trade-offs with regard to the limitations of the cooling tower system include those problems associated with the cooling tower system as opposed to once-through river cooling. Obviously going to a closed system cooling tower arrangement greatly reduces the quantity of heated water discharged to the receiving stream, but at a sacrifice in overall plant efficiency due to operation at higher turbine back pressures. The total solids load in the river would be about the same (some solids may be carried out of towers in the drift), but the concentration of solids in the cooling tower blowdown would be much higher. The intake structure, the water withdrawal facilities, and the discharge facilities are all smaller in size for the closed cooling tower system than would be required for a once-through river cooling system.

Because of evaporation losses associated with cooling towers, the dissolved solids contained in the reservoir water will be concentrated within the circulating cooling water. Since the waters of Chickamauga Reservoir show a tendency to scale, operating the towers at high solid concentrations probably would make it necessary to feed chemicals to the system to prevent scaling and fouling. Operating the system at higher levels of concentrations, while lowering the intake rates, and lowering the heated discharges, would aggravate this problem. As discussed in other sections of this document, no significant impacts are expected from the system as proposed. In addition, the cooling water required for the plant auxiliaries will be used for tower makeup, and normally this flow will provide almost all of the tower requirements. As a result, even if the system were operated at a much higher concentration factor, the withdrawal rate from Chickamauga would only be reduced by a slight amount since cooling water would still be required for the heat exchangers of the raw cooling water systems. TVA believes that where adequate water is available for makeup and adequate water is available in the receiving stream to accept the blowdown without exceeding water quality criteria in either case, the cooling tower concentration factors should be held to low levels to maintain good equipment reliability and lower operating and maintenance costs. Actual operating experience at the plant will be observed and may show that operating under normal conditions at concentration factors above 2 would be practicable in which case the amount of heated blowdown would be reduced.

The following table summarizes the present worth cost comparison (1972 dollars) of the feasible alternatives:

Tower Type	Mechanical Draft	Natural Draft
Average Annual Net Turbine Heat Rate, Btu/kWh	9,705	9,726
Initial Investment	$36,600,000	$41,600,000
Operating Cost	4,800,000	Base
Capability Cost	(-)1,300,000	Base
Maintenance Cost	2,500,000	Base
Total	$42,600,000	$41,600,000

Due to the one million dollar economic advantage and the smaller potential for fogging and icing, TVA concluded that the natural draft cooling tower installation represents the most attractive alternative heat dissipation method for the Watts Bar Nuclear Plant.

Table 2.6-1

OBSERVED WATTS BAR DAM TAILRACE WATER TEMPERATURE DATA

(Weekly Observations)

Week Number	1967-71 Average Temperature °F.	1967-71 Maximum Temperature °F.
1	46.5	48.2
2	42.6	45.3
3	42.4	44.6
4	42.3	45.1
5	42.9	45.1
6	43.8	46.4
7	44.2	46.4
8	45.1	48.2
9	46.4	51.8
10	46.2	50.0
11	49.1	51.8
12	50.1	52.2
13	52.9	55.6
14	55.4	59.0
15	57.7	60.8
16	60.1	64.4
17	61.0	64.4
18	63.2	64.9
19	63.6	66.2
20	66.2	68.0
21	66.0	68.0
22	70.2	73.4
23	71.6	75.2
24	72.0	73.4
25	74.0	75.2
26	74.3	75.2
27	75.6	77.8
28	76.3	77.8
29	75.2	77.0
30	75.6	77.0
31	76.6	80.6
32	76.3	77.8
33	76.6	77.8
34	76.3	77.0
35	76.7	77.9
36	76.5	77.9
37	76.4	77.8
38	75.9	77.8
39	74.3	77.0
40	73.0	77.8
41	71.4	73.4
42	71.1	73.4
43	66.9	69.8
44	65.8	71.6
45	61.6	62.6
46	58.3	60.8
47	55.0	57.2
48	53.4	54.5
49	51.4	53.6
50	50.5	52.7
51	49.6	53.6
52	47.7	52.7

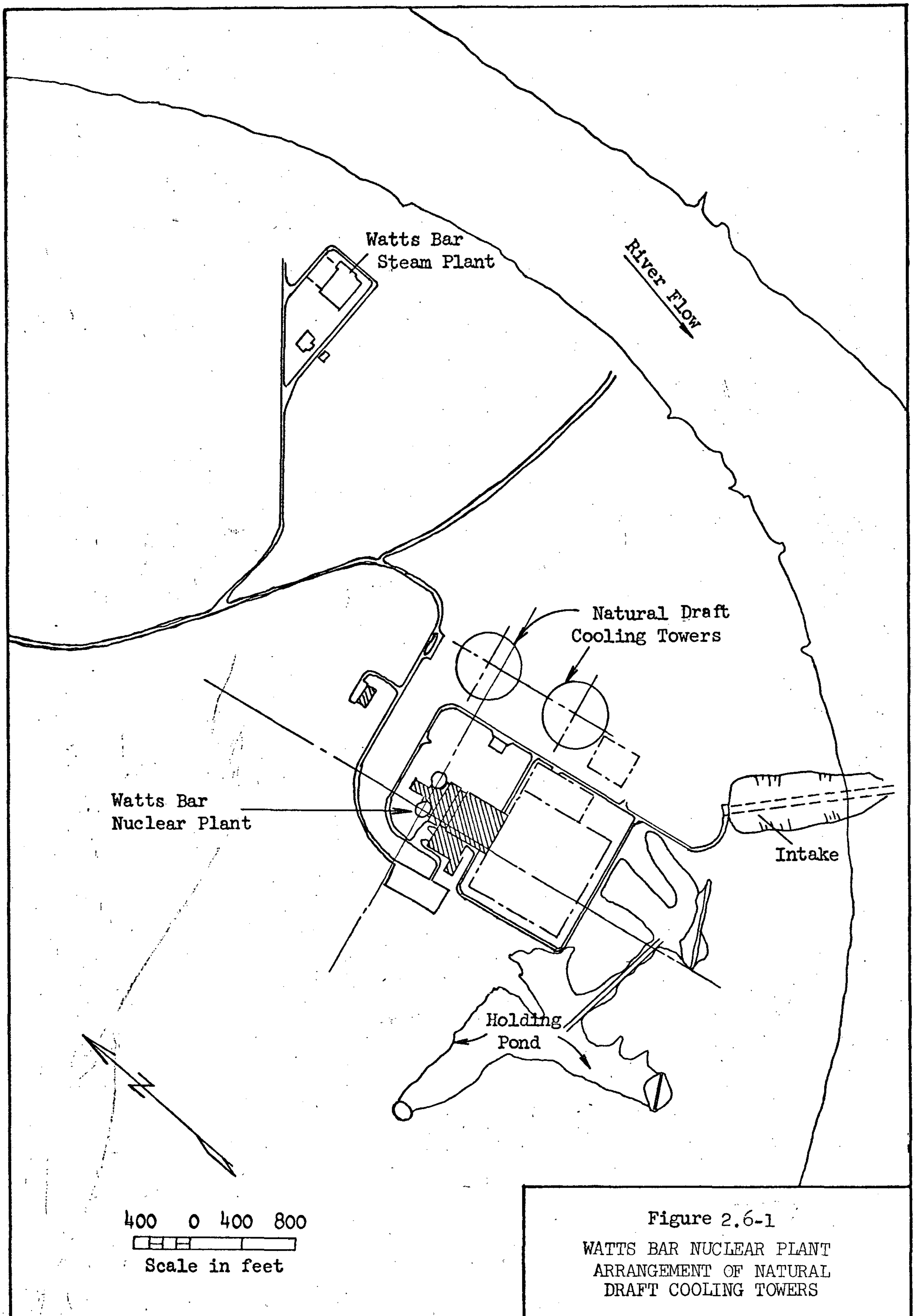
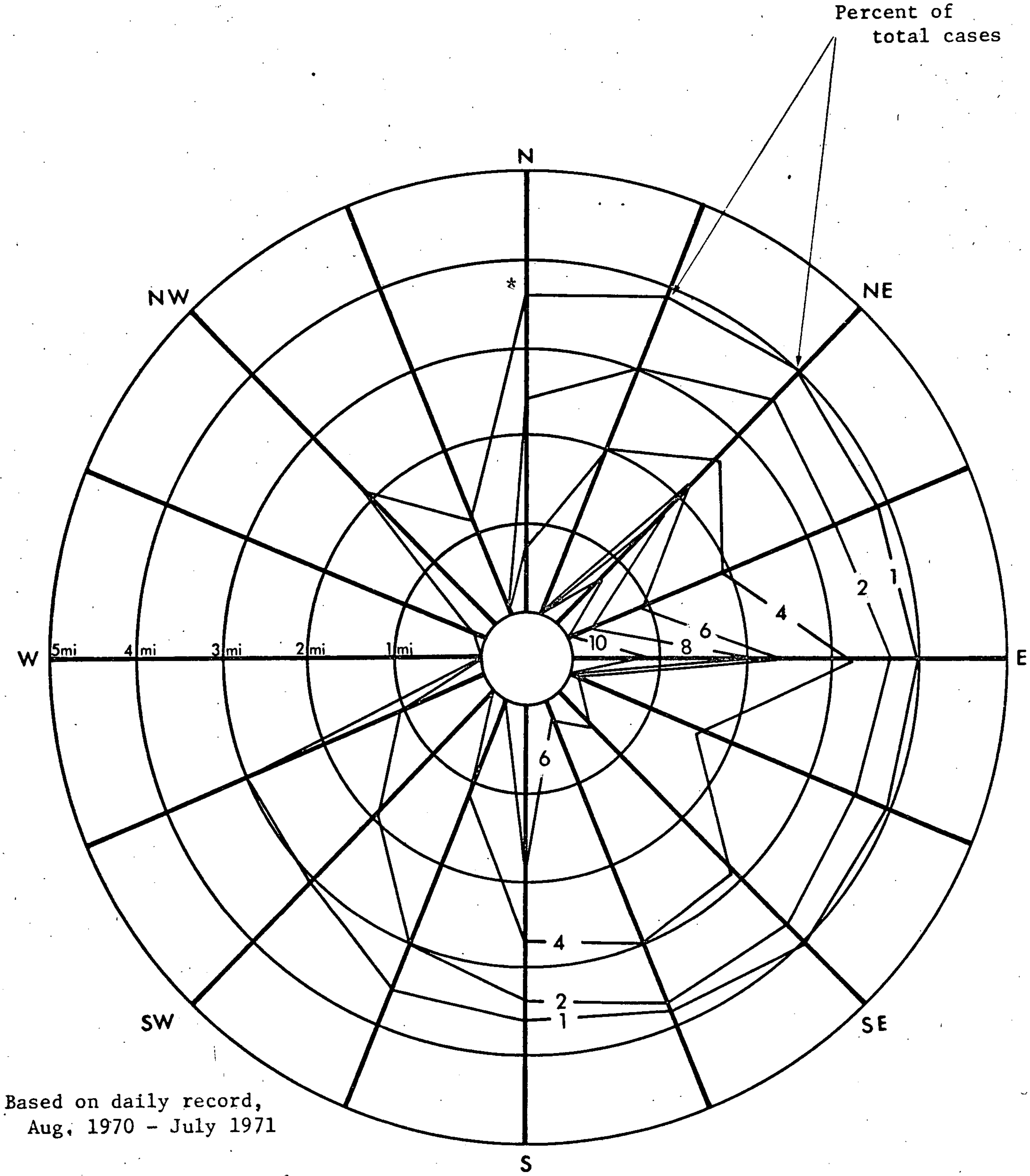


Figure 2.6-1

WATTS BAR NUCLEAR PLANT
ARRANGEMENT OF NATURAL
DRAFT COOLING TOWERS

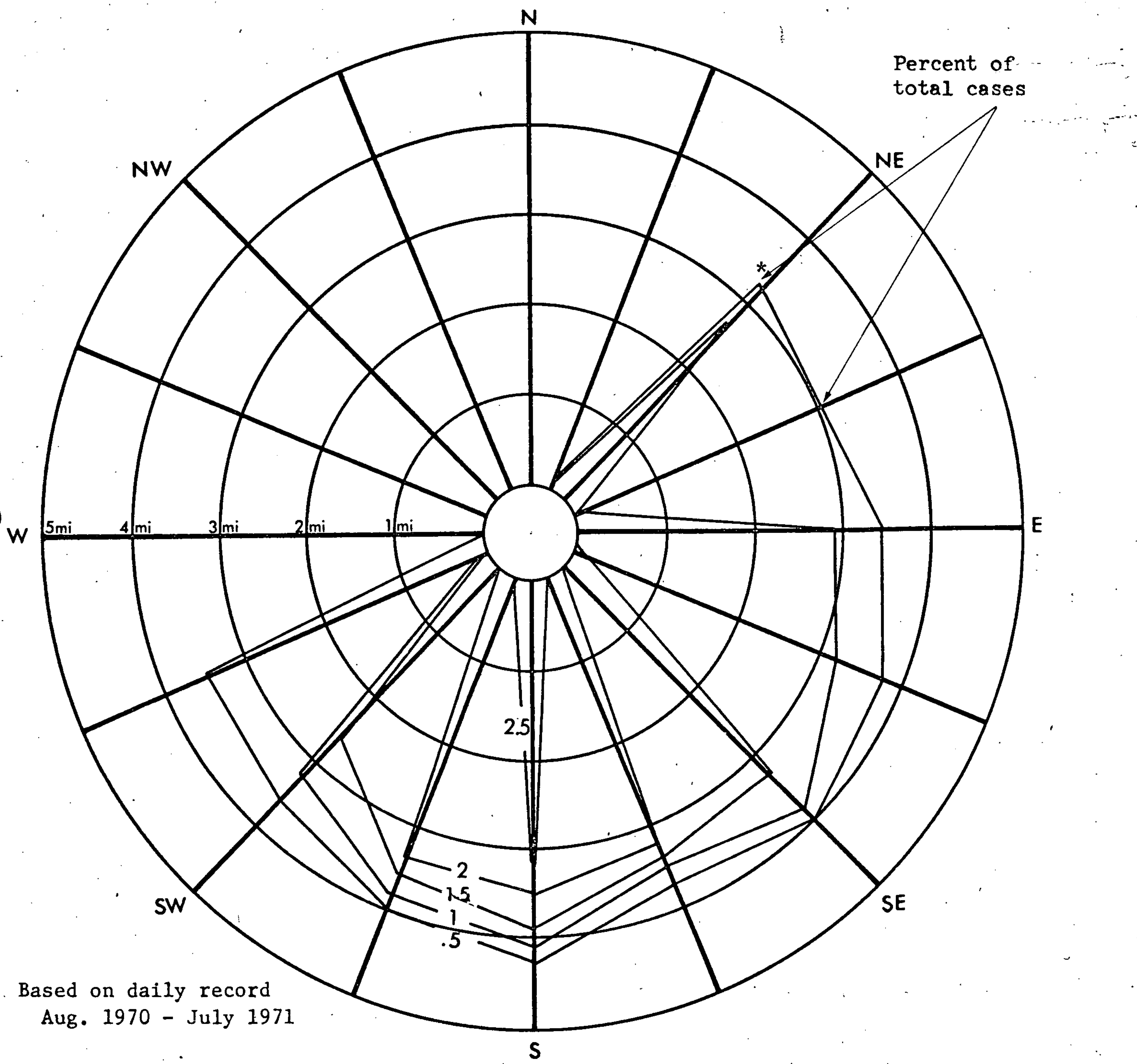
*Example: 1 percent of total cases occur in the 22-1/2° sector north of plant with plume length ≥ 3.5 mi.



Based on daily record, Aug. 1970 - July 1971

Figure 2.6-2 PREDICTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS NATURAL DRAFT COOLING TOWERS WATTS BAR NUCLEAR PLANT

*Example: .5 percent of total cases occur in the 22-1/2° sector northeast of plant with plume length $\geq$ 3.0 mi.



Based on daily record
Aug. 1970 - July 1971

Figure 2.6-3 PREDICTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS (AMBIENT TEMPERATURE BELOW FREEZING) NATURAL DRAFT COOLING TOWERS WATTS BAR NUCLEAR PLANT

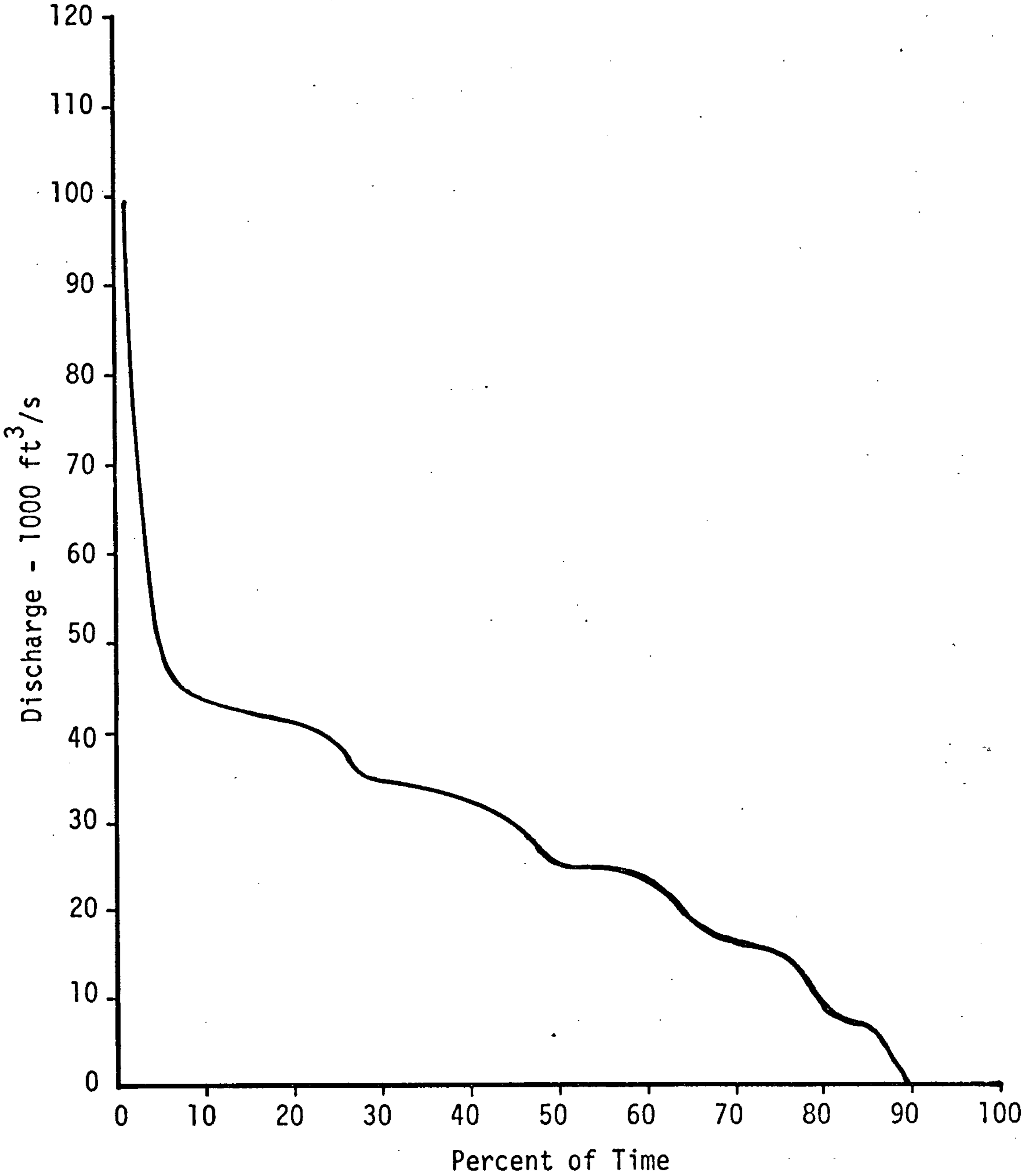


Figure 2.6-4

WATTS BAR DAM HOURLY FLOW
TEN-YEAR AVERAGE
1959-1968

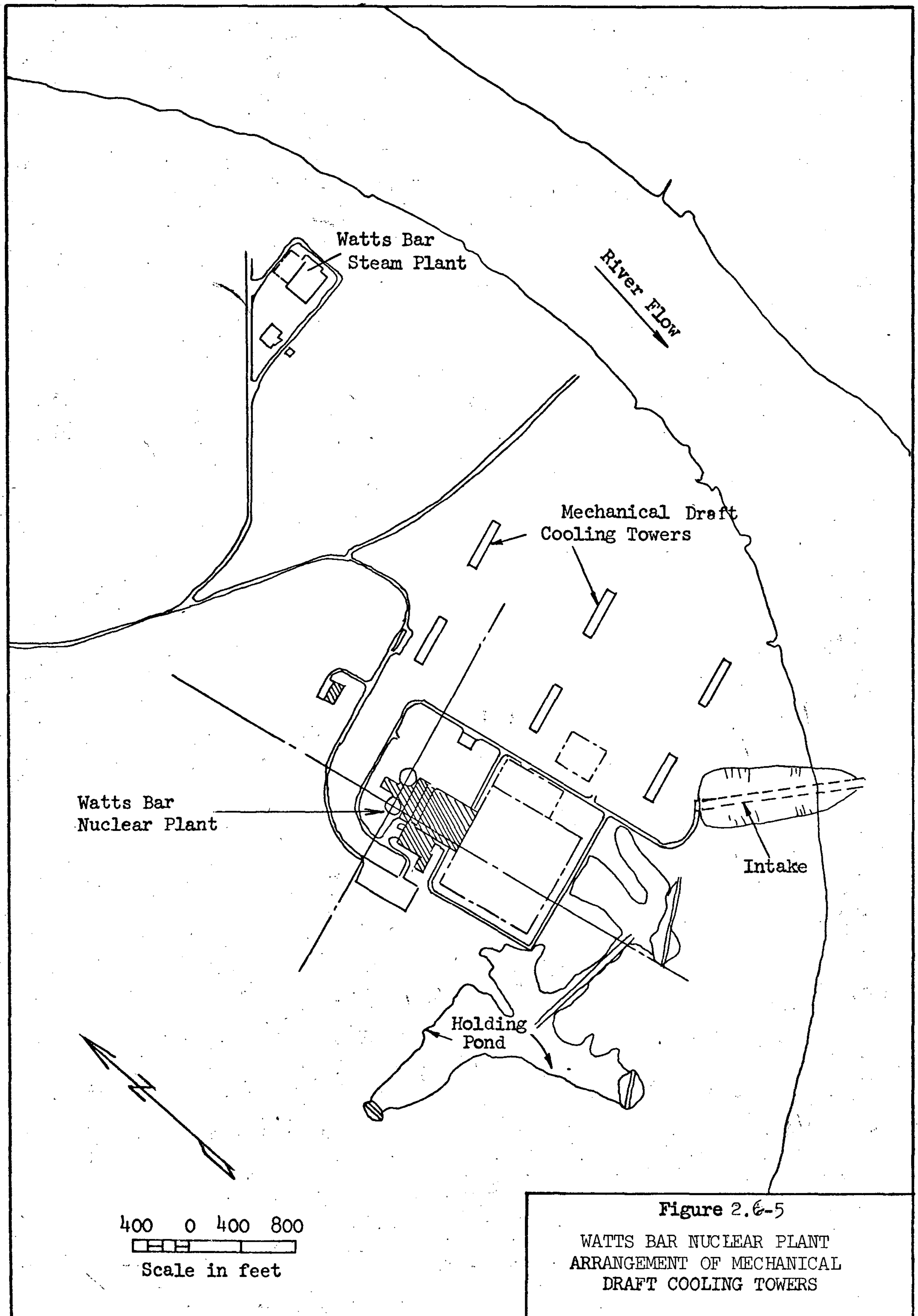
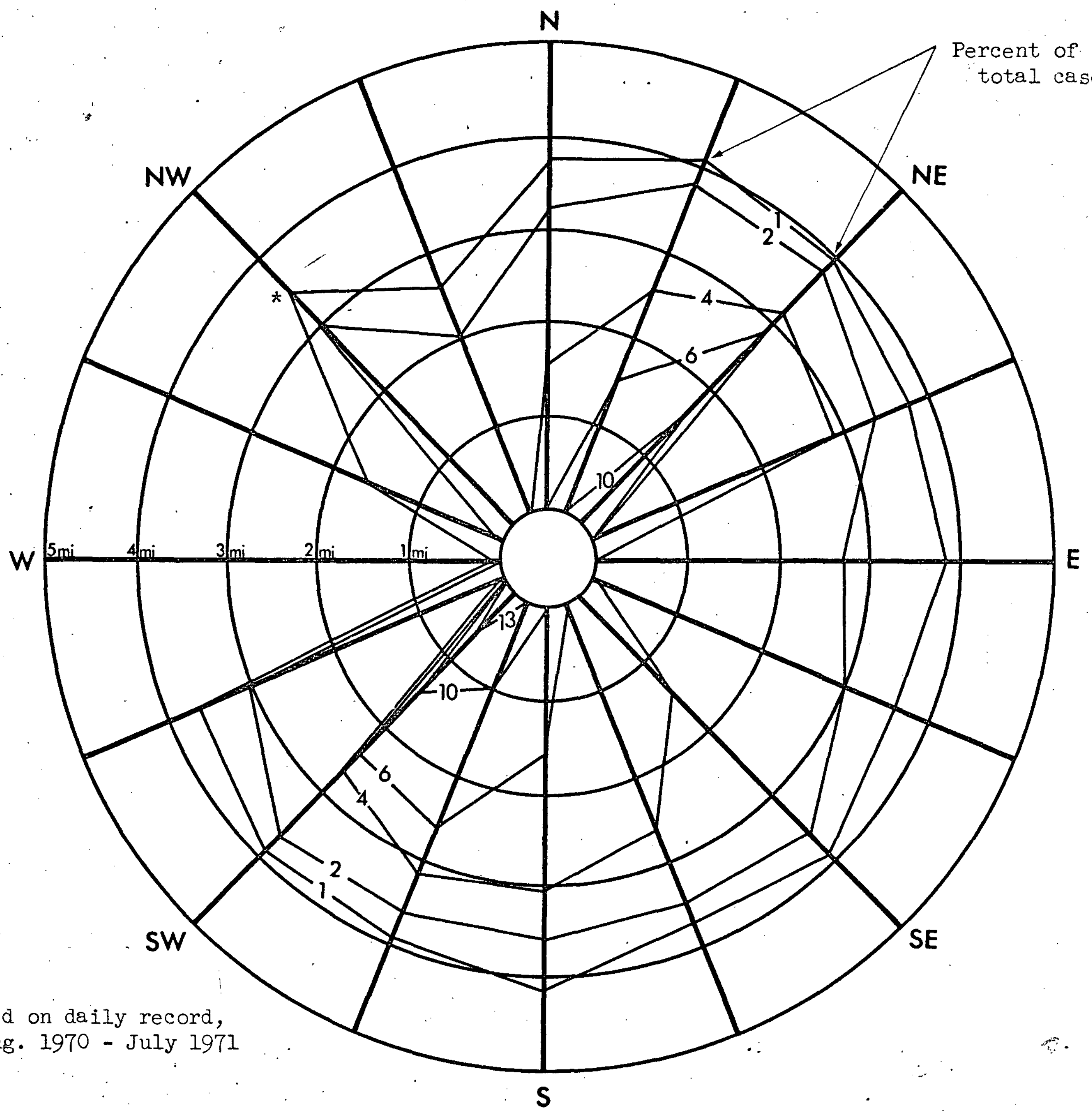


Figure 2.6-5

WATTS BAR NUCLEAR PLANT
ARRANGEMENT OF MECHANICAL
DRAFT COOLING TOWERS

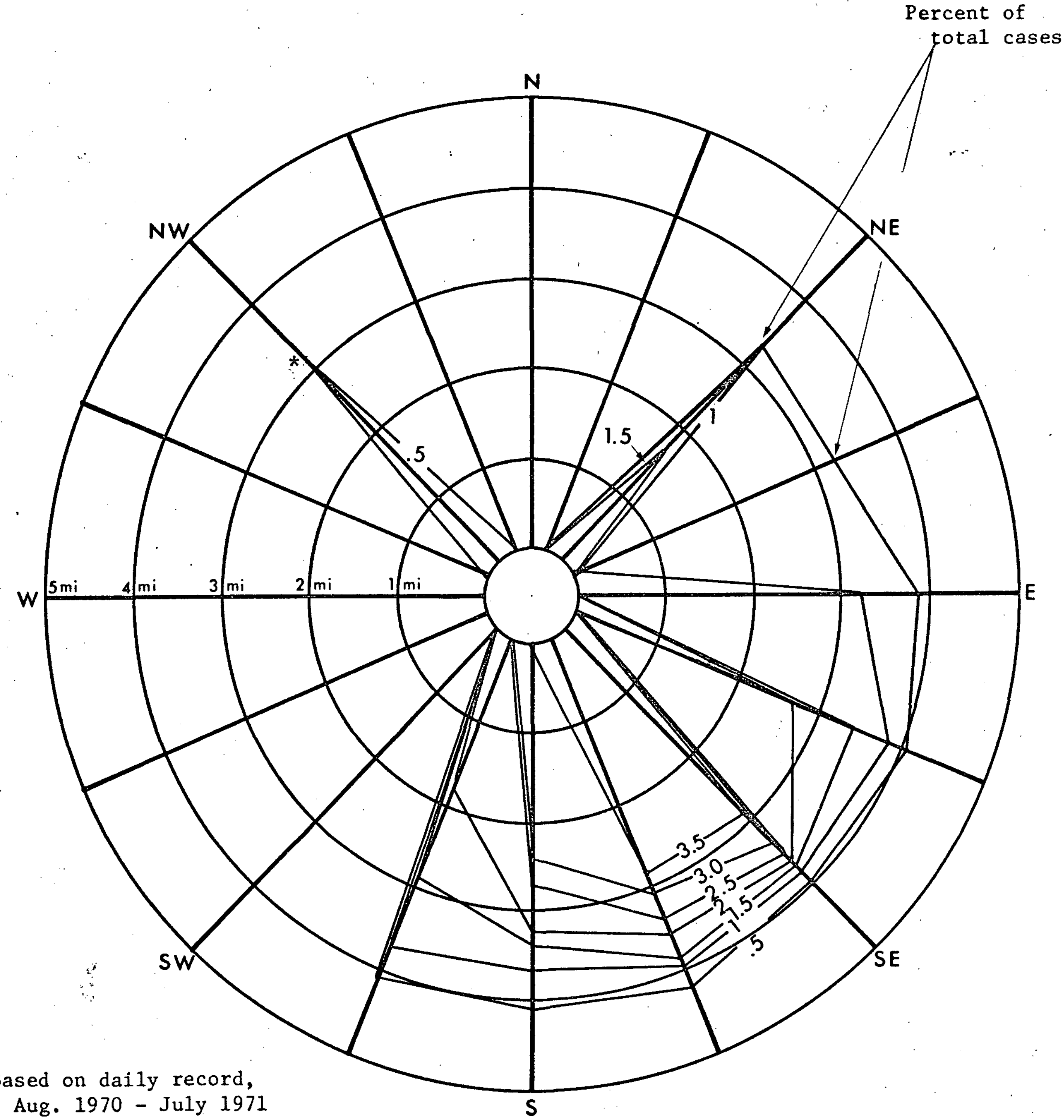
*Example: 1 percent of total cases occur in the 22-1/2° sector northwest of plant with plume length $\geq$ 3.0 mi.



Based on daily record, Aug. 1970 - July 1971

Figure 2.6-6 PREDICTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS MECHANICAL DRAFT COOLING TOWERS WATTS BAR NUCLEAR PLANT

*Example: .5 percent of total cases occur in the 22-1/2° sector northwest of plant with plume length ≥ 3.0 mi.



Based on daily record, Aug. 1970 - July 1971

Figure 2.6-7 PREDICTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS (AMBIENT TEMPERATURE BELOW FREEZING) MECHANICAL DRAFT COOLING TOWERS WATTS BAR NUCLEAR PLANT

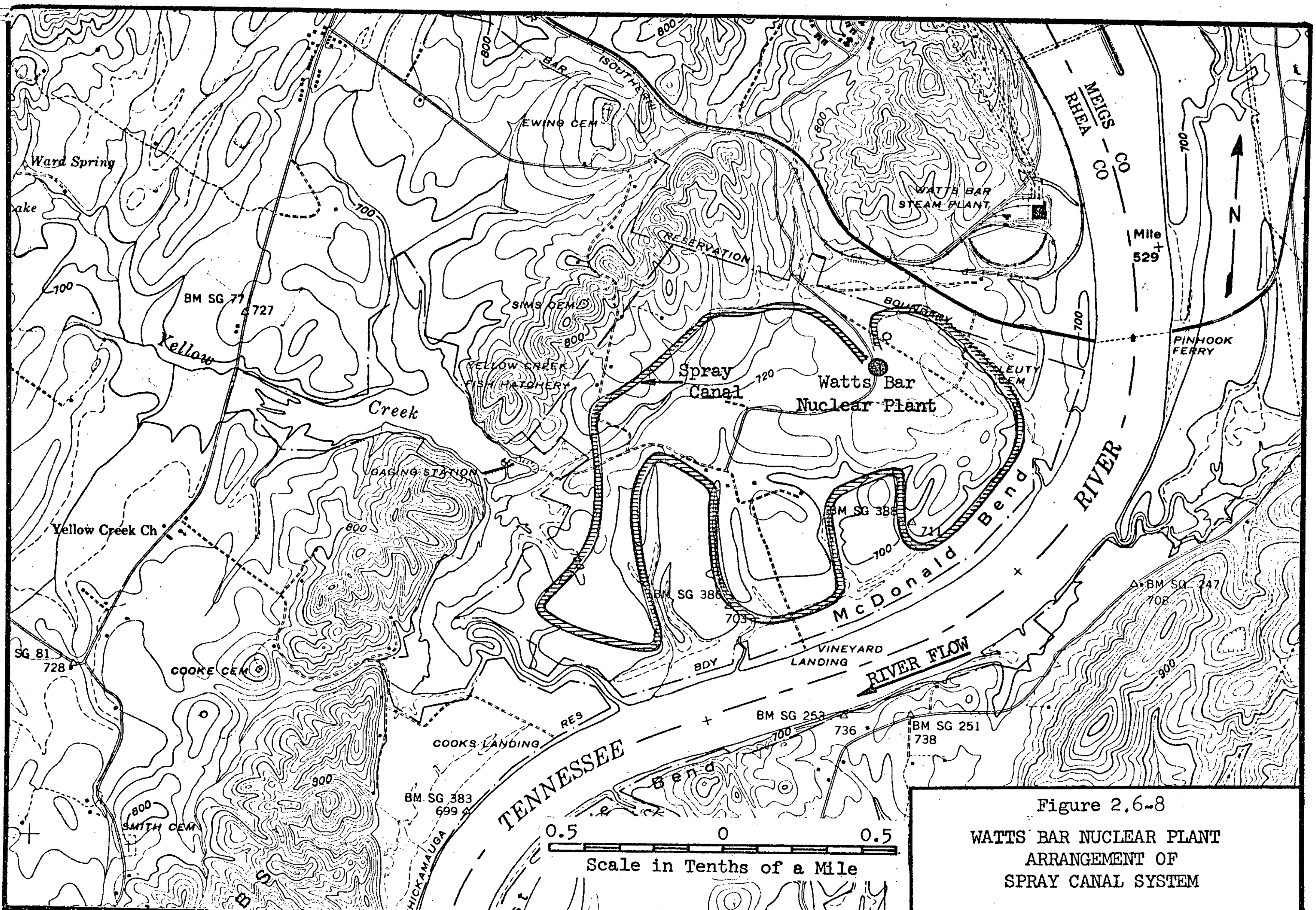


Figure 2.6-8

WATTS BAR NUCLEAR PLANT
ARRANGEMENT OF
SPRAY CANAL SYSTEM

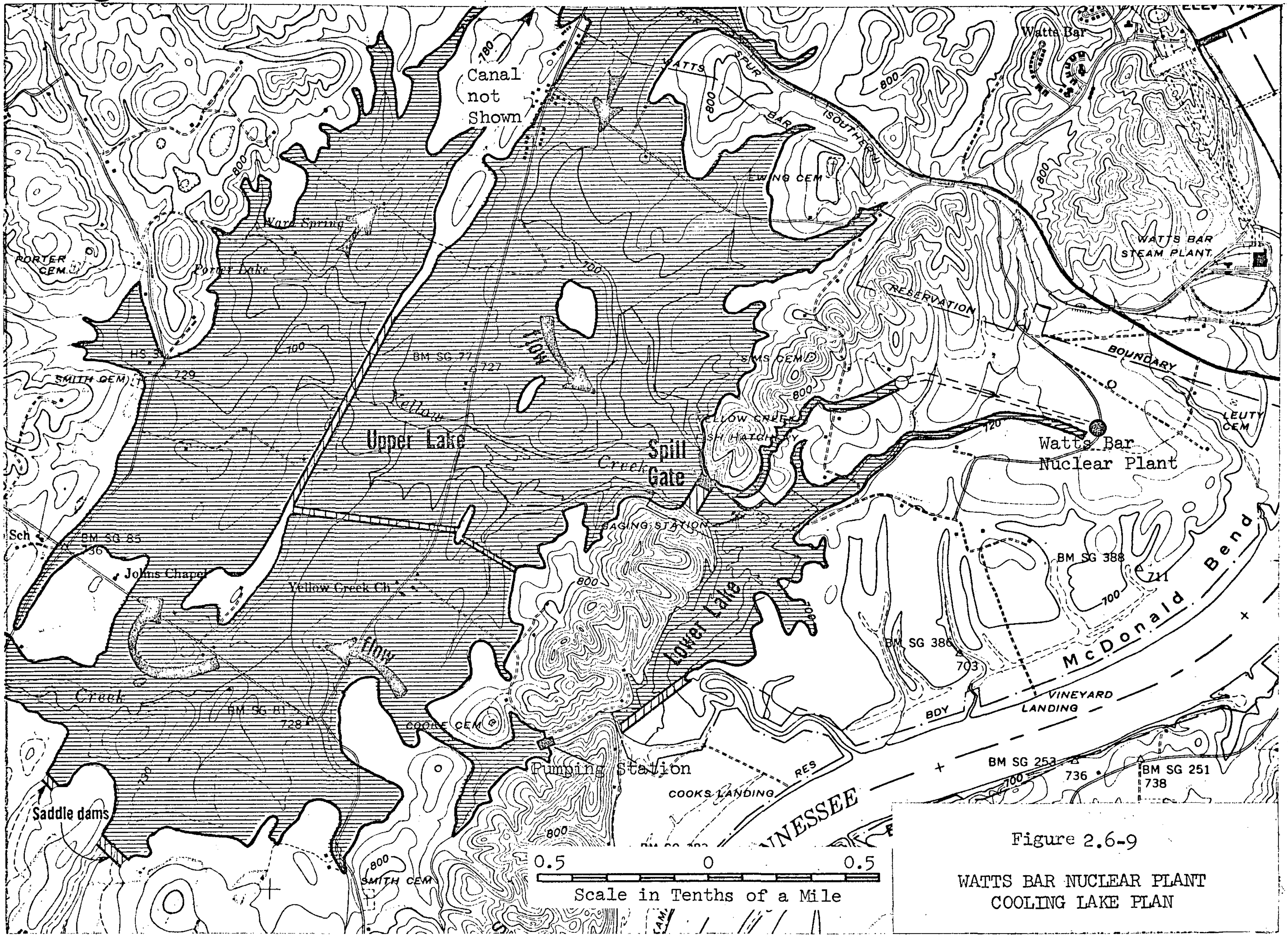


Figure 2.6-9

WATTS BAR NUCLEAR PLANT
COOLING LAKE PLAN

2.7 Biological Impact - An important consideration in carrying out the construction and operation of a nuclear power plant is the formulation, conduct, and analyses of comprehensive ecological studies. These considerations allow documentation of environmental characteristics prior to construction and operation of the plant in order that the effects of construction and operation of the facilities can be determined. In addition, they provide a basis for selecting measures to minimize any projected adverse effects by similar approaches in future work. TVA has developed specific ecological investigative and monitoring programs that will start sequentially before plant construction, during construction, during plant startup, and during all early phases of operation. The relevant programs are discussed below.

1. Ecological studies and analyses performed or planned - The studies that are completed, under way, or proposed document historic and existing characteristics of the environment in the area of the site and are discussed in subsections 1-6 below. Baseline data on the known ecology of the area has been given in Section 1.1, General Information.

(1) Identification of species important to sport and commercial use - Investigative programs have been conducted for upland wildlife, fish and aquatic life. Species are presented in Tables 1.1-15, 1.1-16, and 1.1-17. At least seven game species are supported by the upland wildlife habitats present in the three counties (Rhea, Meigs, and McMinn) surrounding the plant site. These include white-tailed deer, gray squirrel, raccoon, wild turkey, ruffed grouse, cottontail rabbit, and bobwhite quail. Waterfowl investigations indicate

that the vicinity around Yellow Creek Waterfowl Management Area has significance in attracting migratory waterfowl.

Fish monitoring investigations have shown the following fish to be important to sport use: largemouth bass, spotted bass, white bass, crappie, bluegill, and sauger. Important commercial fish are catfish, buffalo, and carp.

Mussel and clam investigations have revealed eight commercial and one invasion species; they are as follows:

Quadrula pustulosa	White wartyback
Cyclonaias tuberculata granifera	Pink wartyback
Pleurobema cordatum	Ohio River pigtoe
Elliptio crassidens	Elephant's ear
E. dilatatus	Ladyfinger
Obliquaria reflexa	Three-horn
Proptera alata	Heelsplitter
Amblema plicata*	Three-ridge
Corbicula manilensis	Asiatic clam (invasion species)

At least three noncommercial but important food-web, thin-shelled species are represented by extensive populations in downstream shallows that contain deep sediments.[1] These species are:

Anodonta grandis	Floater
A. suborbiculata	Paper-shell
Lasmigona complanata	White heelsplitter

Aquatic macrophytes and macroscopic algae are not well represented in the present environment because of a lack of suitable substrate, hydraulic scouring, and the hydraulic drag produced on any specimens attempting to root in the area.

Gastropods and aquatic insects are rare due to a lack of suitable substrate on channel slopes and due to hydraulic effects.

(2) Importance of locale to existence of important species, considering states in life history - The area of the Watts Bar site includes habitat that could support upland wildlife, but it is not considered to be significant in terms of the type, distribution, or quality of cover suitable for den and nesting sites.

The tailwaters of Watts Bar Dam are considered favorable spawning habitat for sauger, white bass, smallmouth bass, and the mussels and clams named above. Construction of the plant is expected to have a direct impact on approximately five to ten acres of bottom substrate by excavation, placement of facilities, or flow interruption and disturbance related to plant supply, intake, or discharge features. Operations, as now planned, should have a minimum adverse effect on this area. Construction activity itself may temporarily disturb the mussel habitat in waters adjacent to the site. Present data (Table 2.7-1) indicate that immediately adjacent to the proposed plant site mussels are scattered across the river, and more than a mile downstream concentrated beds occur in shallower water or on channel slopes. Movements of the several fish species that show extensive ranges of migration are not expected to be significantly changed by the location of the plant in this area.

Local area flights of waterfowl to the Yellow Creek Waterfowl Management Area, located near the plant site, may be affected by the height of the cooling tower structures. The plume, under certain weather conditions, could also offer some difficulty to local flight patterns. However, neither of these effects is expected to have a significant impact on normal waterfowl migration habits.

(3) Time and space changes in temperature distribution - From 1942 through the first week of July 1953, TVA maintained continuous temperature monitors at 0.5 feet, 30 feet, and the bottom at TRM 529.9 (upstream of Watts Bar Dam). Since 1953 a single, early morning (8 to 9 a.m.) weekly temperature record has been obtained from the tailrace of the Watts Bar Dam. During 1960 monthly temperature profiles in Chickamauga were obtained from a number of points. The data obtained for the reach is shown in Table 1.1-21 and figures 2.7-2, 2.7-3, and 2.7-4.

Watts Bar Reservoir begins to stratify in the early spring and remains stratified until late fall. Temperature data collected in the reservoir at the dam, TRM 529.9, for the period 1942 to July 1953 show that the maximum surface temperature has varied from about 80 to 88°F and that the maximum temperature differential between the epilimnion and hypolimnion is on the order to 15 to 20°F (see figures 2.7-2 and 2.7-3). Additional data collected in this reservoir indicate that for normal turbine operations water is withdrawn from both the epilimnion and hypolimnion but is proportionately much less from the epilimnion. Comparison of temperature data collected at TRM 518.0 (figure 2.7-4) and the Watts Bar Reservoir data indicate that for normal turbine operations mixing of the epilimnion and the hypolimnion will result in an increase in the hypolimnetic temperature of about 5-8°F and a decrease in the epilimnetic temperature of about 12-15°F. For turbine releases on the order of 3,500 ft^3/s it is expected that water will be withdrawn only from the hypolimnion. This hypolimnetic water contains smaller amounts of phytoplankton and greater amounts of zooplankton than epilimnetic water; therefore, the turbine passage will affect zooplankton more than phytoplankton.

From among the alternate condenser cooling water systems considered, closed-cycle cooling towers were chosen primarily because the towers would reduce total water intake and would significantly reduce thermal discharges from Watts Bar Nuclear Plant. Interlocking discharges of tower blowdown with hydro plant discharges will significantly reduce time and space changes in temperature in the river. However, organisms moving with the intake pumped water will be significantly affected by the high condenser temperature rise, by long holdup in the towers or holding pond, and by abrupt cold to warm changes due to entrainment at the blowdown diffuser or by spread of the mixed temperature water. These temperature changes will be in addition to those resulting from turbine mixing during reservoir stratification in the late spring, summer, and early fall.

The temperature rise resulting from passage through the turbine into the tailrace of Watts Bar Dam adds as much as 8°F seasonally. Several hours after being released from the dam, some of the organisms will pass over the blowdown discharged from the nuclear plant and may be subjected to an additional 4°F. Similar single-step rises through existing steam plants have not been found to be detrimental to planktonic forms. Therefore, there are no significant biological changes expected with the time and space changes in temperature of the river and most of its volume of organisms. Localized effects on mussels and fish are discussed below.

(4) Implications of withdrawal and return of cooling water - The normal summer pool elevation at Watts Bar is 682.5 feet above mean sea level; normal winter pool elevation is 675 feet above mean sea level. A May-June vector control water level fluctuation adds 0.5 foot to the 682.5-foot level in order to retard shoreline vegetative growth and to help strand flotage and other debris.

The intake for the proposed nuclear plant will be located near Tennessee River mile (TRM) 528, approximately 10,000 feet downstream from Watts Bar Dam. Four locations were examined initially. All indicate a depth of at least 15 feet of water when the Chickamauga pool is at elevation 675. The location selected, figure 2.7-5, will require a minimum amount of excavation of dredging in the river channel and will present the most uniform flow past the intake channel opening. The bottom substrate is an admixture of cobble, rock, sand, and gravel. The bottom topography is as illustrated in the figure. Preliminary design is developed in such a manner that some bottom substrate excavation will have to be completed in order to provide a sloping channel bottom to the intake invert which has a bottom elevation of 652 feet above mean sea level. The intake structure will have four openings slightly more than 5 feet wide and 22 feet high with the top of the openings at elevation 674, 1 foot below normal winter pool level. The intake channel width at the surface, paralleling the river, will be 170 feet (elevation 675). No skimmer will be used, but the intake openings will be fitted with trash racks; between the trash racks and the pumps, vertical, 3/8-inch mesh traveling screens will be installed. The pump deck structures and the actual intake will be 850 feet back from the 683-foot slope contour.

It must be anticipated that all planktonic organisms that pass along the right bank will be exposed to withdrawal when the intake is operating. Efforts are being made to reduce the amount of biota taken into the plant. The major design effort has been to reduce the intake canal velocities. These average velocities are about 0.037 ft/s in summer and 0.073 ft/s in winter into the mouth with a flow of 120 ft^3/s and a velocity of about 0.26 ft/s through the openings to the screens. Young fish should be able to swim back to the mouth of the intake channel. Organisms near the intake openings will experience a maximum velocity of about 0.4 ft/s; once the organisms pass the intake opening they will pass through the screens, the pumps, and the plant and must be considered lost as particulate food. Organisms will reappear at the blowdown diffuser as dissolved, colloidal, or mineralized fragments.

This conversion of organic materials is not expected to have significant implications for the production of heterotrophic slimes in the reservoir because the small quantities contained in the water will be diluted. In addition, a well-developed community of mollusk filter feeders is resident in the ozone.

The effect of elevated temperatures on biological oxygen demand is not expected to be significant. While there will be an increase in the BOD of the water in the closed-cycle cooling system and therefore in the blowdown discharge—as compared to the reservoir water—because of the small volume of the water discharged no significant effect is expected in the DO in the reservoir. Furthermore, upon return to the reservoir, minimal incremental thermal effects will be noted on the DO.

As discussed in section 2.5, some trace metal concentrations in the reservoir may exceed stream guidelines primarily due to geologic sources in upstream tributaries. Some adverse effects to the aquatic biota possibly occur due to the existing background levels.

Although no heavy metals are expected to be added to the cooling water by operation of the power plant, these metals do build up in the cooling system as a result of evaporative losses. The concentration levels for these metals during system operation is controlled by the amount of blowdown and makeup cooling water used. As discussed in sections 2.5 and 2.6, operating procedures now planned for this plant are expected to result in concentrations in the blowdown which will normally be about two times and occasionally as high as four times the value existing in the makeup water. Any increased impacts as a result of the plant will be restricted to aquatic biota in the immediate vicinity of the discharge. By using a diffuser to disperse the blowdown, the biota exposed to higher concentrations will be minimized.

The incremental effects of the plant due to changes in the total effects of trace metal concentrations on the aquatic biota affected are considered to be negligible.

(5) Effect of passage through condensers on planktonic forms and fish larvae - The volume of water drawn from the tailwater of Watts Bar Dam will vary seasonally from 25,000 to 60,000 gal/min and may peak for short periods to 77,500 gal/min. The proportion of water drawn continuously into the plant will vary from

hour to hour as the hydro plant changes operation to meet the cyclic load requirements. When there is zero turbine flow at Watts Bar Dam the raw and essential cooling waterflow of 51,000 gal/min could be drawn from the upper end of Chickamauga Reservoir's pool. Under these conditions the 12-hour demand for makeup water for the nuclear plant will require approximately 112 acre-feet of makeup water. This is an insignificant quantity in a reservoir the size of Chickamauga. The flow to the intake is from a nonrestricted area with about one-half the flow from the upstream side and one-half from the downstream side. Thus, the intake water for the nuclear plant will not cause a significant depletion of water in the 2-mile reach above the nuclear plant intake.

Since the closure of Watts Bar Dam actual riverflows have ranged from 0 to 187,000 ft^3/s with a summer mean flow of 21,500 ft^3/s (9,650,000 gal/min) and a winter mean flow of 35,500 ft^3/s (15,930,000 gal/min).

It is judged that any planktonic organisms pumped through the condensers will be killed by the heat rise (38°F) and/or by the long retention at elevated temperatures while transiting the cooling towers. While the effect of passage through the condensers is easy to predict, the significance of this loss of planktonic organisms to the reservoir is nearly impossible to predict. The proportions drawn in will vary from hour to hour depending on many factors, including:

1. Time of day
2. Response to zooplankton to light
3. Number and position of turbines operating
4. How turbines are operating

5. Pool elevation
6. Velocity at intake
7. Velocity of river
8. Season of year
9. Presence and abundance of each species
10. Nuclear plant load
11. How organisms survive turbine passage
12. Population of fish feeding between dam and intake

Larval fish which pass through the plant in the cooling waterflow will be killed in this closed-cycle cooling system due to the temperature rise in the condensers and to mechanical shock. An accurate assessment of the effects on larval fish populations cannot be made at this time. Concentrations of eggs and larvae available for entrainment and condenser passage will come from two sources: (1) those eggs and larvae produced in the tailwater area and (2) those larvae which pass through Watts Bar Dam. At least two important species (sauger and white bass) spawn in tailwater areas. However, neither the magnitude of spawning efforts for this tailwater nor the magnitude of dam passage is now known for this site.

Even though no estimates of actual fish mortalities are possible since no data are available, no significant adverse effect is expected on the reservoir fish population because of the limited quantities of makeup water required by the closed-cycle cooling system (a maximum of 0.7 percent of the average riverflow), the low velocities in the intake channel, and the locating of the intake channel so as to minimize environmental impact.

Only detailed investigative studies will reveal the significance of the passage of organisms through the dam and nuclear plant intake. Further investigations will be planned and conducted before plant operation and will continue through all phases of startup and early sustained operation.

(6) Siltation and turbidity effects - Limited information is available regarding the possible effects of increased siltation and turbidity due to construction on the Watts Bar Nuclear Plant site on the mussels in this reach of Chickamauga Reservoir. TVA's studies reported in "The Mussel Resource of the Tennessee River" discuss these effects in a general way. There will very likely be a certain amount of increased turbidity and siltation in the reservoir due to construction although control measures will be taken to minimize these effects. The extent of any increased siltation and turbidity cannot be accurately anticipated. It is likely that any increase in turbidity of the reservoir and possible siltation would be confined to a reach along the right bank side of the reservoir from the construction site downstream for a mile or so.

Garner and Kochtitzky[2] estimated the source of the sediment in Chickamauga Reservoir to be 23 percent from Watts Bar Dam releases, 28 percent from the local drainage areas of Chickamauga Reservoir having less than 200 square miles (included bank sloughing), and 49 percent from principal tributaries between Chickamauga and Watts Bar Dam having drainage areas of 200 square miles or larger. No major accumulations of sediment occur in the 2- to 3-mile stream reach immediately downstream from Watts Bar Dam. However, during the period 1956 to 1961, sediment accumulation exceeded 1 foot at TRM 527.3 and 2 feet at TRM 523.7. On an annual basis, the sediment accumulation rate at these two locations would be about 2.5 and 5 inches per year, respectively. The sources of this sediment are the Watts Bar releases and the local drainage area including bank sloughing. Onshore and shoreline riprapping would reduce or eliminate bank sloughing and slumping in the vicinity of the plant site. Protective measures during construction should prevent significant turbidity or sediment contributions from the construction site during all but the extreme storm runoff events. Intake construction and diffuser construction and placement respectively will necessarily destroy any bottom aquatic life in the immediate construction area and contribute some sediment and turbidity that will locally affect the substrates and benthos in deposition zones downstream. Effects on mussels in the 3-mile sanctuary reach below Watts Bar Dam would be limited to the lower half of the sanctuary.

In order to understand the effects that siltation and turbidity will have on the mussel sanctuary, consideration was given to the life history cycle of mussels. The life history cycle of the pigtoe mussel which is the most abundant commercial species now existing in the Tennessee River has been recently described by Yokley[3] and is shown in figure 2.7-1. These historic Tennessee River mussel populations are gradually dying, even in those areas no longer subject to overharvesting, i.e., sanctuaries.

Yokley concluded that:

> The Ohio pigtoe mussel, a commercially valuable species, inhabits the largest rivers of the Ohio River drainage system and also occurs in concentrations or "mussel beds" in the Tennessee River.

Oogenesis and spermatogenesis follow an annual cycle, with spawning and fertilization in April and May. Four to six weeks after fertilization, the marsupial outer demibranchs are found to contain glochidia. Larval development to this stage is dependent on water temperatures above about 21°C. In the laboratory experiments the parasitic glochidia, released mainly in June, attach to the gill filaments of the rosefin shiner, Notropis ardens (Cope), encyst, and transform into independent mussels in 14-18 days. A motile foot develops during encystment, but no increase in overall size results. Within 3 weeks after dropping from the host fish, the free-living naiads double in size. Sexual maturity is reached within four years, and the gonads remain functional throughout the mussel's remaining 25-30 years of life.

Deposition of sediment reduces the percentage survival of young mussels. When juvenile mussels first arrive at the bottom of a stream after completing their transformation they are less than 1/10 inch in diameter; later, while they are still less than 1/2 inch in diameter, they partly anchor themselves with mucous threads. Silt and organic materials can reduce the oxygen supply to the streambed. Mussels of most ages do not survive reductions approaching 20 percent of saturation.

Ellis[4] quantified the mussel-silt problem and found that "mussels were unable to maintain themselves in either sand or gravel bottoms when a layer of silt from one-fourth to one inch deep accumulated on the substrate." Silt deposition also interferes with their filter feeding. In muddy water mussels remain closed 75 to 95 percent of the time.

The populations apparently are experiencing a combination of adverse or less suitable environmental conditions. Corresponding changes in host fish responses result in either fewer or no fish of suitable species being present over gravid mussels during spawning periods. Fish infected with larval mussels (glochidia) drop the young mussels over unsuitable substrates because of changed behavioral patterns and movements in response to the altered environmental parameters. This results in further reduction in the potential mussel stock.

A possibility that cannot be quantitatively documented at present is that the construction of Watts Bar Nuclear Plant will enhance both the amount and type of suitable bottom and shoreline substrate for attachment and burrowing of larval and young mussels. Specifically, the increased exposure of bedrock, the placement of concrete and cobble or gravel to support structures, and the riprapping of the shoreline will provide new suitable substrate for attachment and will reduce shoreline bank sloughing and slumping. In addition, when the plant becomes operational the warmer blowdown discharge may attract and hold potential host fish over gravid mussels and/or substrates suitable for larval mussel attachment. Those mussels that attach to shoreline riprap, bottom gravel, or cobble, and even exposed bedrock, will have an opportunity for longer growing seasons, faster rates of growth, and better quantities of food suspended in the overflowing water masses.

The balance between these positive and negative effects should be in favor of bank protection, improved attachment substrates, host fish attraction, and longer growing seasons.

(7) Measures taken to assure adequate ecological studies - TVA has and will continue to consult with appropriate individuals and state, local, and Federal agencies to plan, conduct, and analyze the adequacy of its ecological studies.

2. <u>Studies to be conducted or continued</u> - TVA's monitoring programs are designed to assess the adequacy of measures taken to minimize the environmental impact of the facility. They also help to identify those aspects of plant design or plant operation which require further effort to resolve questions of environmental impact. Additional studies to resolve questions of environmental impact of the plant will be initiated prior to or concurrent with the subsystem construction or operation that is questioned.

An intensive analysis of the terrestrial ecosystem is being undertaken in order to assess the environmental impact of the proposed Watts Bar Nuclear Plant on the terrestrial ecosystem of the 967-acre construction site. Comprehensive studies of the flora and fauna will be conducted in several phases. Phase I will be a survey and analysis of the vegetation, including forests, shrubs and ground cover. The details of this phase are described in Appendix I. Data collection for Phase I has been completed, and the data analyses are currently underway. Phase II is a survey and analysis of the fauna in the impact area. Phase III is an evaluation and summary of the impact of the nuclear plant's construction upon the area's terrestrial ecosystem. Data for Phase II has not been collected. These studies will provide detailed qualitative and quantitative information on the plant site and will parallel and complement similiar studies of the area's aquatic ecosystem. Based on observations made to date, the area appears to be typical of the region, and it is not anticipated that any significant environmental losses will occur to the terrestrial ecosystem.

The environmental radiological monitoring program for the Watts Bar Nuclear Plant is described in section 2.4 and the locations of sampling sites are given in Table 2.4-5.

The monitoring program as originally described in the draft environmental statement did not specifically state that sediment would be collected at station X because the substrate composition of the bottom of the river channel was insufficiently known. Since that time onsite sampling has revealed the substrate to be an admixture of rock, gravel, and fine particles of coal which can and will be readily sampled routinely during all phases of monitoring.

The eight reservoir cross sections were selected on the basis of known flow characteristics, bottom morphology, sediment depth and composition, historic biological records, obvious reservoir characteristics pertinent to definition of isotope distribution and behavior, workability, access, and representativeness of a particular reach. Overall, they represent the basic types of habitat , substrate, environment, communities, and populations of the upper and middle portions of Chickamauga Reservoir.

Present Watts Bar Dam releases are sometimes below proposed Tennessee DO criteria. There is little noticeable impact on the tailwater biota subjected to these lowered DO levels. Watts Bar Nuclear Plant is not expected to adversely affect the DO levels in the reservoir. Preliminary field tests at TVA's Paradise Steam Plant indicate that the aeration provided by the cooling towers results in a DO level near saturation in the cooling tower blowdown. TVA will document the oxygen level above and below the nuclear plant during initial operation.

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.

Table 2.7-1

CROWFOOT BRAIL COLLECTIONS OF MUSSELS

BELOW WATTS BAR DAM - JUNE 1972

TRM	Location	Amblema costata	Corbicula manilensis	Cyclonaias tuberculata	Elliptio crassidens	Obliquaria reflexa	Quadrula pustulosa
526.8	Mouth of Yellow Creek	-	+	-	5	-	-
527.0	Right bank	-	+	-	-	1	-
	Left bank	1	+	-	1	1	1
527.5	Right bank	-	+	-	-	-	-
	Left bank	-	+	-	-	-	-
528.0	Right bank	-	+	-	-	-	-
	Left bank	-	+	-	-	-	-
528.5	Right bank	-	+	-	-	-	-
	Left bank	-	+	1	-	-	-
529.0	Right bank	-	+	-	1	-	-
	Left bank	-	+	-	3	-	-

Note: + means several specimens

Figure 2.7-1

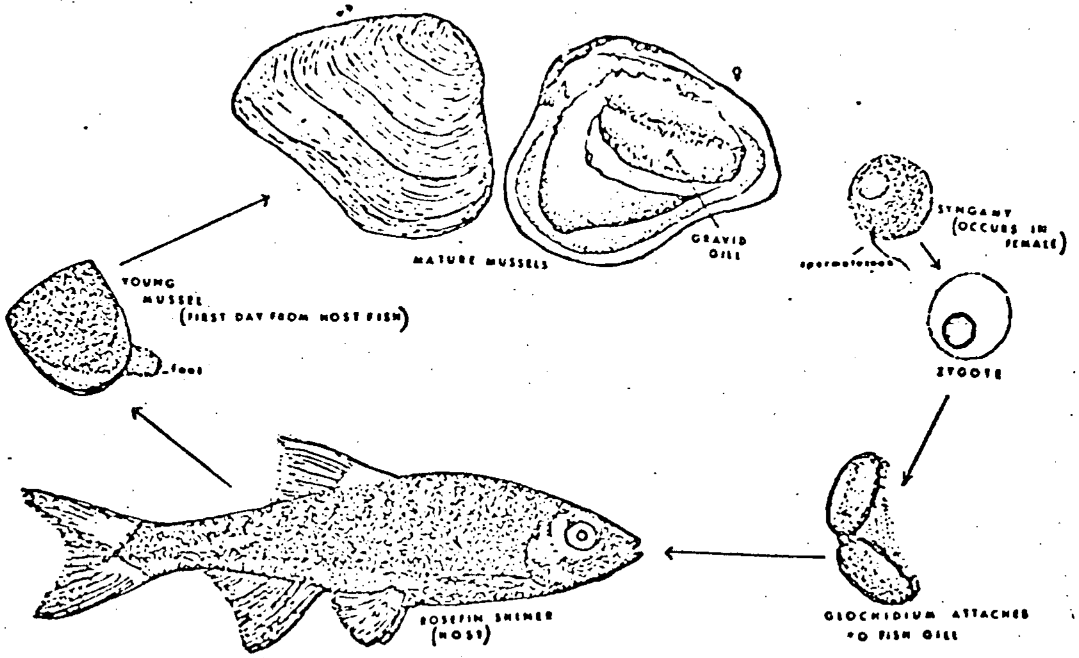


FIG. 1. Life cycle of *Pleurobema cordatum* (Ohio pigtoe mussel).

Yokley, P., Jr. 1972. Life history of Pleurobema cordatum (Rafinesque 1820) (Bivalvia:Unionacea). Malacologia 11(2):351-364.

Figure 2.7-2

Forebay temperature profiles at Watts Bar dam - 1942-47

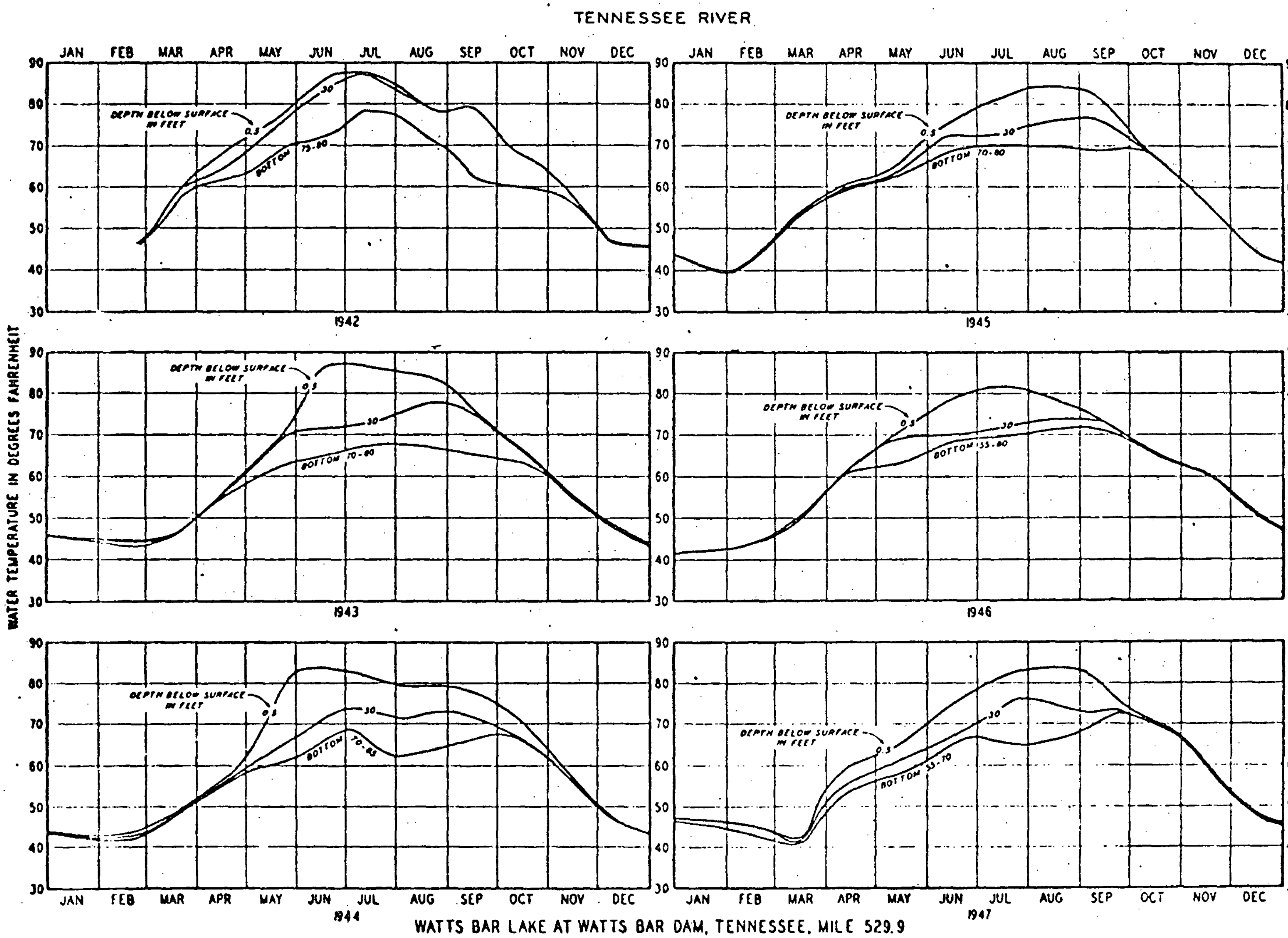
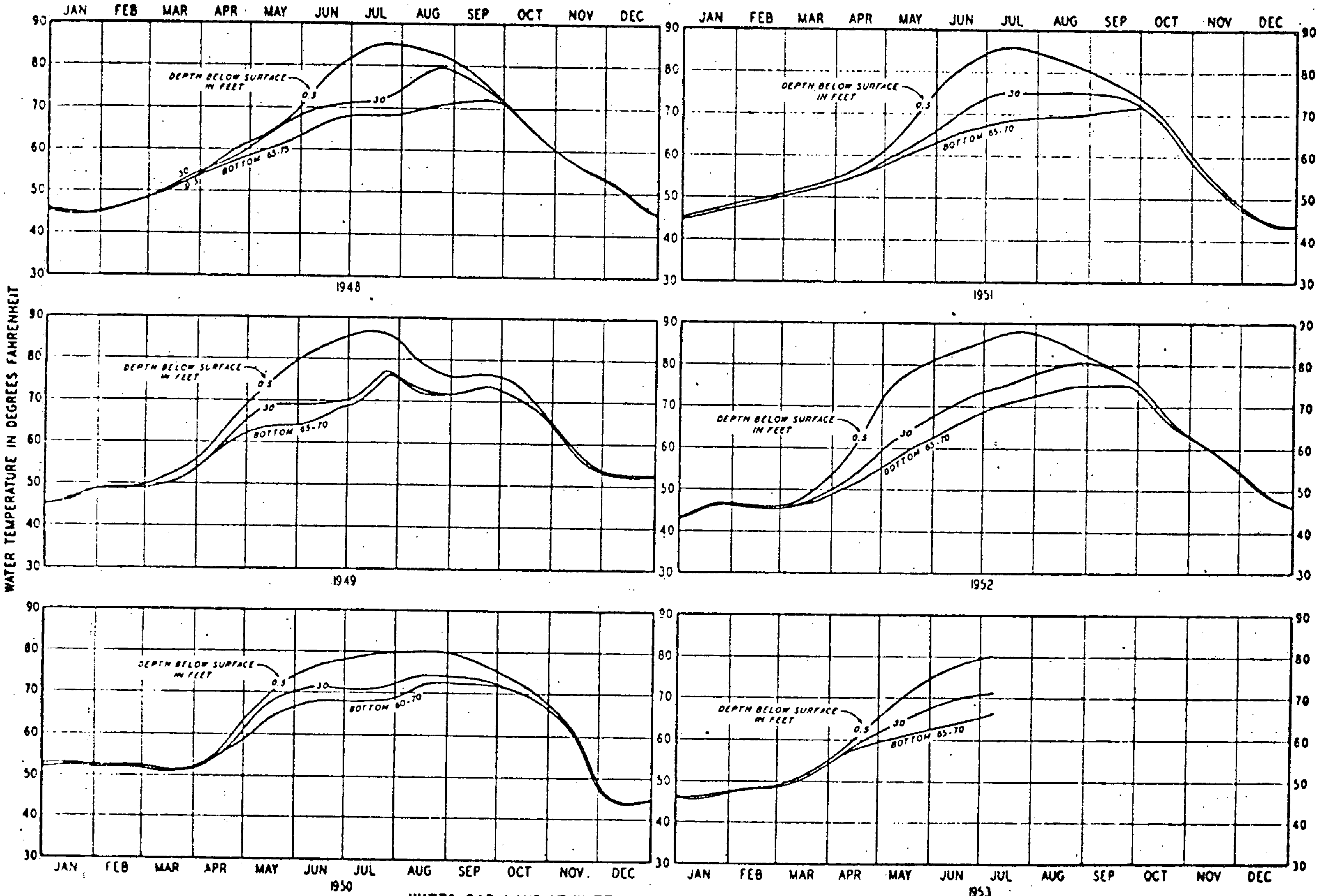


Figure 2.7-3

Forebay temperature profiles at Watts Bar dam - 1948-53

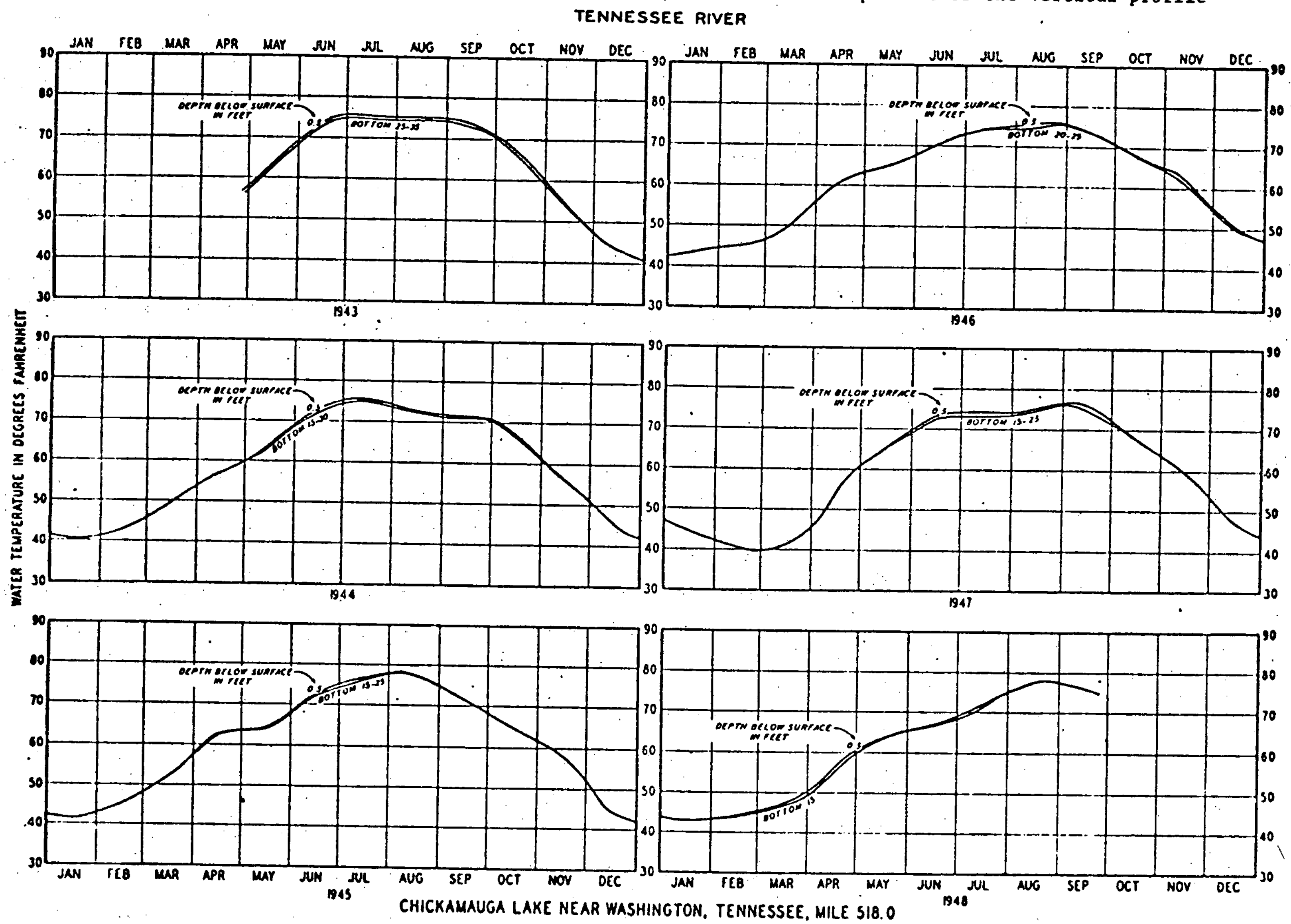
TENNESSEE RIVER



WATTS BAR LAKE AT WATTS BAR DAM, TENNESSEE, MILE 529.9

Figure 2.7-4

Tailrace temperatures resulting from Watts Bar Dam turbine mix of 62 percent of the vertical profile



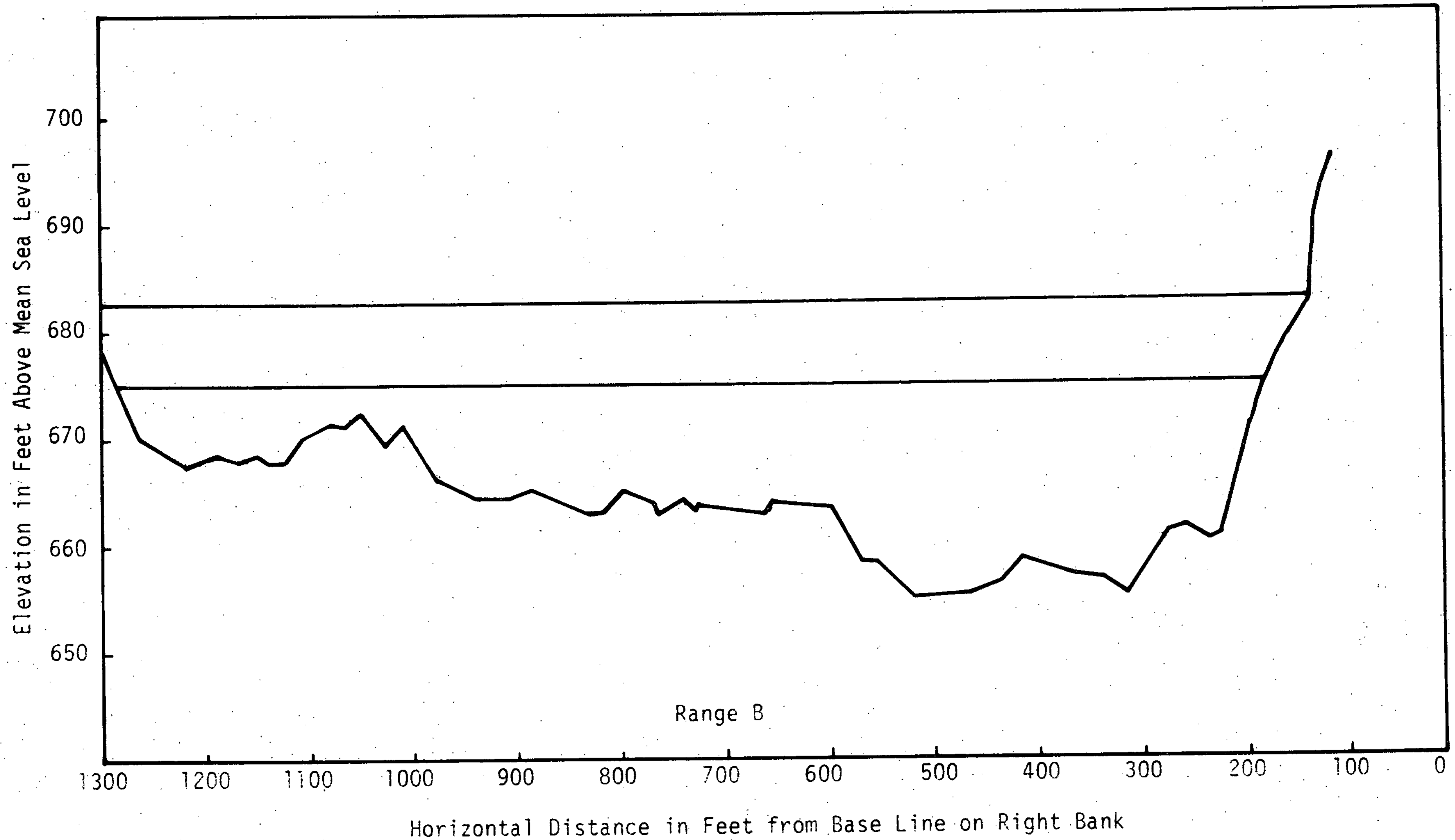


Figure 2.7-5

Reservoir Cross Section for Centerline of Proposed Intake

WATTS BAR NUCLEAR PLANT

2.8 Construction Effects -

1. General construction considerations - To avoid unnecessary peaks in manpower requirements and to take advantage of the relatively dry fall weather for construction work, it is deemed advisable from a construction standpoint to begin the onsite work in the fall of 1972. Initial work will be centered around three main categories of construction activities: (1) general grading of the site; (2) construction of the "Construction Plant Facilities" which include various shop needs, 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 concerns the start of the permanent concreting program for all structures now planned to begin about six months after the start of 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 grounds-keeping and housekeeping 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 50 to 55 acres will be affected by tree cutting and clearing required for the construction area needs. Merchantable timber, if any, will be sold and hauled away by the purchaser. A large portion of the acreage to be cleared lies in a marshy area that needs draining, clearing, and filling in order to improve and upgrade the general area. 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 powerhouse structure area of 1,400,000 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 purchased approximately 967 acres of land to supplement land already owned. The land has been generally cleared by previous owners except for some

263 acres of woodland which are broken up into three major woodland stands plus some minor scattered areas along drainage sloughs and in the vicinity of tenant housing locations.

The main powerhouse complex will be centered in a large previously cleared area. This complex, including the switchyard, will take in an area of approximately 90 acres with less than 10 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	Approximate Area to be Cleared
Powerhouse complex including switchyard	90 acres	6 acres
Holding ponds	40	30
Cooling towers	10	1
Railroad and access road	5	2.5
Construction plant shop and administration	50	8
Parking lots	11	4
Warehouse and storage area	60	2
	266 acres	53.5 acres

The construction plant area was 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 210 acres of woodland will remain undisturbed for the 2-unit installation. This comprises approximately 80 percent of the existing woodland.

(2) General grading and excavation - Design information issued as of the present indicates the following grading and excavation quantities required in the construction of the Watts Bar Nuclear Plant.

	Grading and Excavation Earth (CY)	Excavation Rock (CY)	Backfill or Embankment (CY)
Main PH complex	419,160	120,000	96,820
Switchyard	168,360		35,370
General yard	517,070		457,500
Dikes & holding ponds	39,580		16,620
Intake channel	200,000	2,500	
Pumping station	31,000	10,000	8,000 (est.)
Construction plant	5,000		90,000
Totals	1,380,170	132,500	704,310

Following clearing and the 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 728±. Existing ground elevations in these areas range up to elevation 740 requiring a 12-foot cut at the maximum to reach plant grade. Excavated material will be used to fill low areas in the construction plant and general plant yard areas. Any excess material removed in the general grading process and not required for the fill noted will be used either for permanent embankments and dikes or will be stored in rolled (compacted) mounds for future use.

The next major operation will be the excavation of the powerhouse complex below the plant yard grade of elevation 728. 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 surrounding landscape, covered with topsoil, and seeded and mulched to avoid erosion.

The shale bed underlying the site and serving as the rock foundation for the powerhouse tends to weather badly on exposure. Also there is some concern that blasting may excessively disturb the rock structure below subgrade. Because of these problems, strict limitations have been placed on the methods to be used in rock removal to powerhouse subgrade. Following excavation of the earth overburden, rock excavation will be accomplished with rubber-tired panscraper units, large dozers equipped with ripper attachments, and other special equipment capable of cutting through this shale material. Blasting will not be permitted.

Heavy equipment will work down to subgrade to remove the rock (interbedded layers of shale and limestone). If the heavy equipment excessively disturbs the rock, a final 4- to 6-inch depth of rock will be removed manually and this surface will be covered within 48 hours of exposure by a 4-inch minimum depth of concrete fill for protection. Actual and detailed methods of this final work at the subgrade level will be dependent on the type of equipment that can operate in this relatively soft rock material without damaging the rock bedding.

During the above excavation program a major construction effort will be made to build the construction plant shop and service facilities for use in the construction of permanent plant features. Those temporary facilities have been designed in detail to provide the maximum efficiency in their construction and eventual service requirements. These facilities will include the administration building; 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; sewerage systems; roadways; railroads; etc. Timing for this work will be to complete the facilities required for service in starting the first permanent concreting operation within 6 to 7 months after starting initial onsite work.

During the above operations excavation requirements will be conducted for the intake channel and pumping station for the essential raw water cooling and makeup system. A temporary dike will be left in 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. When water levels are equalized across the dike, the dike will be removed by panscrapers, draglines and/or clamshells, and by dredging. Breeching of the temporary dike will not be done until the water levels are equalized to avoid excessive siltation wash into the channel areas.

Dredging will be required to carry the essential cooling water channel out to the main river channel for maintaining emergency cooling water supply at minimum reservoir water levels.

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. The "diaper" technique offers some possibilities for control of siltation in the reservoir and may be used during this work if the studies being made indicate the feasibility of this type control.

Design details at this stage are insufficient to indicate the extent of use of riprapping to control reservoir bank erosion.

Much consideration has been given to the general plan for controlling erosion and reservoir siltation during construction. A study is under way to determine if two large ponds on the plant property can be used as settling ponds for the construction plant drainage system. The former owners of the large dairy farm obtained by TVA for a portion of the plant site constructed a dike in a twin fork slough and which has backed up two large ponds. The construction plant drainage system has been designed to discharge into this slough area. By constructing a weir in the dike to control outflow and protect the dike and by placing a "diaper" across the ponded area several feet upstream of the dike, it appears that a natural silt pond can be developed.

2. Siltation control - General grading for both the construction plant area and the permanent plant area will be accomplished in accordance with grading plans as 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 avoid erosion and resultant silting of the Chickamauga 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.

The "diaper" technique developed by the Florida Department of Transportation is being considered as a possible method to reduce siltation effects on Chickamauga Reservoir. This method will be employed during phases of construction when it is considered advantageous.

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 pollution 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 a rolled and sloped (mounded) effect to avoid saturation and erosion so that it may later be used 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 Chickamauga Reservoir.

Gravel is used in the construction areas to provide mudfree 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 only one major area of possible dredge or dragline operation which could have any undesirable effects on the quality of the reservoir. This concerns the excavation of an intake channel to the essential cooling water pumping station. As previously described, excavation of this channel will be conducted behind a dike which must eventually be removed by dredge or dragline. Special efforts will be made to minimize silting in the reservoir, including the use of "diapers," if advantageous. However, a certain amount of turbidity and silting is an unavoidable consequence of operations such as this and fine control is very difficult to accomplish.

3. Solid waste - Trees which must be removed that have no commercial value, stumps, and brush will be disposed of by use of one or more of the following: (1) area burning, (2) air curtain incinerator burning, (3) burning on the premises, (4) mechanical chipping machines and using or disposing of chips as the need dictates. All burning will be performed in compliance with Federal, state, and local regulations. Residue from burning and other unburnable type trash will be collected for disposal in a sanitary landfill operation on the site proper. Metal and lumber scraps and other salvable materials will be collected for periodic sale and removal from the site. Minor

construction waste items may be disposed of by controlled burning or by collecting in large containers and hauling away under contract.

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, sewage is collected in contractor-owned tank trucks and is hauled to a local community sewage treatment plant for disposal.

5. Chemical cleaning - 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 substantially below harmful levels. Procedures for chemical cleaning are not final, but our present plans are to clean piping systems and components before erection. Prior to startup or initial operation, the systems will be thoroughly flushed out with a weak solution of trisodium phosphate to remove grease, oil, or similar contaminants and any loose matter, then given a final flush with filtered or demineralized water. The flush water will be discharged to suitable 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 overflow, pond flooding, and similar occurrences 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. One possible disposal method would be to use the oil at one of TVA's conventional coal-fired plants to take advantage of the heat content.

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 would be field-designed to make use of steel piling with the idea of permanency in mind to provide future flexibility in plant material handling needs if considered desirable by the operating force. 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 would be used only intermittently and no significant adverse impact on the use of waterways would be expected to occur.

An alternate method is also being considered. This involves the use of an already-installed coal-handling dock facility at the adjacent Watts Bar Steam Plant. If the use of this dock proves feasible, construction of a new temporary facility will not be required.

To minimize effects of dust during construction, the use of special 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.

TVA plans to provide its own treated (potable) and raw water supply systems. The treated water supply will be pumped from deep wells drilled near the site, a large spring located near the site, or from a combination of the two. Raw water for construction needs in fire protection, green cutting of concrete, equipment cooling, and other services will be pumped from Chickamauga Reservoir using a temporary, construction-erected pumping station located slightly offshore. Since both treated and raw water facilities will be constructed for use by TVA, there should be no significant impact on the local community water systems. A central compressor plant will be located at a sufficient distance from the primary work area to avoid excessive noise problems associated with stationary-type air compressor operation.

7. Monitoring - TVA will initiate a monitoring program designed to determine existing turbidity and siltation levels,

An alternate method is also being considered. This involves the use of an already-installed coal-handling dock facility at the adjacent Watts Bar Steam Plant. If the use of this dock proves feasible, construction of a new temporary facility will not be required.

To minimize effects of dust during construction, the use of special 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.

TVA plans to provide its own treated (potable) and raw water supply systems. The treated water supply will be pumped from deep wells drilled near the site, a large spring located near the site, or from a combination of the two. Raw water for construction needs in fire protection, green cutting of concrete, equipment cooling, and other services will be pumped from Chickamauga Reservoir using a temporary, construction-erected pumping station located slightly offshore. Since both treated and raw water facilities will be constructed for use by TVA, there should be no significant impact on the local community water systems. A central compressor plant will be located at a sufficient distance from the primary work area to avoid excessive noise problems associated with stationary-type air compressor operation.

7. <u>Monitoring</u> - TVA will initiate a monitoring program designed to determine existing turbidity and siltation levels,

to measure siltation rates and turbidity levels during construction, and, consequently, to minimize increases in levels due to construction effects. This program is expected to yield valuable information as to whether procedures employed for minimizing impacts are sufficient and whether better procedures should be sought.

This program will be followed prior to start of significant excavation and grading and during the portions of the construction activities when the potential exists for significant siltation and turbidity effects. The results of this program at Watts Bar and other projects is expected to put the impacts of construction activities into proper perspective with high, naturally occurring turbidity periods such as periods of heavy rainfall or flooding.

2.9 Socioeconomic Impact - Population in the area will continue to grow along with the industrial growth in the region. Construction of the Watts Bar 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 Watts Bar 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.

Based on the experience at other similar construction projects, TVA has estimated that the "impact area" will extend to between 30 and 35 miles from the plant site but extending no further west than Walden Ridge. This area includes all or part of Loudon, Roane, Rhea, Meigs, McMinn, Hamilton, and Bradley Counties. The "impact area" is extensive due primarily to the lack of any significant concentration of available accommodations.

Workers moving into the area are estimated to comprise between 20 and 25 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 highly skilled workers.

Approximately 50 percent of those workers moving into the "impact area" are expected to buy or rent houses. An additional 35 percent are expected to buy or rent mobile homes. The remaining 15 percent probably will rent apartments or sleeping rooms.

Workers who move and bring their families should make up about 70 percent of all movers. The remaining 30 percent should be mostly single men or men who will live in the area during the week and go home on weekends. On the average, workers who bring their families will have about one school age child per family.

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 2.9-1. This table does not include estimates for effects on service-related functions such as housing construction, additional stores and businesses, etc. Table 2.9-2 contains the projected construction employment to help estimate the timing of the impact. Since local initiative is such a large determinant of impacts, no specific estimates were developed for any specific town or location.

However, the nearby rural community of Spring City is expected to be most directly affected during and after construction. During construction, it is estimated that 20 to 25 percent of the migrating employees are likely to locate there due to its proximity to the site and the relatively inexpensive living costs. This will result in increased loads on water supplies, housing, and sewage disposal, and increased traffic problems in the immediate vicinity of the plant. After construction, the major impact is expected to shift from housing, schools, etc., to commercial establishments because of the numerous tourists and visitors attracted to the area by the nuclear plant.

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 2.9-3 shows that these people will start working there very near the point of peak construction employment and will all be employed over a year before the estimated completion of construction.

Their impact on the project area will be in addition to that estimated in Table 2.9-2 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 in excess of $1.5 million. However, there are no previous surveys to provide a basis for estimating their housing choice, family size, or family composition. 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, among other considerations.

3. Mitigation of impacts - TVA has been working with state and local authorities on both a formal and an informal level since August 1970. The Resource Analysis Staff has had continuous contact with the school boards in Rhea, Meigs, and Roane Counties in order to help school systems anticipate the influx of students which would be caused by construction in the area. The Assistant Commissioner of Education for the State of Tennessee has been informed of the possible impact of the project on education. In addition, TVA has had extensive consultation with many other local and area officials, some of which are described in Section 1.3, Environmental Approvals and Consultations.

Future meetings with local leaders are planned to discuss sewage collection and treatment, solid waste management, improvement of health services, industrial development, increased assistance for education, and transmission line relocation.

TVA, in cooperation with the Tennessee State Planning Commission and the Southeast Tennessee Development District, will be working with area officials in establishing a local developmental planning program. It is anticipated that these secondary impacts will have long-lasting social and economic implications for the area. TVA will continue to work with state and local officials and civic groups throughout the construction and operation of Watts Bar Nuclear Plant to mitigate possible socioeconomic impacts caused by the project.

Table 2.9-1

ESTIMATED IMPACT

WATTS BAR NUCLEAR PLANT CONSTRUCTION EMPLOYEES

SELECTED EMPLOYMENT LEVELS[1]

Employment Level	1,000	2,000
Percent Movers	20	25
Number of Movers	200	500
Demand for:		
Houses	100	250
Mobile Homes	70	175
Apartments and Sleeping Rooms	30	75
Movers with Families	140	350
Movers without Families	60	150
School Age Children	140	350
Total Population Influx	420	1,050

1. Impact will be spread over 7-county areas. Those counties include Loudon, Roane, Rhea, Meigs, McMinn, Hamilton, and Bradley.

Table 2.9-2

PROJECTED CONSTRUCTION EMPLOYMENT

WATTS BAR NUCLEAR PLANT

Month	Projected Employment
September 1972	0
December 1972	480
March 1973	600
June 1973	780
September 1973	1,020
December 1973	1,190
March 1974	1,350
June 1974	1,500
September 1974	1,680
December 1974	1,880
March 1975	2,040
June 1975	2,140
September 1975	2,260
December 1975	2,320
March 1976	2,290
June 1976	2,260
September 1976	2,200
December 1976	2,060
March 1977	1,850
June 1977	1,660
September 1977	1,380
December 1977	1,090
March 1978	830
June 1978	630
September 1978	430
December 1978	290
March 1979	20
June 1979	0

Note: The number of employees is that expected to be on the job at the end of the corresponding month.

Table 2.9-3

PROJECTED PERMANENT EMPLOYMENT

WATTS BAR NUCLEAR PLANT

Month	Projected Employment
June 1975	30
September 1975	35
December 1975	45
March 1976	80
June 1976	150
September 1976	160
December 1976	170 (expected total permanent employees)

Median annual salary based on present pay scales is about $10,000.

2.10 Other Impacts - The following potential environmental impacts have been considered in addition to those discussed elsewhere in this document.

1. Land use compatability - The major impact on land will be the conversion of approximately 967 acres of land to industrial use. That portion of this land which will be occupied by the buildings housing the nuclear steam supply system must be considered irretrievable for the foreseeable future. However, there are no anticipated routine operations of the plant which would prohibit attaining full use of the surrounding land. Other specific impacts related to land use are listed below:

. Government reservations identified in Section 1.1, General Information, will not be significantly affected by the construction and operation of the plant nor is it expected to curtail the future development of Government reservations in the region should the need arise.

. Localized clearing required for construction of the plant and transmission facilities will be the only effect on the region's forestry and clearing will be minimized.

. Recreational development will be stimulated in the area because of the visitor appeal of a nuclear power plant. Provisions will be made for picnic and recreational facilities and a visitors' information lobby at the plant site.

. The construction of this plant will require improvements in the existing rail and highway access facilities.

2. 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 1.1, General Information, as baseline environmental data.

Because of the relatively small quantities of both radioactive and nonradioactive liquid discharges released to Chickamauga 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 Chickamauga Reservoir. The most popular water use of Chickamauga Reservoir in the Watts Bar area is for recreation. The present usage of this portion of the Tennessee River will not be altered in any way by the construction and operation of the Watts Bar plant.

The Watts Bar plant will use approximately 86 million gallons of process water per day which will not curtail known or projected industrial water uses of the average quantity of 17.2 billion gallons of water flowing by the site each day.

Dose commitments due to the operation of Watts Bar Nuclear Plant for the annual intake of drinking water from groundwater (well, spring) sources have been calculated for the 26,000 people assumed to be living within 0.5 miles of the Tennessee River between Watts Bar and Paducah, Kentucky. Conservative estimates for these calculations which are given in Appendix B assumed that the radioactivity in ground water sources within 0.5 mile of the Tennessee River is 100 percent of that present in the river. Based on these assumptions the maximum population dose commitment (thyroid) for an annual release of 0.92 Ci in the liquid effluent is calculated to be 0.16 man-rem. This calculated dose is only 0.004 percent of that which would be incurred from the natural occurring background radioactivity dose to the same assumed 26,000-person population group and the actual dose is expected to be even less.

Operation of the holding pool is not expected to adversely affect ground water supplies in the vicinity. The facts that no toxic materials will be discharged to the holding pool and that ground water movement is expected to be toward the reservoir should preclude the possibility of adverse impacts on nearby ground water.

3. Aesthetics - The plant is located on a river terrace overlooking the Chickamauga Reservoir, surrounded by steep wooded slopes. The entrance road approaching the plant will orient the visitor first to the large cooling towers which will be the most predominant feature on the landscape. To reduce the visual impact of the large facilities, the structures are grouped on a diminishing progression of scale from the reactor, auxiliary, control, turbine, and service building 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. In addition, the forms are designed to relate to the function within and careful consideration is given to detail, such as the forms of the intake and exhaust air houses.

Particular attention is given to the site development and landscaping. Natural features of the terrain are preserved as much as possible, and even utilized to reduce the impact of the installation on man and his environment. The landscaping is designed to provide a recognizable yet harmonious transition between the natural setting and the plant site. The plant design, integrated with the landscape, creates an inviting and pleasant setting for both employees and visitors.

The location of three different types of electric generating facilities in one area, along with the surrounding recreational developments, provides a unique and interesting place to visit for both educational and recreational purposes. Circulation will be sensitively coordinated to provide easy access for and smooth flow between each facility. A visitors' center and overlook on a ridge above the TVA installation is proposed and feasibility will be explored.

4. Archaeology - The archaeological investigations of the site consisted of the excavation of two sites. The findings on Leuty site (Dig No. 40RH6) were of limited importance and those on the McDonald site (Dig No. 40RH7) were considered significant. Charcoal samples taken of the Mississippian culture found at the McDonald site were suitable for radio carbon dating. Investigations of these sites are completed and future work on the first terrace areas along the reservoir edge is not expected to conflict with construction activities.

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 Watts Bar 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 identified.

1. Water pollution - Some unavoidable impacts to Chickamauga Reservoir will occur as a result of 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 of 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 disposed of in an upland fill area to avoid excessive siltation of the reservoir.

. Berms, diversion dikes, check dams, sediment basins, fibre mats, netting, gravel, mulches, grasses, special drains, and other control devices will be used to control surface drainage and erosion during grading operations.

. Diaper technique will be used for siltation control when it is considered advantageous.

. Soil and earth from excavation work will be used as fill or stored in compacted mounds to prevent wind and rain erosion until needed.

. 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 Watts Bar will result in small amounts of heat, chemical, sanitary, and radioactive liquid wastes being discharged into Chickamauga Reservoir. Mitigation of possible related effects will be accomplished as follows:

. A diffuser will rapidly mix the heated cooling tower blowdown with unheated reservoir water.

. A 2-basin lagoon will remove settlable 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 tritium retained.

. Radioactive steam generator blowdown will be treated by evaporation.

As indicated, adequate treatment of liquid effluents is provided prior to being discharged to ensure that all applicable standards are met and that the quantities and concentrations released will be small enough to ensure that any adverse environmental effects are insignificant or undetectable. Water, aquatic life, and life systems will be carefully monitored to detect possible adverse environmental effects.

2. Air pollution - The construction of Watts Bar 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. In addition, large quantities of waste heat and moisture in the cooling tower plumes may result in some alteration of the local environment. 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 which permits decay of essentially all noble gases except krypton-85 before release. Careful monitoring of these releases will be conducted to detect probable effects.

. Natural draft hyperbolic cooling towers disperse heat and moisture to the atmosphere at an elevation 478 feet above ground.

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 Watts Bar Nuclear Plant will result in a change in land use of approximately 967 acres from predominantly farming to industrial use. It will affect the economic status of Rhea County and increase the demand for community services. In addition, right-of-way easements will be obtained on approximately 3,165 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, the economic stimulus, and the demand for services 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 the closed-cooling system. The extent of the presence of fish larvae near the proposed water intake is not known at this time. To the extent that the plankton drawn into the water intakes serves as a food source for aquatic life, its 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 0.3 to 0.5 percent of the average annual flow, 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. Conclusions - While the construction and the operation of Watts Bar 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

Section 102(2)(C) of NEPA requires a discussion of alternatives to the proposed action.

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. Alternative methods of generation and alternative plant sites are discussed in detail in sections 4.1 and 4.2, respectively.

1. Alternative systems for reductions of radioactive discharges - Analyses of alternative systems for the reduction of radioactive discharges include consideration of subsystems for both liquid and gaseous radioactive discharges. These systems were considered using feasibility, environmental impact, and cost as factors in the analyses.

(1) Liquid radwaste alternatives - Modifications to the original system design have resulted in further reduction in releases of water containing radioactive products. The methods include the recycling of tritiated liquid, the extended treatment of radioactive steam generator blowdown, and the use of Ag-In-Cd control rod absorbers to reduce tritium generation.

As shown in section 2.4, the system of tritium recycle and extended treatment of steam generator blowdown will hold releases of radioactive liquids to the lowest level practicable.

(2) Gaseous radwaste alternatives - The system originally planned for treatment of gaseous radioactive discharges was to provide a 45-day holdup period to permit decay of radioactive gases. In keeping with TVA's policy to keep the discharge of all wastes from its facilities at the lowest practicable levels, additional systems were considered which might further reduce the releases to the environment. The alternative systems for reduction of gaseous discharges which were evaluated in terms of cost, feasibility, and environmental considerations were a 60-day holdup, cryogenic distillation, gas absorption in a fluorocarbon solvent, and a hydrogen recombiner.

The analysis of these alternatives is discussed in sections 2.4 and 8.3 and concludes that the 60-day holdup alternative represents the best balance of cost, feasibility, and reductions in the environmental impacts.

2. Alternative heat dissipation methods - The systems which were given consideration as alternative heat dissipation methods include once-through cooling using a diffuser system, mechanical draft cooling towers, natural draft cooling towers, a spray canal system, and a cooling lake. These alternatives were considered using feasibility, environmental impact, and cost as factors in the analyses.

As described in section 2.6.4, the once-through cooling system and spray canal alternatives were not considered feasible for this site, and the cooling lake was environmentally unacceptable. Consequently, detailed cost analyses were made only on the two types of cooling towers. The results of these studies indicated that the natural draft cooling tower alternative was the best choice. The decision to incorporate this alternative into the plant design and the associated environmental impacts are described in sections 2.6 and 8.3.

4.1 Alternative Generation - 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 Watts Bar 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 1977, 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 1977 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 suitable in the TVA service area 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 gas in the TVA area in order to secure a 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 gas supply for these gas turbines. The gas contracted for is only available in the summer, and no gas could be obtained for year-round operation. On the basis of these investigations, it was concluded that a gas supply was not available in the quantity required for a gas-fired plant of the capacity of the Watts Bar Nuclear Plant.

TVA solicited and consulted oil companies in May and June 1970 to determine procurement prospects for furnishing the requirements of oil-fired units. As a result of these inquiries, TVA concluded that the long-term requirements of an oil-fired generating facility could not be assured. Because of the lack of a reliable fuel supply, an oil-fired unit was not a feasible alternative.

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 is tabulated below:

	Coal-fired Plant	Nuclear-fueled Plant
Plant investment - \$ millions	630.0[a]	607.0
Plant net electrical capacity - MW	2,522.0	2,258.6
Plant investment - \$/kW	249.8	268.8
Levelized fuel cost - ¢/10^6 Btu	25.0	15.5
Net plant heat rate - Btu/kWh	8,947.0	10,355.0
Estimated Annual Production Expense[b] - $\frac{\text{mill}}{\text{kWh}}$		
Plant investment	3.1	3.3
Operating and maintenance cost	2.7	1.9[c]
Total	5.8	5.2
Difference	0.6	base

a. Includes the cost of fly ash and SO_2 removal equipment.
b. Based on a 10-year present worth evaluation at 8 percent interest.
c. Includes estimated cost of nuclear insurance.

Based on the 0.6 mills/kWh difference indicated above, TVA estimates that the selection will result in an annual cost saving of about \$10 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 25 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.

Since the Watts Bar draft statement was issued in May 1971, the Valley states have adopted SO_2 emission standards which make the feasibility of a coal-fired plant more questionable. Although TVA is proceeding on the development of a SO_2 removal process on the Widows Creek Unit 8, major improvements in SO_2 removal technology have not become a reality since the Watts Bar draft environmental statement was issued. 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 is a severe economic penalty associated with their implementation.

Consequently, economical and feasible solutions to the problems associated with SO_2 emissions are not available.

Also, the large quantities of coal and the resulting ash associated with a fossil-fired plant present large-scale materials-handling problems, both at the plant site and along transportation routes, which are significantly greater than for a nuclear plant.

A comparison of impacts of coal-fired and nuclear-powered plants shows the following:

- Heat rejected to receiving waters would be small for both types of generation utilizing auxiliary cooling facilities (less than 5 percent of the total heat rejection) with the coal-fired plant rejecting slightly less than the nuclear plant.

- The amount of transportation required annually for the coal-fired plant (approximately 70,000 rail car shipments) would be much greater than that required for the nuclear plant (approximately 13 rail car and 35 truck shipments), including new and spent fuel and radwaste.

- The nuclear plant would require an annual commitment of about 400 tons of U_3O_8 while the coal-fired plant would require commitment of about 7 million tons of coal.

- Based on achieving 80 percent removal and using 3 percent sulfur coal, the coal-fired plant would release approximately 75,000 tons per year of SO_2 to the atmosphere. In addition, it would release approximately 46,000 tons per year of NO_x and about 9,000 tons per year of particulates. Ash which must be handled on the plant site would amount to about 1 million tons per year. Releases of similar constituents from a nuclear plant are negligible (see Section 2.5, Nonradioactive Discharges).

- Radioactivity releases to the atmosphere from either type plant result in insignificant doses to the public. Doses resulting from operation of the nuclear alternative are described in Section 2.4, Radioactive Discharges, while the doses resulting from the coal-fired plant's operation are unknown.

- Radioactive releases to receiving waters from the nuclear alternative would be so small as to be considered insignificant as described in Section 2.4, Radioactive Discharges. Releases of a similar nature from the coal-fired plant would be expected to be even less.

- Land usage requirements are slightly less for the nuclear alternative.

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 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. Power plants have exacting requirements and the number of usable sites are limited. Among the general considerations involved in determining these locations are:

1. Environmental factors
   a. Physical characteristics such as meteorology, hydrology, and seismology
   b. Compatability with surrounding environment
2. Location with respect to populated areas
3. Sufficient land areas
4. Accessibility to the site by highway, rail, or barge
5. Distances to centers of power use
6. Transmission facilities required to interconnect to the system network
7. Proximity to adequate and competitively priced fuel supply

Through the above mentioned investigations, TVA had identified and had under consideration several sites on the upper portion of the Kentucky Reservoir and on the Pickwick, Guntersville, Chickamauga, and Watts Bar Reservoirs for possible location of the 2-unit nuclear plant for operation in the 1976-77 time period. On the Guntersville, Chickamauga, and Watts Bar Reservoirs, TVA had the following sites under consideration for the location of these units:

Site	Reservoir	Location
A	Guntersville	TRM 369L
B	Guntersville	TRM 386.5R
C	Guntersville	TRM 392R
D	Guntersville	TRM 398.5R
E	Chickamauga	TRM 499L
F (WBNP)	Chickamauga	TRM 528R
G	Watts Bar	TRM 559R

While the best location from the standpoint of power system load growths only would have been in the western portion of the TVA system, the seismic conditions of those sites in the Kentucky and Pickwick Reservoirs were not clearly defined, and more investigations and studies would have been required before a nuclear plant could have been designed and licensed in that area. TVA has undertaken these investigations and is using consultants in order to define the seismic conditions in the Pickwick area.

2. Environmental considerations -

(1) Chickamauga and Watts Bar Reservoir Sites - For the sites on the Chickamauga and Watts Bar Reservoirs, the following qualitative environmental factors of the area were known from previous data gathered for the preparation of the preliminary safety analysis report for the Sequoyah Nuclear Plant under construction at TRM 484.5.

(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 Watts Bar Dam located at TRM 529.9 forms the 72.4-mile long Watts Bar Reservoir which has a surface area of 39,000 acres and a volume of 1,010,000 acre-feet at normal pool elevation of 741.0. The average annual flow at the dam is 26,600 ft^3/s.

Both reservoirs are 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 each of the sites would be dependent upon the underlying geologic formations.

Each of the sites have ready access to the Tennessee River for an adequate supply of water for necessary heat dissipation, auxiliary cooling, and other plant needs.

(b) Seismology - Like the Sequoyah Nuclear Plant, all of the sites on these two reservoirs lie 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 Watts Bar and Chickamauga sites are 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 - Each of the three sites on the Chickamauga and Watts Bar Reservoirs are remotely located from large population centers. Site G is about 25 miles from Oak Ridge and is the site nearest to a large population center.

(e) Land requirements - The total site desired for a nuclear plant of this size is about 1,000 acres. However, the exact acreage required for each site would be determined only after a detailed site analysis. The property not presently in TVA ownership and required to provide the plant needs is shown on Table 4.2-1.

(f) Conclusion - From consideration of the above environmental factors, TVA concluded that any of the above sites for Chickamauga and Watts Bar Reservoirs would be suitable for the location of a nuclear plant, provided foundation conditions were found suitable.

(2) Guntersville Reservoir sites - For the four sites located on the Guntersville Reservoir similar qualitative information was available for consideration of the above mentioned environmental factors.

(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 1,018,000 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 upon 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 - All of the 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 - Each of the four sites is remotely located from large population centers. Site A is about 30 miles from Huntsville and is the site nearest to a large population center.

(e) Land requirements - Table 4.2-1 indicates the additional land which would have to be purchased by TVA. The extra acreage required at Site C results from the fact that it lies on a peninsula and the entire peninsula would have to be purchased.

(f) Conclusion - From consideration of the above environmental factors, TVA concluded that the Guntersville sites would be suitable for the location of a nuclear plant, provided foundation conditions were found adequate.

3. Feasibility - Table 4.2-1 summarizes the physical characteristics of the above sites which were pertinent in the determination of the feasibility of each for locating this nuclear plant.

A discussion of the factors listed follows in the paragraphs below.

(1) Access facilities - Each site was suitable for barge access. The amount of highway improvement required was least at Site E where Tennessee Highway 60 is at the site and at Watts Bar where Tennessee Highway 68 is at the site. Rail access to

Watts Bar would have required only about one-half mile to connect into the existing Watts Bar Steam Plant access railroad.

(2) Site grading - Except for Site G, there is a moderately good balance between the excavation and fill requirements. For Site G, the excess excavation of approximately 1.2 million cubic yards would require disposal by other alternative uses.

(3) Proximity to populated areas - Each of the sites is remotely located from large population centers. Since each site was remotely located, the proximity to population centers was not considered a significant siting factor between sites.

(4) Distance to nearest transmission lines - While the actual transmission facilities required are determined only after detailed evaluations, the distance to the nearest transmission line is an indicator of the relative amounts of transmission line construction required. As shown on Table 4.2-1, sites D, E, and Watts Bar are the more favorably located sites with respect to both 161- and 500-kV transmission lines in existence.

(5) Conclusion - From consideration of the above environmental factors, no significant physical characteristic was identified that would preclude the location of this nuclear plant at any of the proposed sites. However, the site having the more favorable characteristics was Watts Bar. Because of the existence of the Watts Bar Steam Plant adjacent to this site, the rail and highway access was superior to other

sites and only minimal extension of the existing facilities would be required for the construction and operation of a nuclear plant. Barge access could also be easily accommodated. The amount of site grading required was not excessive. Its location was remote from population centers, yet was in close proximity to existing transmission facilities connecting to the load centers at Knoxville and Oak Ridge. In addition, the foundation conditions of the Watts Bar site were known from core drillings performed in 1950. These investigations indicated that rock was at a favorable depth.

4. Additional considerations -

(1) Schedule - Since generally more site-related data was available on the Watts Bar site than the other sites, particularly in regard to foundation conditions, selection of Watts Bar provides the lead time required for the scheduled commercial operation of the units.

(2) Cost - A qualitative comparison of the site-related cost factors--namely the amount of land to be purchased, site grading, foundation requirements, access, and the probable transmission line requirements--showed the Watts Bar site to be favorable relative to the other alternative sites.

(3) Fuel availability - Due to the flexibility to transport nuclear fuel by rail, truck, or barge, nuclear fuel could be available at any of the sites considered.

5. Conclusion - Since the Watts Bar draft environmental statement was filed in May 1971, TVA has conducted site studies at other locations and onsite studies at the Watts Bar site. The specific onsite studies include the collection of onsite meteorological data, archaeological surveys, detailed core drillings, foundation exploration, onsite ecological studies, and detailed design studies to determine the specific equipment requirements related to the location of the 2-unit pressurized water reactor plant at the Watts Bar site. As a result of these studies, some modification of the original equipment has been made. In particular, the containment system has been modified as a result of meteorological data collected at the site. The onsite meteorological data collected in the 11-month period (July 1971 - May 1972) showed more adverse dispersion conditions than originally anticipated. With this modification radioactive releases are expected to be well within applicable standards.

In addition, TVA has continued its site investigations in other areas. These continuing investigations have not identified any other sites which would be more suitable than the Watts Bar site for the location of this 2-unit plant.

After considering alternative sites for this plant, TVA has concluded that the Watts Bar site is a suitable location for this 2-unit plant and is the site which provides the best opportunity for meeting TVA's power supply obligations in the late 1970's.

Table 4.2-1

SUMMARY OF SITE EVALUATION FACTORS

Site	A	B	C	D	E	Watts Bar	G
1. Additional Land Required - Acres	400	900	1,400	800	600	900	1,000
2. Access Facilities - Miles							
Highway	16	1	2½	1	-[b]	-[b]	6
Rail	27	2½	3½	2	19	½	8
Barge[a]	---	---	---	---	---	---	---
3. Site Grading - 10^6 yd^3							
Excavation	1.2	0.9	0.8	1.2	0.3	1.4	1.5
Fill	1.0	0.4	0.4	0.3	0.5	0.7	0.3
4. Proximity to Populated Areas							
Nearest Town	Grant, Ala.	Scottsboro, Ala.	Hollywood, Ala.	Stevenson, Ala.	Dayton, Tenn.	Decatur, Tenn.	Rockwood, Tenn.
Distance - Miles	6	4	3½	6	6	6	5
Population	382	9,324	301	2,390	4,361	698	5,259
Nearest City	Huntsville, Ala.	Huntsville, Ala.	Huntsville, Ala.	Chattanooga, Tenn.	Chattanooga, Tenn.	Oak Ridge, Tenn.	Oak Ridge, Tenn.
Distance - Miles	30	36	39	37	30	42	25
Population	137,802	137,802	137,802	119,082	119,082	28,319	28,319
5. Distance to Nearest Transmission Lines - Miles							
500 kV	28	13	10	6	3½	5	6
161 kV	4	2	2	1	6	1	7

a. All sites had barge transportation available and would not require extensive dredging.
b. Highway at the site.

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.

The local short-term uses of the environment are those required to construct and operate the plant. These include the preparation of the site and construction of buildings and facilities, the use of the ambient air for the dispersion of gaseous effluents and heat, and the use of Chickamauga Reservoir for the dissipations of minor amounts of waste heat, liquid radioactive effluents and chemical discharges. However, the effects of these uses will be minimized and will have no long-term effects on the environment.

Most of the short-term uses of the site will result in no significant effect on the long-term productivity of the land affected since only that portion occupied by the reactor system buildings will be affected for a period much longer than the useful life of the plant. The long-term productivity of no other land will be irreparably damaged.

The operation of the Watts Bar plant will not result in any significant long-term environmental degradation. All effluents discharged to the air, water, and land will be well within levels which are considered acceptable for the short-term uses of the environment. Environmental monitoring programs will include the sampling and analysis of air, water, aquatic life, and elements of the food chain near the facility. This will provide a baseline inventory for detecting and evaluating specific parameters of environmental impacts which might lead to long-term effects, in order that timely corrective action can be taken if required.

In view of the foregoing environmental considerations, the immediate benefits to be derived from the initiation of this project are not expected to noticeably curtail the long-range beneficial uses of the natural resources of the area. The cumulative long-term effect of the Watts Bar Nuclear Plant will be the localized shift of the usage of 967 acres of land to meet the demand for power.

Thus, in the sense that each generation is trustee of the environment for succeeding generations, the Watts Bar Nuclear 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 Watts Bar Nuclear Plant. This required identifying the extent to which operation of the facility curtails the range of beneficial uses of the environment.

The construction and operation of the Watts Bar Nuclear Plant will involve the use of a certain amount of air, water, and land. Except for the plant site itself, the range of beneficial uses of the environment will not be curtailed. However, the site on the Watts Bar Reservation will continue to be dedicated to power production for the foreseeable future.

About 700 kilograms per year of U^{235} and about an equal amount of U^{238} will be consumed by each unit. About 4.8×10^6 gallons of fuel oil is required for the auxiliary boilers and for testing the diesel generators. To the extent that this fuel is consumed and not subject to being recycled to other uses, it is 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 and will have lost their value. 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 are 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 for the foreseeable future.

The commitment of natural resources associated with this plant's construction are small when compared to the benefit obtained from the electricity which will be generated. Moreover, the dependable production of electricity is essential to the health, safety, and welfare of the people.

7.0 AGENCY REVIEW COMMENTS

Responses to agency review comments are included in the topical discussions of this statement. The numbers noted in the margins of the agency comments indicate the sections in which the questions are answered.

Atomic Energy Commission
Department of Agriculture
Department of the Interior
Department of Housing and Urban Development
Department of the Army
Department of Health, Education, and Welfare
Southeast Tennessee Development District
Environmental Protection Agency
Department of Transportation
Office of Urban and Federal Affairs, State of Tennessee
  Tennessee Department of Conservation
  Tennessee Department of Public Health
  Tennessee Historical Commission
  Department of Highways
  Tennessee State Planning Commission
  Tennessee Game and Fish Commission
Department of Commerce
Federal Power Commission

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

SEP 6 1971

Docket Nos. 50-390
50-391

Mr. James E. Watson
Manager of Power
Tennessee Valley Authority
818 Power Building
Chattanooga, Tennessee 37401

Dear Mr. Watson:

Thank you for your letter of May 14, 1971, forwarding for our review and comment a copy of your Draft Environmental Statement for the Watts Bar Nuclear Plant, Units 1 and 2. The report has been reviewed by representatives of this office, and specific comments are provided in the enclosed summary.

As I indicated to Mr. Hughes during our telephone conversation of September 2, we are examining the implications of the decision of the District of Columbia Circuit Court of Appeals in the Calvert Cliffs case with respect to the procedures set forth in Mr. Harold Price's letter of June 30, 1971, that will be followed by TVA and AEC in implementing certain of the requirements of NEPA for TVA applications for facility license. We will communicate further with you concerning this

Sincerely,

Lester Rogers

Lester Rogers, Director
Division of Radiological and
Environmental Protection

Enclosure:
Comments

Comments on Watts Bar Nuclear Plant

Units 1 and 2

1. Water Budget -

It is difficult to evaluate the impact of plant operation on river flow based on the information given. For example, the discussion on p. 33 of process water utilization indicates that 8.6×10^7 gal/day (max) of water is required. Evaporative loss is estimated to be as high as 3.7×10^7 gal/day (p.36), apparently resulting in a flow into the holding pool of at least 50 million gallons per day. Although average summer flow of water is given on p.22 as about 1.4×10^{10} gal/day, no data on minimum river flow are provided. It appears that maximum evaporative loss could occur during periods of minimum river flow, and that coolant water of maximum temperature (about 10°F) will be returned to the reservoir during this period. The final Environmental Statement could benefit by considering the following:

2.6.2(1)
2.6.4(1)

a. Expanded discussion of stream flow at Watts Bar Dam, particularly the water temperature and volume during conditions of minimum flow.

2.6.2(1) b. Volume and temperature of condenser cooling water as it is returned to the reservoir by way of the holding pool, particularly during periods of minimum flow.

Table E-1, Table 2.5-2 c. Expected chemical and radioisotope concentrations by species in the discharge effluent would be helpful.

2. Heat Dissipation

An expanded discussion of certain aspects of heat dissipation would be useful. Those aspects of particular concern include the following:

2.6.1, 2.7.1(4) a. A more definitive description of water intake structure design in terms of its effect on reservoir biota; such as screen mesh size, intake dimensions, fish escape pathways, and depth of intake structure.

2.6.2(1) b. Holding pool characteristics, including water budget, expected seasonal flow and temperature characteristics of discharge water, and a discussion of expected effects of floods on the holding pond.

3. Ground Water -

1.1.3(7)(a) 2.10.2

Operation of the holding pool will recharge the ground water system and no doubt modify the local ground water gradient. A discussion of potential impact on the ground water table and on individual water wells in the immediate vicinity would be useful.

4. Radiological Aspects -

Several comments regarding radiological aspects of the report are as follows:

1.1.3(6)

a. A summary of temperature inversion information, including duration, frequency, relationship to fog, and wind velocities would be relevant.

Table 2.4-2
Table E-3
Table E-4

b. The man-rem dose calculations are based on populations within a 5-mile radius. Calculations based on a larger radius would be more representative of the general population. The AEC routinely utilizes a 50-mile radius for man-rem calculations. Also, some consideration should be given to man-rem doses to populations utilizing the river as a source of public water supply. Some of these centers are in a down-stream direction beyond the 50-mile radius, but well within the range of potential effects.

Table 2.4-2
F.3
F.4

c. The discussion on radiation doses from gaseous releases (sec. 2. 3. 7. 4) considers external doses from noble gases. The 3.5 mrem/year reported on line 9, p. 61, is a dose rate rather than a dose, and the value is of such a magnitude that it probably represents both gamma and beta radiation. Some consideration should also be given to the halogen and particulate releases and their effects by inhalation and ingestion.

Table 2.4-2
Table E-3
Table E-4

d. An estimate of doses that could be expected by ingestion of edible aquatic organisms from the reservoir (e.g. fish and clams) would provide a more complete evaluation of total impact of the plant operation.

5. Environmental Monitoring Program -

Table 2.4-5
2.7.2

The monitoring program appears to be extensive and adequate. The only comment in this regard relates to the sediment sampling schedule described on Table 21, in which no samples are collected at Station X. Sediment samples at this point would provide useful comparative data.

7.1-4

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

Docket Nos. 50-390
and 50-391

MAY 26 1972

Dr. Francis E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
720 Edney Building
Chattanooga, Tennessee

Dear Dr. Gartrell:

This is in response to your letter of April 10, 1972, transmitting the Supplements and Additions to the Draft Environmental Statement for the Watts Bar Nuclear Plant. We have reviewed the Draft Environmental Statement (DES) as well as the Supplements and Additions, (S&A) in accordance with the requirements placed on Federal Agencies by the National Environmental Policy Act of 1969.

Consistent with the letter from Mr. Harold L. Price to Mr. James E. Watson dated June 30, 1971, we have concentrated our review on the radiological impact of normal plant operation and the impact of radiological accidents. Comments on these portions of the DES and the S&A are given in Enclosure 1.

Enclosure 2 represents our analysis of the environmental impact of radiological accidents utilizing the uniform models and calculational techniques that we are applying to other nuclear plants.

If we can assist you further in this matter, please let us know.

Sincerely,

Daniel R. Muller

Daniel R. Muller, Assistant Director
Environmental Projects
Directorate of Licensing

Enclosures:
1. Comments on Radiological Impact Section
2. Environmental Impact of Accidents

Docket Nos. 50-390
and 50-391

ENCLOSURE 1

COMMENTS ON RADIOLOGICAL IMPACT SECTIONS OF THE DRAFT ENVIRONMENTAL STATEMENT FOR THE WATTS BAR NUCLEAR PLANT

I. Radiological Effects - Draft Environmental Statement Supplements and Additions, Section 3.1.4

1. No attempts were made to check all of the dose calculations presented in the subject statement, however, a few calculations were made by us using the liquid releases shown in Table 3.1-6, effluent discharge flow rate of 30,000 gpm and an individual liquid intake of 2200 ml/day. The following annual organ dose commitments were calculated for individuals drinking plant effluent water prior to dilution: Bone - 0.20 mrem, G.I. Tract - 0.036 mrem, Thyroid - 2.9 mrem and Total Body - 0.11 mrem. The draft environmental statement in Table 3.1-8, B. indicated annual doses (mrem) of 0.26, 0.28, 4.3, and 0.14 for the respective organs cited above. In Table 3.1-2, "Dose Commitments From Tritium Per Curie Released," item B indicates a total body dose of 1.7×10^{-3} mrem while our calculation results in a total body dose of 2.8×10^{-3} mrem. E.1

   These differences in dose calculations even though they are not significant, should be reconciled to be certain there are no inconsistencies in dose calculations and assumptions presented in the statement.

2. In Table 3.1-1 the activity released in liquid effluents (excluding tritium) is noted as 0.70 Ci/yr while Table 3.1-6 indicates 0.46 Ci as the estimated annual liquid release (excluding tritium and releases resulting from primary to secondary leaks). The difference in the activity released is appropriately noted in the tables, however, it appears that the dose commitments from liquid effluents have been calculated for the most part on the basis of 0.46 Ci/yr. To be realistic the value of 0.70 Ci/yr should be used throughout to calculate dose commitments and the nuclides listed in Table 3.1-6 should be adjusted to reflect the higher total release value. Table 2.4-2 Table E-1

II. Monitoring Programs - Draft Environmental Statement Section 2.3.6-3

Even though the radiological monitoring program will be considered in the AEC licensing procedure, the following comments are offered.

2.4.3(2) 1. The bases for selecting the locations of the 10 monitoring stations should be given.

2.4.3(3) 2.4.3(4)(a) 2. There is no indication of a plan to sample animals. If there is significant meat animal raising in the vicinity then this type of sample should be considered. A representative sampling of food crops should be included in the program. The monthly and quarterly sampling frequencies for domestic water supplies are not as satisfactory as composite samples which would be more likely to detect abnormal concentrations which might be missed by grab type samples as indicated in Table 20.

2.4.3(3) Table 2.4-4 3. Charcoal filters should be analyzed weekly, rather than biweekly for I-131. Milk samples should also be analyzed weekly for I-131. Rainwater samples should be analyzed for H-3 on a monthly basis.

III. Transportation Aspects - Draft Environmental Statement - Supplements and Additions, Section 2.1

2.1.1 1. The statement is made that the fuel will be shipped in containers "safe in infinite geometry." This is inconsistent with the statement that the packages will meet Fissile Class II or III. Such packages are not required to be "safe" in an infinite geometry but rather are required to be "safe" in the allowable number of packages according to the regulation. It is unlikely that the packages used will be safe in an infinite geometry.

The statement could be revised to indicate that the containers "will have been demonstrated to assure nuclear criticality safety under both normal and accident conditions as provided in 10 CFR Part 71."

2.1.4(2)(a) 2. The statement is made that new fuel assemblies are enclosed in polyethylene wrappers and placed in a metal container <u>which provides insulation for fire protection</u>. In fact, the metal container provides little or no insulation for fire protection. Some designs include an outer wooden container which provides insulation for fire protection. The metal container provides only minor protection from impact or fire; the ceramic pellets contained in the zircaloy cladding, which is the fuel assembly, provides the fire resistant characteristics on which containment in an accident depends.

IV. Radiological Effects of Accidents - Draft Environmental Statement, Supplements and Additions Section 2.3

2.3 1. The statement that conservatisms are supplied in the safety analysis reports to "...place upper bounds on radioactive releases resulting from postulated accidents." is not quite correct. The purpose of the safety analysis report conservatism is to establish some limit for design bases.

Table 2.3-2 2. The heading of the fifth column of Table 2.3-3 is misleading. The data presented are not in "% of limit," but in fractions of the limit.

2.3 3. In general, there are differences between TVA results as given in Table 2.3-3 and AEC results as given in Enclosure 2. These may be attributable to TVA's use of on-site meteorological data (although this is not stated in the report). In any event, conclusions as to the environmental risks due to postulated radiological accidents are the same.

ENCLOSURE 2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Estimated Fraction of 10 CFR Part 20 at Site Boundary 1/	Estimated Dose to Population in 50 Mile Radius, man-rem
1.0	Trivial incidents	2/	2/
2.0	Small releases outside containment	2/	2/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.046	1.7
3.2	Release of waste gas storage tank contents	0.18	6.6
3.3	Release of liquid waste storage tank contents	0.005	0.18
4.0	Fission products to primary system (BWR)	N.A	N.A
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	2/	2/
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	0.001	<0.1
5.3	Steam generator tube rupture	0.06	2.2
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.010	0.35

Class	Event	Estimated Fraction of 10 CFR Part 20 at Site Boundary 1/	Estimated Dose to Population in 50 Mile Radius, man-rem
6.2	Heavy object drop onto fuel in core	0.17	6.1
7.0	Spent Fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	0.006	0.22
7.2	Heavy object drop onto fuel rack	0.024	0.88
7.3	Fuel cask drop	N.A.	N.A
8.0	Accident initiation events considered in design basis evaluation in the Safety Analysis Report		
8.1	Loss-of-coolant accidents		
	Small break	0.1	7
	Large break	0.11	15
8.1(a)	Break in instrument line from primary system that penetrates the containment	N.A	N.A.
8.2(a)	Rod ejection accident (PWR)	0.011	1.5
8.2(b)	Rod drop accident (BWR)	N.A.	N.A.
8.3(a)	Steam line breaks (PWR's outside containment)		
	Small break	<0.001	<0.1
	Large break	<0.001	<0.1
8.3(b)	Steamline breaks (BWR)	N.A.	N.A.

1/ Represents the calculated fraction of a whole body dose of 500 mrem or the equivalent dose to an organ.

2/ These releases are expected to be in accord with proposed Appendix I for routine effluents (i.e., 5 mrem/yr to an individual from all sources).

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

July 23, 1971

VIA AIR MAIL

Mr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Mr. Gartrell:

We have had the environmental statement for Units 1 and 2 of the Watts Bar Nuclear Plant reviewed in the relevant agencies of this Department, and comments prepared by the Forest Service, the Soil Conservation Service, and the Agricultural Research Service are enclosed herewith. Two copies of the statementare returned.

Sincerely,

T C Byerly

T. C. BYERLY
Assistant Director
Science and Education

Enclosures

U.S. Department of Agriculture
Forest Service

Re: Watts Bar Nuclear Plant Units 1 and 2, TVA

The plant will be located in Rhea County, Tennessee, on land adjacent to the TVA Watts Bar Dam Reservation at Tennessee River mile 528 on the west shore of Chickamauga Lake. The plant will consist of two reactor containment buildings, turbine and service buildings, two cooling towers, auxiliary building, transformer yard, a switchyard, and a sewage treatment plant.

The Cherokee National Forest is located some 40 miles east of the proposed plant. However, we are not aware of any major items of concern to National Forest Administration that would occur as a result of the construction and operation of the plant.

In connection with our non-Federal forest land program responsibilities we are pleased to note that TVA will employ all practical measures available to prevent or abate pollution of the environment. To assure this, they will conduct a comprehensive environmental monitoring system that will include observations of the existing levels of radioactive materials in the environment, and ecological studies to determine if any biological changes occur as a result of low-level radiation exposure.

The statement does not discuss possible effects of accidental radioactive releases on the environment. Unless an accident can be ruled
2.3 out as impossible, the environmental statement should consider its potential consequences to Lake Chickamauga. In this connection TVA should consider the possible need for alternate or supplementary waste treatment facilities. In addition, the establishment of
2.4 higher water quality standards or the detection of unanticipated adverse environmental effects may require additional waste treatment facilities. It would seem important that radioactive disposal processes be provided sufficient flexibility in order that additional controls can be added.

COMMENTS OF

Soil Conservation Service
U. S. Department of Agriculture

on

Draft Environmental Statement Prepared by
Tennessee Valley Authority

Watts Bar Nuclear Plant Units 1 and 2

2.9.1 The statement discusses the impact of the proposed facility in the context of relatively large political areas, e.g., counties. The statement would be strengthened if it were expanded to include some specific discussion of expected effects on the social and economic aspects of the rural community in the immediate vicinity.

Review of Environmental Statement

Tennessee Valley Authority, Watts Bar Nuclear Plant Units 1 and 2. Draft Environmental Statement, Dated May 14, 1971. Type of Proposed Action: Administrative

The subject environmental statement has been reviewed by the Agricultural Research Service. No basis appears for rejecting the proposal based on permanent damage to soil and water resources involved. However, statements made in the report that contain phrases such as "is expected to have no adverse impact" and "is expected to have no significant adverse impact" are not reassuring, especially to those living in the area. This is especially true as releases of small quantities of radioactivity in low-level concentrations to the environment during normal operations are expected. It is good to see that during grading operations provisions for controlling surface drainage to avoid erosion and selling the reservoir and for dust control are being made.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Southeastern Area, State and Private Forestry
Atlanta, Georgia 30309

1940

April 27, 1972

Dr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Here are our comments on the draft environmental impact statement prepared by the Tennessee Valley Authority.

Project - Watts Bar Nuclear Plant Units 1 and 2

Construction of new transmission lines requires withdraw of 2,373 acres forest land and/or potential forest land. This classification represents 75% of the total acreage withdrawn from line construction. Holding to the view that forest resources should be kept at maximum production, the rights-of-way should be available for growing forest products or supporting forest based facilities. Choices available to the landowner for using his property as described on page 2-39 of the draft, second paragraph,
2.2.2(2) open some questions as to specific uses.

It is suggested that it be made clear the character of forest resource development permitted under terms of an easement. Is it permissible to grow such products as Christmas trees, posts and pulpwood? Can the landowner create conditions that are meant to encourage recreational use of the property?

The above comments were made by Richard L. Zweig, Resource Specialist.

We appreciate the opportunity of reviewing and commenting on this statement.

Sincerely,

R. K. Smith

R. K. SMITH
Area Environmental Coordinator

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

May 10, 1972

Mr. F. E. Gartrell
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Mr. Gartrell:

We have had the draft environmental statement for TVA's Watts Bar Nuclear Plant, Units 1 and 2, reviewed in the relevant agencies of the Department of Agriculture and comments from the Soil Conservation Service, an agency of the Department, are attached.

It is our understanding that Forest Service of the Department of Agriculture handled its review directly with TVA.

Sincerely,

T C Byerly

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Attachment

cc: Director, Division of Radiological and Environmental Protection
Atomic Energy Commission, Washington, D.C.

Soil Conservation Service
U. S. Department of Agriculture

Comments on Draft Environmental Statement
Prepared By
Tennessee Valley Authority
For
Watts Bar Nuclear Plant Units 1 and 2

Statement did not provide for control of sediment during construction of Power Plant, Cooling Towers, Transmission Lines and appurtenant works.

Control of erosion by the appropriate application of sediment
2.2.4 control measures is needed to assure that runoff from exposed
2.8.1(2)
2.8.2 construction site will not enter Tennessee River or onto adjoining properties.

Sediment control measures are particularly needed during excavation and grading of structure sites.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JUL 22 1971

Dear Mr. Gartrell:

You requested the Department's comments on a draft environmental statement for the proposed Watts Bar Nuclear Plant, Units 1 and 2, Rhea County, Tennessee (AEC Dockets 50-390 and 50-391) furnished in accordance with Section 102 (2)(C) of the National Environmental Policy Act of 1969.

Overall the report is a good discussion of the environmental impact of the proposed power generating plants. Although the two units at Watts Bar will begin operation at different times (fall 1976 and spring 1977), the TVA environmental statement considered the plant as operating with both units in order to accurately assess the cumulative effects of their impact on the environment. The use of cooling towers and holding ponds also minimize some of the problems that might occur. In order to make the final statement an even better product we offer the following comments for your consideration.

Need for Quantitative Information--It was difficult to determine the probable impacts, positive or negative, that some aspects of the plant's construction and operation would have because of the use of percentages or the lack of defined values. Examples are to be found in the section Impact of Heat Dissipation and also those discussing the exact nature of water discharged from the plant and chemical discharges.

Plant Siting--The Geological Survey is reviewing geologic and hydrologic data relevant to Watts Bar Nuclear Plants, Units 1 and 2, as supplied by the Tennessee Valley Authority in a Preliminary Safety Analysis Report to the Atomic Energy Commission. This review pertains to geologic and hydrologic aspects of the site such as earthquake effects, foundation conditions, and flooding potential.

2.10.2 Groundwater--Approximately 25 feet of unconsolidated terrace
2.4.1(1)(a) material overlie bedrock at the plant site. The possibility of seepage of water from the plant discharge holding pond into groundwater

requires greater consideration. The applicant should ascertain if
2.10.2 shallow domestic wells tap the terrace material sufficiently close
2.4.1(1)(a) and at such location as to be subject to possible contamination. It appears from the description provided the holding ponds will be used for dilution purposes with cooling water, chemical discharges and water from storm drains being directed into it.

<u>Monitoring</u>--The Sequoyah Nuclear Plant site is located on the west bank of Chickamauga Reservoir, 44 miles downstream from the Watts Bar site. Thus, two nuclear plants may eventually discharge
2.4.3(4)(a) radioactive wastes into the reservoir. We suggest that more fre-
2.7.2 quent samples than the ones indicated in the statement should be taken at the first section just downstream of the plant, to detect any buildup of radioactive contaminants and possible leakages. We also suggest that the more common or abundant species of upland game
2.4.3(3) and waterfowl be considered for environmental radiological monitor-
2.4.3(4) ing along with sport and commercial fish species described under the section on <u>Biological Impact</u> on page 47.

<u>Transmission Lines</u>--Although reference is made to the need for lines for power transmission, a discussion of the need for specific additional transmission lines or substations required by this power unit was not considered in the draft statement. If additional exten-
2.2 sive support facilities will be needed their impact could be as great or greater than those of the proposed action; therefore, we suggest that these facilities be considered as part of the proposed action in the final statement. We also believe it would be helpful
2.10.3 if additional descriptions of the visual impacts of the main facilities, as well as any support facilities were included.

<u>Alternatives</u>--This section of the environmental impact statement indicates consideration was given to coal-fired generating units and that the idea was discarded for sufficiently good reasons. We would like to point out that because of the several factors, such as recent controversies about the operation of nuclear power plants and improve-
4.1 ments in the coal supply situation since the calculations were made in 1970, further consideration should be given to coal-fired units. Coal that is presently considered to be environmentally unacceptable could be used because of recent improvements in technology to remove sulfur from high-sulfur coal and to remove fly-ash.

Historical and Archeological--The project will not affect existing or known potential units of the National Park System or units eligible for registration as National Historic or Natural Landmarks. However, it is suggested that the State liaison officer for the National Register be consulted to determine whether the project will affect any properties being considered by the State for nomina-
1.1.3(11) tion to the Register. The State liaison officer for Tennessee is
2.10.1 Mr. Stephen S. Lawrence, Executive Secretary, Tennessee
2.10.4 Historical Commission, State Library and Archives Building, Nashville, Tennessee 37219. The results of this consultation should be reflected in the statement. The environmental statement should also recognize the possible effect of the project on archeological
1.1.3(11) resources and indicate that a survey has been made and give the results thereof. The appropriate official to contact on archeological resources is Dr. Alfred K. Guthe, Department of Anthropology, University of Tennessee, Knoxville, Tennessee 37916.

We sincerely appreciate the opportunity of commenting upon this proposal.

Sincerely yours,

Jack Horton

~~Deputy Under~~ Secretary of the Interior

F. E. Gartrell, Dr. P. H.
Director of Environmental Research
and Development,
Tennessee Valley Authority
Chattanooga, Tennessee 37401

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

MAY 11 1972

Dear Mr. Gartrell:

This is in response to your letter of April 10, 1972, requesting our comments on the Tennessee Valley Authority's draft environmental statement, supplements and additions, dated April 7, 1972, on environmental considerations for Watts Bar Nuclear Plant, Units 1 and 2, Rhea County, Tennessee.

General

Preface — Although this environmental statement, supplements and additions, provided additional environmental information not in the earlier draft of May 14, 1971, it involves a rather cumbersome review since the reviewer must use both volumes simultaneously. We suggest that if it is desirable to supplement or add to the draft statements in the future to the extent done in this case, the additional information be meshed into one volume and titled 2nd draft environmental statement or revised draft environmental statement. The time saved in the review process and the general usefulness of the statement would more than compensate for the additional cost.

Our comments of July 22, 1971, in regard to groundwater and transmission lines should be considered in addition to suggestions in this letter. Our comments on the environmental statements, supplements and additions are given on a sectional or subject basis. They also include several comments on the draft environmental statement dated May 14, 1971.

Historical and Archeological Significance

1.1.3(11) — It does not appear that the proposed nuclear plant will affect any existing or proposed unit of the National Park System or any site eligible for registration as a National Historic, Natural, or Environmental Education Landmark; however, the statement should show evidence of consultation with the State Historic Preservation Officer concerning protection of properties which may be under consideration for addition to the National Register of Historic Places. He is the Executive Secretary, Tennessee Historical Commission, State Library and Archives Building, Nashville, Tennessee 37219.

Recreation

2.10.1 The draft environmental statement, dated May 14, 1971, described the extensive recreational use of the Chickamauga Reservoir and the recreational facilities provided by TVA. In view of the importance of recreation in the project area, we think that the final statement should provide a discussion of the administrators and users of the recreation facilities in the area. The discussion should be closely allied to the proposed visitor center and overlook on the ridge above the project installation mentioned on page 66 of the May 14, 1971, draft, as well as the associated need for supporting public and private services.

Monitoring

2.4.3(3) 2.4.3(4) 2.4.3(4)(a) We suggest that the more common abundant species of upland game and waterfowl be considered for environmental radiological monitoring along with sport and commercial fish species described on page 47 of the May 14, 1971, draft statement. We also think that additional consideration as to the frequency of samplings should be given since other sources of waste products may compound the effects.

Cumulative Effects

2.4.2(3) The draft statement should assess the cumulative environmental effects resulting from other sources. For example, the radiological effects on aquatic life resulting from the operation of Watts Bar and Sequoyah Nuclear Plant, located 44 miles downstream, should be evaluated. Independent assessments of environmental impacts can only give incremental effects for each plant.

Environmental Aspects of Transmission Lines

2.2.2 The annual loss of forest products due to the construction and operation of transmission lines should be recognized as an irretrievable loss on page 2-40. However, we suggest that TVA undertake an investigation to utilize these transmission line corridors for "Puckerbrush Forestry".

This could prove to more than compensate for normal loss of forest products. Dr. Harold E. Young at the University of Maine has done considerable work in the development of this concept of total use of forest products.

Since TVA is in the forefront of developing and demonstrating good land use and since forest industries are presently using reconstituted wood products, we suggest that TVA examine the possibilities of developing a demonstration area of "Puckerbrush Forestry" on the transmission rights-of-way. We recommend that Dr. Young should be contacted for consultation regarding this possibility.

2.2.2

We also think that the statement should discuss the possibility of TVA coordinating the use of these transmission corridors for recreation trails similar to their coordination of wildlife programs. Primitive trails could be roughed in as an incidental activity during the operation and maintenance work.

We urge that the method mentioned on page 2-27 of selective cutting to feather the tree line and planting of wildlife food and cover be used whenever possible instead of clear cutting. Clearing to ground in wooded areas is inconsistent with guideline principles and should be resorted to only when absolutely necessary. We recommend that TVA urge owners of wooded sections of rights-of-way to sanction the feathering and planting of wildlife food and cover.

Environmental Impact of Postulated Accidents

The radiological effects of accidents are given only in terms of estimated doses to the population from air borne emissions. However, the environmental effects of releases to water is lacking. We think that the final environ-
2.3 mental statement should include estimates of the pathways
D.3(1) of the escaping radionuclides and quantities involved.
D.5
D.9

We also think that Class 9 accidents resulting in radioactive releases to both air and water should be described and the impact on human life and the remaining environment discussed as long as there is possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects which could last for centuries.

Chemical Discharges

Dissolved solids carried by drift from the cooling towers are not discussed. Since such solids could cause damage
2.5.1(1) to property and the environment, an estimate of the quantity contained in the drift and the procedures to be followed in minimizing adverse environmental impacts should be given.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

METROPOLITAN DEVELOPMENT OFFICE
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
PEACHTREE SEVENTH BUILDING, ATLANTA, GEORGIA 30323
Room 645

REGION IV

June 4, 1971
IN REPLY REFER TO:
4MB

Dr. F. E. Gartrell
Director, Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Subject: Environmental Statement
Watts Bar Nuclear Plant
Units 1 and 2

I am pleased to acknowledge receipt of your May 20, 1971, letter requesting HUD review of the above project under the requirements of the National Environmental Policy Act of 1969.

We have reviewed the information submitted along with your referral and have investigated the environmental aspects falling within the Council on Environmental Quality designated area of special HUD interest or expertise. From the information available to us, we find no basis for objecting or recommendation of alternates. However, we do call your attention to Attachment "A" of this letter and request that you initiate action to satisfy the several noted items.

Sincerely yours,

Thomas J. Armstrong
Assistant Regional Administrator

Enclosure

Attachment "A"

DHUD COMMENTS ON DRAFT
ENVIRONMENTAL IMPACT STATEMENT

Project Identification: Watts Bar Nuclear Plant Units 1 and 2

Project Location: Rhea County, Tennessee

The following includes the general caveats and remarks which we feel should be brought to the attention of any State, local or Federal agency which has requested DHUD review of and comment on a draft Environmental Statement under the Environmental Policy Act of 1969 and the CEQ Guidelines. We have checked those comments which seem to be particularly applicable to the draft statement identified above; however the letter of transmittal will amplify these general comments if appropriate.

COMMENTS

/__/ Inasmuch as HUD has no direct program involvement in Historic sites or structures effected by the subject project, we defer to the Advisory Council on Historic Preservation with respect to Historic Preservation matters.

/__/ HUD has direct program involvement in the Historic Preservation aspects of the proposed project and appropriate comment is included in the transmittal letter.

/__/ The subject project effects an urban park or recreational area and appropriate comment is included in the transmittal letter.

/__/ The subject project effects only rural parks and recreational areas and HUD therefore defers to the Forest Service of the Department of Agriculture, the Bureau of Outdoor Recreation, Bureau of Land Management, National Park Service and the Bureau of Sports Fisheries and Wildlife with respect to comments on the Parks, Forests and Recreational effects thereof.

/__/ This project will probably involve a statutorily required HUD review under Section 4(f) of the Transportation Act of 1966. Therefore, we defer comment on the parks and recreational aspects of the project pending request by D.O.T. for such a review.

/ / This review covers the HUD responsibilities under Section 4(f) of the Transportation Act of 1966.

/X/ The Draft Environmental Statement fails to reflect clearance or consultation with the appropriate local planning agency which is: Rhea County Planning Commission, Dayton, Tenn.

1.3 /X/ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate areawide planning agency which is: Southeast Tennessee Development District 423 James Building, 731 Broad Street, Chattanooga, TN. 37402

/X/ The Draft Environmental Statement fails to reflect consultation or clearance with the appropriate State Clearinghouse as required by Circular A-95, Office of Management and Budget. The A-95 Clearinghouse of jurisdiction is: Office of Urban and Federal Affairs, 321 Seventh Avenue, North, Nashville, Tenn. 37219

/ / The project apparently requires the displacement of businesses or residences. The Draft Environmental Statement does not reveal full consideration of the requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646). If relocation assistance is desired, please contact Mr. Joseph C. Behrens, Room 645, Peachtree-Seventh Street Building, Atlanta, Georgia 30323 at 404-526-3521. In the local community the person or office most familiar with relocation resources is: ______________________________ .

/ / The draft statement does not discuss apparently feasible alternatives which may have a more beneficial effect on the urban environment. See letter of transmittal for possibly overlooked alternatives.

/X/ In general, HUD defers to other agencies with respect to establishing and enforcing air and water quality standards, thermal pollution standards, radiation and general safety standards. We have no formal jurisdiction over such matters and no comments contained herein should be construed as assuming such responsibility or jurisdiction.

/X/ Since this project raises issues involving radiation safety, we recommend consultation with: Dr. Joseph Lieberman, Radiation Office, E.P.A., 5600 Fishers Lane, Parklawn Building, Rockville,
1.3 Maryland 20852.

/X/ We recommend that you write or call the Office of Management and Budget for a copy of "Directory of State, Metropolitan and Regional Clearinghouses under B.O.B. Circular A-95," and consult with such clearinghouses as appropriate.

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

IN REPLY REFER TO
ORNED-P

16 July 1971

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Your letter of 20 May 1971 forwarding a copy of the draft environmental statement for Watts Bar Nuclear Plant Units 1 and 2 to Dr. Louis M. Rousselot, Assistant Secretary for Defense, was referred to this office by the Chief of Engineers for reply.

We have reviewed the draft statement and believe that the environmental impacts have been recognized and identified. There are, however, a few comments and suggestions we are offering for your consideration.

Seven species of mussels were mentioned as being found in the mussel sanc-
tuary situated between Tennessee River miles 529.9 and 526.9. It may be
2.7.1(1) desirable for the scientific names of these organisms to be enumerated
for further taxonomic and ecological clarification. Furthermore, since
this area is a sanctuary, it is suggested that any temporary disturbance
2.7.1(2) of the present ecosystem be commented on in some detail, as shifting sands
and mud can produce an inimical strain on Pelecypodan physiology. It may
be desirable to include a diagram depicting the life-cycle of a typical
indigenous fresh-water bivalve to aid in the recognition of life-cycle
2.7.1(6) phases that could be highly susceptible to construction effects. This
could be done on page 42 under <u>Importance of locale to existence of im-
portant species considering states in life history</u>. Finally, in relation
to page 53 and the discussion on the disposal of radioactive residues, it
2.1.3(1)(a) is suggested that the locations of those offsite disposal areas be dis-
cussed in this paragraph.

The opportunity to review the draft statement is appreciated.

Sincerely yours,

WILLIAM F. BRANDES
Colonel, Corps of Engineers
District Engineer

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

IN REPLY REFER TO
ORNED-P

10 May 1972

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Your letter of 10 April 1972, forwarding a copy of supplements and additions to the draft environmental statement for Watts Bar Nuclear Plant Units 1 and 2 to Dr. Louis M. Rousselot, Assistant Secretary for Defense, has been referred to this office by the Chief of Engineers for direct reply.

We have reviewed the statement and have no comments to offer.

The opportunity to review the statement is appreciated.

Sincerely yours,

W. M. Vogel

WILLIAM M VOGEL
Major, Corps of Engineers
Deputy District Engineer

CF:
Director
Division of Radiological and
Environmental Protection
Atomic Energy Commission
Washington, D. C. 20545

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

JUL 16 1971

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

The Environmental Statement for Watts Bar Nuclear Plant -- Units 1 and 2 have been reviewed by this Department. This project, when completed will add electrical generating capacity of some 2,540 megawatts to the TVA system.

On Page 60 the statement is made that "reliable long-term release data for an operating pressurized water reactor plant similar in
2.4.2(3) design and operation philosophy to the Watts Bar Nuclear Plant
Table are not available at this time." This statement, coupled with the
2.4-2 fact that the radioactive discharges are into a lake that serves as the water supply for almost 250,000 people, is a source of
Table public health concern. Are the concentration factors in marine
2.4-2 life influenced by this river-lake complex? With regard to down-
E.4(2) stream water supplies, we suggest there be included in the final environmental statement a description of the program to be
1.4 implemented in the event of an inadvertent release of radioactivity into the river-lake complex.

Thank you for this opportunity to comment on this draft environmental statement. When the final statement is prepared we would be pleased to receive a copy.

Sincerely yours,

Merlin K. DuVal M.D.

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

cc:
AEC, Washington, D.C.

...'ED
JUL 19 1971
DIV. ENV. RESEARCH
and DEVELOPMENT

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
WASHINGTON, D.C. 20201

OFFICE OF THE SECRETARY

Dr. F. E. Gartrell
Director of Environmental
Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in response to your letter dated April 10, 1972, wherein you requested comments on the draft environmental impact statement for Watts Bar Nuclear Plant, Units 1 and 2.

This Department has reviewed the various health aspects of the above project as presented in the documents submitted. We offer no comments.

The opportunity to review this draft environmental impact statement is appreciated.

Sincerely yours,

Merlin K. DuVal, M.D.

Merlin K. DuVal, M.D.
Assistant Secretary for
Health and Scientific Affairs

Southeast Tennessee
DEVELOPMENT DISTRICT

BLEDSOE
BRADLEY
GRUNDY
HAMILTON
MARION
McMINN
MEIGS
POLK
RHEA
SEQUATCHIE

423 JAMES BUILDING
735 BROAD STREET
CHATTANOOGA, TENN. 37402
PHONE 615/265-2371

C. L. THRAILKILL
Executive Director

August 6, 1971

Mr. M. I. Foster, Director
Division of Navigation Development
and Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

SUBJECT: Draft Environmental Impact Statement
Watts Bar Nuclear Plant, Units 1 and 2

Dear Mr. Foster:

In accordance with the Office of Management & Budget Circular A-95 their letter dated October 10, 1969, designating the Southeast Tennessee Development District as the Regional Clearinghouse for federal grant programs, we have reviewed the Tennessee Valley Authority draft Environmental Impact Statement - Watts Bar Nuclear Plant, Units 1 and 2.

Our comments are as follows:

.1 On page 9, the statement is made "There is no indicated potential for any oil or gas production in the Watts Bar area. The nearest test wells that have been drilled, without production, are on the Cumberland Plateau fifteen to twenty miles west of the plant." As you may be aware, since publication of the draft Environmental Statement, exploratory drilling has been initiated on a site in the near vicinity of the proposed nuclear plant.

1.1.3(5)

.2 On page 12, reference is made to public water supplies taken from Watts Bar and Chickamauga Reservoirs. For purposes of potential impact of the project, the proposed Decatur regional water system, with water-intake and treatment plant on Watts Bar Reservoir, should be included.

1.1.3(7)(c)

.3 On page 40, the statement indicates that there is little likelihood of liquids moving from the holding pool to wells in the area as any liquids seeping into the ground are expected to filter into the reservoir at points north east and southwest. As it is not specifically mentioned in the Monitoring Program, pp. 45-51, we would suggest

1.1.3(7)(a)
2.10.2

Page 2
Mr. M. I. Foster
August 6, 1971

that some method of monitoring ground water in the immediate vicinity of the plant be included. This monitoring should specifically include those areas in the opposite directions from which liquid seepage is expected to occur.

We do not consider that the Regional Clearinghouse is technically qualified to comment on the technical data and computations relative to Section 2.3.7, Radioactive Discharges, pp. 52-62. However, for purposes of clarity in the statement, we make two comments.

.4 On page 53 there is a description of the disposal by evaporation of high level radioactive liquid wastes with the residues packaged for offsite disposal. In
2.4.1(2)(a) such process, is the gas thus released radioactive? If so, we assume it is controlled for further processing. However, the statement is not clear on this.

.5 Beginning on page 60 is a description of the "Potential increase in annual environmental radioactivity levels and annual radiation dose from principal radionuclides." This section describes the amount of radiation which a person could receive in various locations in the project vicinity under various conditions. Recognizing that the conditions described can only be based on assumptions,
2.4.2(3) the Environmental Statement should also show by comparison the safe level of radiation which a person can sustain without consequence.

We would also offer the following general comments applied to the project as a whole:

.6 Water and sewer projects are presently being initiated by Spring City, Dayton and Decatur. Each of these three city governments, along with the governments of Rhea County and Meigs County, can expect to encounter certain problems and possible temporary financial hardship in meeting the demand for governmental services which should occur in conjunction with the in-migration of construction personnel. We are pleased to note the Tennessee Valley Authority has recognized these potential problems in the Environmental Statement and intends to work with local governments to minimize these problems.

2.4.2(3) .7 In the course of the Regional Clearinghouse review, con-
Appendix H cern has been expressed relative to the combined effect of the Watts Bar Nuclear Plant and the Sequoyah Nuclear Plant on the Chickamauga Reservoir and the Nickajack

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

September 3, 1971

OFFICE OF THE ADMINISTRATOR

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

Thank you for your letter of May 20, 1971, requesting comments on the Draft Environmental Statement for the Watts Bar Nuclear Plant Units 1 and 2. We are pleased to provide the enclosed report which summarizes our evaluation of the radiological effects of operating the proposed facility.

We concur in the decision of the Tennessee Valley Authority to recycle tritium insofar as that decision will reduce the discharge of tritium to the environment. However, the tritium that builds up in the reactor must finally be disposed of and the Draft Environmental Statement does not describe that disposal method. In order to evaluate the desirability of tritium recycle, it is necessary to consider the final disposal method particularly with respect to the possible discharge of concentrated tritium or the long-range commitment of natural resources. We therefore encourage you to present your analysis of both the short-term and long-term implications of recycling all water containing tritium so that the total environmental impact of operating the facility can be evaluated.

Environmental contamination and resultant population exposure in the event of a radiation incident are important factors in assessing the potential environmental impact of a nuclear facility. The population dose that may be received from such incidents is dependent upon planning procedures and protective measures; therefore, we believe it extremely important to discuss details in the Environmental Statement with respect to all arrangements that have been made with offsite agencies who may respond to an emergency situation. The responsibilities and authorities of all involved offsite agencies should also be clearly stated.

We appreciate the opportunity to review and comment on the potential environmental impact of the Watts Bar Nuclear Plant. If we can assist you further in this matter, please let us know.

Sincerely yours,

George Marienthal

George Marienthal
Acting Director
Office of Federal Activities

Enclosure

EPA/DTA 71-38

ENVIRONMENTAL IMPACT REVIEW

WATTS BAR NUCLEAR PLANT

UNITS 1 and 2

Coordinated by
Office of Radiation Programs
ENVIRONMENTAL PROTECTION AGENCY
5600 Fishers Lane
Rockville, Maryland 20852

August 1971

PREFACE

The following report summarizes an evaluation of the environmental impact of the Watts Bar Nuclear Plant and has been prepared by the Environmental Protection Agency. The evaluation is based on a detailed technical review of the design information for the facility as well as the Draft Environmental Statement submitted by the Tennessee Valley Authority pursuant to the requirements of the National Environmental Policy Act of 1969. The radiological effects have been evaluated by the Division of Technology Assessment of the Office of Radiation Programs; this Division coordinates the review with other operating offices of the Agency. Where possible and relevant, suggestions are made which, if incorporated into the design and operating procedures for the facility, will minimize the potential environmental impact associated with the operation of the facility.

This evaluation is directly responsive to the requirements placed on Federal agencies by the National Environmental Policy Act of 1969 and in addition, is intended to provide information to the State involved for its use in developing and conducting environmental programs for the particular nuclear activity.

INTRODUCTION AND CONCLUSIONS

The Watts Bar Nuclear Plant will be a two-unit pressurized water reactor generating facility located on the Tennessee Valley Authority's Watts Bar Dam Reservation at Tennessee River Mile 528. Both units will be manufactured by the Westinghouse Electric Co., and each will have a generating capacity of approximately 1270 MWe. Unit 1 is scheduled to go into full operation in 1976; Unit 2 is scheduled for the spring of 1977.

The evaluation is based on information presented in the applicant's Preliminary Safety Analysis Report,(1) and Draft Environmental Statement(2) for Watts Bar Nuclear Plant, Units 1 and 2. In this evaluation particular attention is given to radioactive waste treatment, expected levels of radioactive waste discharges, potential population radiation dose levels, environmental surveillance, and emergency planning. The principal conclusions are:

1. The facility can be operated within current regulations of the Atomic Energy Commission for discharges of radioactivity to unrestricted areas.

2. Certain tritium concentrations and operating procedures presented in the Draft Environmental Statement are based on the periodic discharge of tritiated water. In view of the decision to recycle tritium, several parameters should be reevaluated, especially:

   a. primary coolant tritium concentration

   b. potential doses associated with the venting of steam generator blowdown.

c. potential doses due to evaporation of tritiated water which has been discharged or which has resulted from leaking systems in the plant.

d. contingency planning to dispose of primary coolant tritium before and at the decommissioning of the plant.

3. In discussing the problem of primary to secondary leakage in a steam generator, the statement does not describe in detail the procedures to be taken regarding the treatment of air ejector gases, steam generator blowdown, and the criteria used to initiate such procedures. Specifically, the activity levels of the steam generator blowdown and ~~the air~~ ejector gases at which secondary system waste treatment procedures are begun should be determined and stated in the Final Environmental Statement.

In addition, with regard to primary to secondary leakage, it is noted that the applicant intends to treat only the blowdown from the leaking steam generator in the event of a primary to secondary leak. It should be recognized that all steam generators become equally contaminated in a short time in this situation, and blowdown from all generators should be routed through the radwaste system.

4. The Draft Environmental Statement indicated that additional attention will be given to the treatment and control of those liquid wastes containing chemicals which could have an adverse effect on organisms in the river. We agree that additional attention is required and recommend that the description of the control to be provided be submitted as an

amendment to the Draft Environmental Statement. It would be desirable that the plans for controlling these chemical wastes be submitted for review before the Final Statement so that any changes will not be unduly difficult and expensive.

5. The environmental monitoring program while being very comprehensive, does not include any provision for monitoring atmospheric tritium. With increased concentration of tritium over the life of the plant, plans should be made to monitor for atmospheric tritium.

6. Emergency plans were not presented in the Draft Environmental Statement although such plans were discussed in the PSAR. In addition to the clear recognition of the value of adequate planning expressed in the PSAR, the statement should describe in detail all of the arrangements that have been made with off-site agencies to respond to emergency situation. The responsiblity and authority of these agencies should be clearly described in the Final Statement.

7. If the conclusions of this review receive proper consideration, the potential environmental impact of the radioactive waste discharges from the Watts Bar Nuclear Plant Units 1 and 2 will be reduced to the lowest level practicable. On the basis of this low environmental impact, there is no apparent need to develop alternate means to produce the proposed amounts of electricity since no unreasonable commitment of environmental resources need occur during operation of the plant.

WASTE TREATMENT

It is stated in the Draft Environmental Statement that the gaseous waste treatment system allows holdup of gaseous waste for 60 days in storage tanks, followed by controlled release to the atmosphere. Use of this extended decay time, which is longer than that stated in the PSAR should reduce doses from gaseous waste to the lowest practicable level. Solid wastes are drummed in 55 gallon drums at a facility on the site and the solid wastes are shipped off-site for disposal.

Liquid waste is treated by filtration, ion exchange, and evaporation. The main system evaporator has a capacity of 2 gallons per minute. In addition, there is an auxiliary evaporator with a capacity of 15 gallons per minute to treat steam generator blowdown in the event of a primary to secondary leak. In discharging processed liquid waste, the effluent is diluted with at least a 30,000 gallon per minute dilution stream to a holding pool. The contents of the holding pool are removed by flow into the Tennessee River, the discharged water being made up by cooling tower blowdown and river water intake, to maintain a volume in the pool.

The Draft Environmental Statement states that to reduce radioactive discharge levels to the lowest level practicable all water which contains tritium will be recycled. It is noted that the waste treatment procedure as described in the PSAR and Draft Environmental Statement differ in that the PSAR states that tritiated water will be discharged amounting to an estimated 1590 Ci of tritium released annually. In view of the

decision to recycle tritium, the concentration of tritium in the primary coolant should be reevaluated. The concentration of tritium in the primary coolant (2.42μCi/ml) presented in the PSAR was calculated using a discharge of 1590 curies per year of tritium to the environment. Tritium recycle will increase the quantity of tritium contained in the primary coolant over the life of the plant; therefore, the concentration
2.4.1(1)(b) of tritium in the primary coolant should be recalculated. It would be most useful to express the tritium concentration as a function of the number of fuel cycles or the number of recycled years. Also the total mixing volume and the total amount of tritium stored as a function of time should be stated.

We believe that the dose consequences of tritium in the atmosphere, both in-plant and outside of plant, should be estimated. The in-plant atmospheric concentration of tritium should be examined taking into account the anticipated release of coolant due to leaks and subsequent
2.4.1(1)(b)
Table 2.4-2 evaporation, and to evaporation of tritiated water during a refueling operation. If necessary, procedures should be developed to reduce the radiation exposure of personnel to atmospheric concentrations of tritium during refueling.

Evaporation of tritiated water from the holding pond, release of atmospheric
2.4.1(1)(a) tritium to the environment through the containment from souces in the
2.4.1(1)(c)
2.4.1(2)(a) plant, and venting of steam from steam generator blowdown should be
Table 2.4-2
considered in evaluating the off-site doses. Results of these analyses should be presented in the Final Environmental Statement.

TRITIUM DISPOSAL

The committment to retain tritium implies that an alternative to the discharge of the tritium has been or is being actively sought and that the discharge of the tritiated coolant to the environment has been determined to be an unacceptable practice. We concur in that determination and would note that the retention of tritium also requires that a plan be presented in the Final Statement for final disposal of the tritium
2.4.1(1)(b) and contingency plans for the timely action which will be taken if tritium in the coolant reaches an undesirable level. ~~The contingency~~ plan should include a description of the method to be employed to lower tritium levels such as the shipment of off-site portions of the tritiated coolant. Plans for the final disposal of all tritiated water at plant decommissioning, and contingency plans for disposal, as may be necessary during the life of the plant, should be described in the Final Environmental Statement.

PRIMARY TO SECONDARY LEAK

The applicant has indicated an awareness of the problem of primary to secondary leakage in PWR generating plants and has designed a waste
2.4.1(1)(b) 2.4.1(1)(c) treatment system to include an auxiliary evaporator to treat contaminated
Table 2.4-2 Table E-1 secondary coolant. We believe that in view of the decision to recycle tritium, a more detailed reevaluation of the consequences of a primary to secondary leak is required.

An evaluation of the consequences of a primary to secondary leak should include a description of the exigency procedures that will be employed and the criteria to be used to initiate such procedures. Specifically

2.4.1(1)(c) the applicant should state the numerical value of the radioactivity level at which safety procedures for primary to secondary system contamination are initiated, when these activities are realized through monitoring of the steam generator blowdown or condensor air ejector gases. The applicant should also specify what procedures are undertaken to minimize

2.4.1(1)(c) 2.4.1(2)(a) the contamination of the secondary system coolant and the resultant off-site doses.

The Statement indicates that in the event of a primary to secondary leak in a steam generator, only blowdown from the leaking steam generator is routed to the radwaste system. Our study has shown, however, that all generators become equally contaminated in a relatively short time when a primary to secondary leak occurs in one generator. Therefore, in the event of a primary to secondary leak in one generator, all generators should be blown down to the radwaste system until the leak can be stopped

2.4.1(1)(c) Table 2.4-2 or isolated. In this situation at the Watts Bar Nuclear Plant, the waste treatment system may not be adequate to treat the total amount of contaminated water. The total waste system evaporator capabilities for both units of the plant is 17 gallons per minute. However, in the case of a primary to secondary leak with all blowdown being treated, approximately a 40 gallon per minute evaporator capacity would be required to adequately treat the blowdown volume. Without the capability to treat all secondary system blowdown it may be necessary to release secondary system water containing radioactive contaminants usually removed by evaporation. We believe that the potential problems of a primary to secondary leak should be examined in some detail, particularly since it has been decided to recycle tritium. The statement also mentions that approximately 1/3 of the blowdown routed to the blowdown holding tank flashes to steam and is vented to the atmosphere. The discharge

2.4.1(1)(c) of this steam could have an environmental impact depending upon the amount of tritium in the secondary coolant. The dose consequences of the venting should be estimated with doses expressed as a function of the primary-to-secondary leak rates and blowdown rates. The results of such a dose estimation may indicate whether consideration should be given to condensing and retaining the steam.

In the event of a primary to secondary leak, non-condensable gases from the air ejector could lead to significant dosimetric consequences if not retained and treated by the gaseous waste system. Conservative calculations by EPA Staff have indicated that for a one-gallon-per-

Table 2.4-2
Table F-2
Table F-3

minute leak rate and 1% defective fuel, off-site dose rates on the order of 10 mrem/hr can result. Estimates should be provided for the range of off-site dose rates that can be expected from the radioactive off-gas release which could occur in the event of a primary to secondary leak. In the event of a primary to secondary leak air ejector gases may have to be subjected to treatment for removal of certain radionuclides.

2.4.1(1)(b)
2.4.1(1)(c)
Table 2.4-2

The applicant has not stated whether secondary system water will be discharged or recycled when this water contains tritium due to a leak. It would seem that increased storage capacity for recycled tritiated water would be required if secondary system water is retained. Such increased storage capacity has not been indicated in the PSAR or Draft Environmental Statement. If the applicant plans to discharge tritiated secondary system water instead of recycling, this intent should be stated, and dose estimates should be evaluated considering contributions from this source. The Final Environmental Statement should state whether secondary system water will be discharged or retained in the event of a primary to secondary leak, and include dose estimates from discharges if that procedure is chosen.

ENVIRONMENTAL IMPACT

In our opinion, the most significant radiological effect of the operation of the station will be the population dose that results. The applicant, in the draft environmental statement; has estimated, disregarding the recycling of all water containing tritium; that the whole body dose at the site boundary would be 16.9 mrem/yr. This estimate which is based on the design condition of 0.5 percent leaking fuel includes the dose due to gaseous discharges and the dose due to drinking the undiluted liquid discharged directly from the plant. The applicant has also estimated a total annual population dose from all sources to persons residing within 5 miles of the plant at 30.5 man-rems per year. This includes the effect of gaseous releases and assumes all 1805 people residing within 5 miles of the site obtain their drinking water untreated from the discharge pipe. These very conservative assumptions, when used in calculating the doses, result in estimates that are much higher than would be expected to actually occur during the normal operation of the facility. In order to compare the environmental impact of this facility with other similar facilities, it would be useful in the Final Environmental Statement included a population dose estimate, stated in man-rems, for

Table 2.4-2
Table E-3
Table E-4

the population surrounding the plant within a 50 mile radius and which takes into account the recycling of tritium. Also a reevaluation of the maximum individual dose taking into account the recycling of all water containing tritium is indicated.

WATER QUALITY

It is noted that natural draft cooling towers will be employed to dissipate waste heat. The cooling towers will be part of a closed condenser cooling water system with the principal waste discharge from the system being the blowdown. The blowdown is discharged to a holding basin which in turn empties into the Tennessee River. The Statement recognizes that discharge of chemicals in the blowdown and from other sources can have a detrimental effect on the river and it is further stated that

2.5.1 the treatment to be given these chemicals had not been determined at the time the Statement was written. A description of the treatment given those materials is essential to a complete evaluation of environmental impact. For that reason it is recommended that the information be provided by an amendment to the Draft Environmental Statement rather than waiting for the Final Detailed Statement at which time changes in treatment processes and equipment may be unduly difficult and expensive to make.

Attention should also be given to the possible discharge and environmental effect of metal ions, especially corrosion products from the
2.5.1(1) condenser materials. Also if zinc strips are to be used as sacrificial corrosion inhibiting electrodes, the environmental effect of discharging the dissolved zinc should be examined.

The Statement notes that the plant site is located about midway in a three mile reach which has been designated by the State of Tennessee as a mussel sanctuary. The effects of discharges of heavy metals and
Table 2.4-2
E.4(2)
2.7.1(4) radiochemicals on these mussels, Asiatic clams and other aquatic life should be examined. Mussels from areas of the Tennessee ~~River are~~ commerically harvested and shipped to Japan. Potential radiological
E.2 consequences of the use of these harvested mussels should be discussed.
2.7.1(6) Possible siltation and turbidity effects should also be discussed.

Treatment of domestic wastes is proposed by an extended aeration treatment facility designed for a construction force of 2,000 persons (peak level). This facility should provide adequate treatment during construction, however, when the power plant is placed in operation only
2.5.4 170 permanent employees and an unknown number of visitors will be served by the treatment facility. Under these conditions, the facility will be receiving a load far below design and will probably not function adequately. Discharge of organics to the extended aeration facility should be provided.

2.4.1(1)(a)
2.5.1
2.6, 2.6.1
2.6.2(1)
2.6.4(1) Inclusion of cooling towers is anticipated to cause no long-term effects on the aquatic ecology of Chickamauga Reservoir; however, insufficient information is presented to determine if short to moderate term effects

may be encountered. Thermal criteria proposed by the State of Tennessee have not been approved by EPA. Tennessee proposed an allowable rise of $1^{o}F$ to a maximum rise of $3^{o}F$ in impoundments at the extremities of a mixing zone. Under approved sections of the Tennessee Water Quality Standards, thermal (and chemical) limits must be met under all flow conditions for an impounded stream. However only average stream flow

2.4.1(1)(a) values are presented and used as a basis for discussions.

2.5.1
2.6, 2.6.1
2.6.2(1)
2.6.4(1)

Information should also be presented on steam flow variations and possibility of extremely low flow or no-release conditions from Watts Bar Dam. The resulting thermal, chemical and radio-chemical concentrations and the possible effects of these concentrations, including the required mixing zone size and characteristics should be evaluated. Low flow effects on consumptive use, withdrawal rates and kill of entrained organisms should be presented. It is to be noted that discharges from

1.1.3(10)(c) Watts Bar Dam are released from low-level intakes which are already
Table 2.6-1
2.7.1(3) low in dissolved oxygen and viable fish organisms. Seasonal and diurnal temperature patterns should be discussed.

2.8.1(2)
2.8.2

Erosion controls to be used during construction to minimize silt and turbidity additions to Chickamauga Reservoir should be presented in greater detail.

2.6.2(2)

Interactions between the existing fossil fueled power plant and the cooling tower plume from the proposed nuclear units should be further detailed. The possibility of sulfuric acid formation and resultant effects from that acid should be considered. The applicant notes

that some deleterious effects could occur during simultaneous operation
2.6.2(2) of both plants and that steps will be taken such as changing fuel, using operating limitation, or temporarily shutting down, should adverse conditions exist.

Other considerations that should be made and presented in the Final Environmental Statement are: existing levels of copper, zinc, and
2.5.1(1) other heavy metals in water due to mining, discharges, and leaking; including nuclear plant discharges and future changes in existing levels due to better treatment and control; diking of tankage for fuel
2.5.3 oil for auxiliary boilers, diesel generators, etc; a detailed evaluation
4.1 of alternative or concurrent use of pumped storage; and the Requirements
1.3 for Section 10 and 13 from the Corps of Engineers.

ENVIRONMENTAL SURVEILLANCE

In general, the environmental monitoring program is quite complete. The applicant has identified critical pathways and designed the surveillance program to monitor all these critical pathways. However, in order to adequately assess the effectiveness of the containment and
2.4.3(2) retention of tritium, there should be a tritium analysis performed on atmospheric samples. Since the environmental monitoring program is designed to evaluate any tritium in the water environment, but does not sample for the possible tritiated releases to the atmosphere, it is suggested that such a procedure be included in the environmental monitoring program. With the exception of the above point, the Watts Bar Nuclear Plant environmental program appears quite adequate for the purpose of documenting the presence of environmental radioactivity due to operation of the plant.

EMERGENCY PLANNING

The Draft Environmental Statement does not discuss emergency planning arrangements that have been made to assist and mitigate any radiological contamination that may occur from incidents and we believe that it should. Emergency planning is discussed in the PSAR in the context of the licensing procedures under 10CFR50, however, a discussion of the potential
1.4, 2.3 D.9 environmental impact of the facility must include the potential for environmental contamination and population exposure from radiation incidents no matter how unlikely. Since the degree of population doses received from such incidents is a function of planning procedures and protective measures related to them, it is extremely important to discuss some of the emergency planning details in the Environmental Statement.

In the PSAR, the applicant indicated that the emergency plans for the Watts Bar nuclear plant will be contained in the Site Emergency Plans Manual. In the preliminary discussion of the emergency plan presented in the PSAR, the applicant states that, "advance plans and arrangements will be made in conjunction with State and local authorities, where applicable, for warning the local populace of an emergency and possible evacuation, evacuating the area around the plant site, preventing entry of the public to affected areas, medical care of injured or exposed personnel, surveying the affected areas for radioactivity, and restricting use of water supplies and foods." The applicant's general discussion of emergency plan shows a clear recognition of the value
1.4 of adequate planning. However, additional details should be provided in the Final Environmental Statement with respect to all contacts that

have been made with off-site agencies who may respond to an emergency situation. The responsibilities and authorities of all involved off-site agencies should also be clearly stated.

1.4 It should be recognized that the authority for control of all radiological incidents which may affect public health and safety of the citizens of the State is vested with the Tennessee Department of Public Health. A written confirmation should be made of the agreements between State agencies and the Tennessee Valley Authroity for joint emergency action so that prompt and effective action will be taken in the event of a reactor incident.

REFERENCES

1. Tennessee Valley Authority, "Watts Bar Nuclear Plant, Units 1 and 2 - Preliminary Safety Analysis Report," AEC Public Document Room, AEC Docket No. 50-390 and AEC Docket No. 50-391, May 14, 1971.

2. Tennessee Valley Authority, "Draft Environmental Statement - Watts Bar Nuclear Plant, Units 1 and 2, May 14, 1971.

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF THE ADMINISTRATOR

25 MAY 1972

Mr. Lynn Seeber
General Manager
Tennessee Valley Authority
Knoxville, Tennessee 37802

Dear Mr. Seeber:

The Environmental Protection Agency has reviewed the Draft Environmental Statement and Supplement for the Watts Bar Nuclear Plant Units 1 and 2.

We recognize the difficulty in determining the appropriate degree to which an agency should go in developing and providing data to support conclusions reached in the impact statement. It is our judgement, however, that this statement should contain additional information in order to fully evaluate the environmental impact of the operation of the Watts Bar Nuclear Plant.

The additional information which we believe should be included in the final statement concerns evaluation of the radiological effects due to sources such as in-plant coolant leakage and direct shine, evaluation of the recycle capability based on available tank storage capacity, and futher information regarding assumptions used to evaluate radioactive waste treatment systems.

Regarding the non-radiological water quality impact, we feel that alternative cooling tower blowdown discharge systems should be discussed. In addition, a cost-benefit analysis of the proposed plant should be provided in the final statement.

We will be pleased to discuss our comments with you or members of your staff.

Sincerely yours,

Sheldon Myers
Director
Office of Federal Activities

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

May 1972

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Watts Bar Nuclear Plant Units 1 and 2

TABLE OF CONTENTS

	PAGE
INTRODUCTION AND CONCLUSIONS	1
RADIOLOGICAL ASPECTS	3
Radioactive Waste Management	3
Transportation and Reactor Accidents	8
NON-RADIOLOGICAL ASPECTS	11
MONITORING AND SURVEILLANCE	14
COST BENEFIT ANALYSIS	15
ADDITIONAL COMMENTS	16
Radiological	16
Non-Radiological	17

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental statement for the Watts Bar Nuclear Plant, Units 1 and 2, prepared by the Tennessee Valley Authority and issued April 7, 1972. Following are our major conclusions.

1. In order to achieve lowest practicable radwaste discharge levels, the waste treatment systems should be utilized to their full capabilities.

2. The assumptions or bases supporting the choice of values for dose and effluent evaluation parameters including coolant leak rates, iodine partition factors, and charcoal system efficiency should be included in the final statement since they are vital to several analyses presented.

3. In developing the estimates of radioactive waste releases and doses, two important sources were not considered: secondary system coolant leakage and direct shine from outdoor coolant storage tanks. The contribution of these sources to discharged effluents and doses should be included in the final statement.

4. The final statement should indicate how the objective of tritium recycle can be achieved considering the storage tank capacity for Watts Bar is significantly lower than that for other similar pressurized water reactor plants.

5. An evaluation should be made of the capability of the liquid waste treatment system to treat the contaminated secondary system leakage and blowdown from both units 1 and 2.

6. We commend TVA for adopting the closed-cycle cooling system for the Watts Bar plant. We believe this system will permit the plant to operate in compliance with applicable water quality standards and to adequately protect the aquatic environment. The final statement, however, should include design, operational and environmental information on the proposed diffuser system for cooling tower blowdown. In addition, comparable information should be provided on alternative discharge systems.

7. A comprehensive analysis of the costs vs. the benefits of the proposed facility should be developed and included in the final statement.

Radioactive Waste Management

Throughout the draft environmental statement TVA repeatedly indicates a policy to maintain environmental releases of radioactivity to "low as practicable" levels. The statement indicates, however, that waste treatment equipment will be by-passed if the proposed
2.4 Appendix I criteria can be achieved without utilization of the equipment. Furthermore, the evaluation of the ability to meet Appendix
2.4.1 I criteria failed to address secondary system leakage as a potential input to the waste management equipment; assumed that leaking steam
2.4.1(1)(c) generators exist in only one unit at a time; and assumed some parameters, such as coolant leak rate, iodine partition factors, and charcoal filter
2.4.1 system efficiency, without providing bases or justification. Also, EPA believes that the various systems (chemical and volume control, boron
2.4.1 management and waste treatment) in Watts Bar which relate to the quantity of radioactive wastes discharged to the environment should be described in the environmental statement.

The estimated releases of radioactive waste and the indicated design capability of the shared liquid waste treatment system apparently did not include consideration of potential sources from secondary system liquid leakage nor contaminated steam generator
2.4.1
2.4.1(1)(c) blowdown from both units simultaneously. Operational data indicate that the magnitude of secondary water leakage may be comparable to the volume of steam generator blowdown. Furthermore, there is no apparent reason to expect that steam generator tube leakage will exist in only one unit at a time.

Therefore, the design capability of the liquid waste treatment system and the expected releases of radioactive liquid waste should be reevaluated to include secondary system liquid leakage inputs and contaminated steam generator blowdown from both units.

The final statement should include a presentation of the
Table E-1 expected releases of radioactivity from steam generator blowdown
Fig 2.5-1 and should include a description of the effluent discharge system to
2.6.1
2.6.2(1) Chickamauga Reservoir (as described in Amendment 3 to PSAR). In comparing the Watts Bar tankage capacity with those provided for other plants of similar size, it appears that, even though Watts Bar is recycling tritiated liquids, several tanks are sized substantially smaller than those found in other facilities. For example, the following table illustrates the proposed total capacities of various tanks in Watts Bar compared with those in comparable plants (e.g., Sequoyah, Zion, McGuire, and D.C. Cook).

2.4.1(1)(a)

	Capacity-Gallons	
Tank	Watts Bar	Other Plants
Holdup	224,000	384,000 (Typical)
Monitor	18,000	86,400 (Typical)
Laundry and Hot Shower	1,200	10,000 (McGuire)
Waste Condensate	3,000	10,000 (McGuire)
Primary Waste Storage Tank	224,000	374,000 (Sequoyah)

While McGuire station is also a tritium recycle plant, it utilizes an ion exchange system to control the boron content of the reactor coolant. Thus, much smaller volumes of reactor coolant will be passed than at a plant, such as Watts Bar, which utilizes an evaporator to recover the coolant's boron. The final statement should address the bases for the significantly smaller tank capacities

2.4.1(1)(a) in the Watts Bar plant and the adequacy of the Watts Bar components to process radioactive waste to a level which can be considered as low as practicable.

Whether or not the proposed waste management equipment had adequate capacity to process the liquid radioactive waste, the system should be utilized to its full capacity to minimize environmental releases. According to the environmental statement, the auxiliary waste evaporator is to be by-passed if Appendix I limits can be achieved. It is
2.4 difficult to rationalize that the release of radioactivity can be construed to be "low as practicable" or minimized if existing waste management equipment is by-passed. Therefore, EPA strongly encourages TVA to make maximum use of the waste treatment equipment to minimize releases of radionuclides.

Apparently, significant operational information on fuel performance has been developed since the original environmental statement was issued in May 1971. According to the original statement (p. 61) "Operating data from reactors with zircaloy-clad fuel suggest that fuel leakage is approximately 0.5 percent." On the other hand, according to the
2.4.1 supplemental statement, TVA has concluded clad defects in fuel pins which produce 0.25 percent of the core power is a reasonable number on which to evaluate expected releases (based on operational data). The bases for the differences in these numbers should be discussed in the final statement. Furthermore, the rationale for evaluating routine releases on 0.25% failed fuel and accident consequences based on 0.5% failed fuel should be presented.

The gaseous releases are based on optimistic expectations regarding coolant leakage in the containment and the auxiliary buildings, optimistic partition factors for iodine releases from the leaking

2.4.1 coolant, leakage of "cold coolant" in the auxiliary building, and high efficiency for iodine removal by charcoal filters. The bases for the assumed values should be presented in the final statement.

EPA encourages TVA to utilize the plant filter systems to minimize releases of particulate and halogen radioactivity by placing

2.4.1(2)(a) them on-line (if they are routinely on a by-pass) whenever there is a measurable quantity of radioactivity being released from the respective vents.

TVA should evaluate the potential release of iodines and particulates from the gas decay tank system. The feasibility of providing particulate and charcoal filtration of these discharges using existing planned

D.3(3)
2.4.1(2)(a)
Table 2.4-2
Table F-3

filters or by adding a new filter system should be discussed. Furthermore, it is recommended that whenever there is ^{131}I contamination in the secondary coolant system, consideration should be given to means of eliminating the iodine releases to the environment.

Tritium Recycle

The environmental statement should be expanded to provide more definitive information regarding the environmental consequences of

2.1.3(1) tritium recycle. Of particular interest are the expected frequency, volume, and quantity (curies) of low specific activity tritiated wastes which will be shipped off-site for burial. Furthermore, environmental considerations regarding the method of transportation should be evaluated. Once the wastes are at the ultimate disposal site, there will be additional environmental considerations regarding contamination of the environment, and these should also be addressed.

2.1.3(1)

Tritium recycle will result in the accumulation of larger volumes of contaminated reactor coolant quality water on-site than without recycle, including "...much of the other radioactive material in the primary coolant..." The environmental statement should present evaluations of the direct shine doses from outside storage tanks which will contain this contaminated liquid. Safeguards, such as curbs, dikes, sumps, etc., provided to collect leakage, spillage or other releases from outside storage tank failures should be described.

Table 2.4-2
Appendix G

According to the statement, TVA expects to ship off-site some quantities of low specific activity tritiated liquids. However, apparently the section covering waste shipment (p. 2-12 of the supplement) does not include quantities (gallons and curies) of radioactive waste to be shipped nor dose evaluations enroute. If this material is to be shipped as a liquid, the statement should address any special considerations (packaging, contamination of water sources, etc.) which might be involved.

2.1.3(1)

Dose Assessment

In making estimates of annual doses to individuals and populations, meteorological data from "...sites similar to the Watts Bar site..." were grouped into three stability categories and six wind speed ranges

Appendix F

(1 to 13 meters/second). Since the six months of on-site meteorological data presented in the PSAR indicates very poor diffusion characteristics at this site, it is important to clearly define and justify as applicable

Appendix F the atmospheric dilution factors utilized in making whole body and thyroid dose assessments. If a longer period of meteorological data is available from the Sequoyah plant, which has the same regional topographical and climatological characteristics as Watts Bar, use of this data would provide more meaningful estimates of expected

Appendix F dispersion at Watts Bar than would data from other sites. The relationship of the Watts Bar and Sequoyah meteorological data could be determined by comparing the accumulated on-site data. Actually, almost a complete year of record should now be available from the Watts Bar meteorological station.

Transportation and Reactor Accidents

In its review of nuclear power plants, EPA has identified a need for additional information on two types of accidents which could result in radiation exposure to the public: (1) those involving transportation of spent fuel and radioactive wastes and (2) in-plant accidents. Since these accidents are common to all light-water nuclear power plants, the environmental risk for each type of accident is amenable to a general analysis. Although considerable work on safety aspects of such accidents has been conducted for a number of years, we believe that a thorough analysis of the probabilities of occurrence and the expected consequences of such accidents is necessary. A general study would result in a better understanding of the environmental risks than would a less-detailed examination of the questions on a case-by-case basis in individual impact statements. For this reason, we have reached an understanding with the AEC that they will conduct, concurrent with reviews of impact statements for individual facilities, such general analyses with EPA participation and will make the results public in the near future. Thus, detailed comment on the Watts Bar analyses is not included since TVA has elected to follow the general guidance given by AEC. We believe that any changes in equipment or operating procedures for individual plants required as a result of the investigations can be included without appreciably changing the overall plant design. If major redesign of the plants to include engineering changes were expected, or if an immediate public or environmental risk were being taken while these two issues are being resolved, we would, of course, make our concerns known.

In its consideration of accidents involving spent fuel, TVA has apparently placed great reliance on the "mitigating effects of proposed emergency actions" in concluding that exposure to the public will be negligible and has not presented an evaluation of the potential
2.1.2(2)(b) dose consequences from the release of ^{131}I. Since people characteristically are attracted to the vicinity of accidents, it is questionable that the potential dose consequences of an accident involving spent fuel can be disregarded on the basis of emergency actions. The potential dose consequences of this type of accident should be presented as a function of distance. Reasonable emergency
2.1.1(2)(a) 2.1.2(2)(a) 2.1.3(2)(a) A.2 action can then be related to the ability to maintain individual

2.1.1(2)(a) 2.1.2(2)(a) 2.1.3(2)(a) A.2 doses to "negligible levels." In addition to the general population exposures, the dose consequences of transportation of radioactive material should include effects on the vehicle operators.

TVA has concluded that "...the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials within the Maximum Permissible Concentrations (MPC) of Table II of Appendix B of 10 CFR Part 20". Furthermore, TVA concludes "...that the environmental risks due to postulated radiological accidents are exceedingly small and constitute a negligible hazard when compared to the benefits gained from the plant operation." These conclusions are based on the standard accident assumptions and guidance issued by the AEC for light-water cooled reactors as a proposed annex to Appendix D to 10 CFR Part 50 on December 6, 1971. EPA commented on this proposed annex in a letter to the Atomic Energy Commission on January 13, 1972. These comments essentially stated the necessity for a detailed discussion of the technical bases of the assumptions involved in determining the various classes of accidents and expected consequences. We believe that the general analysis mentioned above will be adequate to resolve these points and the results will apply to all licensed commercial light-water-reactor facilities.

NON-RADIOLOGICAL ASPECTS

Water Quality Effects

The Watts Bar nuclear power plant will employ a closed-cycle cooling system using two natural draft cooling towers. We believe this system, when fitted with a well designed blowdown discharge structure, can be operated in compliance with water quality standards and in a

2.6.1 manner that will protect aquatic biota. We commend TVA for adopting a closed-cycle cooling system for this plant and recommend that information on the design and operational characteristics of the discharge structure be made available as soon as practicable.

Although the draft environmental impact statement and the supplement indicate that the discharge of cooling tower blowdown will be accomplished using a diffuser system that has yet to be designed,

2.6.1 other alternative discharge systems should have been explored in greater detail. The final statement should present an expanded discussion of all practicable alternatives to the diffuser system indicating the economic, operational and environmental characteristics of each. In addition, the discussion should specify the engineering and operational trade-offs with regard to limitations of the cooling tower system, discharge structure characteristics, chemical treatment requirements, make-up water supply factors, discharge treatment system possibilities,

2.6.2(1) hydrological characteristics of the receiving waters, and other relevant

2.6.4(6) factors. Of major importance, however, is a discussion of how these engineering and operational factors relate to the ability of the Watts Bar plant to meet thermal and other water quality standards and to operate in a manner that will adequately protect the aquatic environment.

The draft impact statement indicates that a concentration factor (CF) of two will be maintained by regulating the blowdown discharge rate to 70 cfs. This leads to approximately 200 mg/l of dissolved solids.
2.5.1(1) It is possible, however, to allow the CF to rise to 5 or higher, depending on the discharge system employed, and still meet applicable water quality standards of 500 mg/l dissolved solids. In addition to the requirement to meet standards, the upper limit for the CF will depend on consideration of corrosion rates, scale formation, and other factors.

There are several environmental advantages to increasing the
2.6.4(6) CF value. For example, reducing the discharge rate, in order to raise the CF, would reduce the environmental impact of the heated blowdown water released. In addition, because less make up water would be required, the problem of entrainment of aquatic biota would be reduced. In our opinion, these advantages warrant further consideration of higher
2.7.1(5) CF's and the final statement should describe in detail the environmental benefits of this type of operation.

Another advantage in planning operation at reduced discharge rates, particularly prior to selection of a discharge system, is that
2.4.1(1)(a) other types of systems may be environmentally acceptable and, thus,
2.6.1 would be viable alternatives. For example, since the draft statement indicates that there will be no blowdown discharges when the river flow is less than 3,500 cfs, a side stream discharge might be employed. This system, in addition to having a possible economic advantage, would
2.8.1(2) eliminate the need for dredging and other construction activities which might destroy the mussel habitat that exists in the river.

2.8.1(2) Such construction effects and the procedures to avoid or mitigate adverse environmental impacts should be addressed in the final statement. As a part of the expanded discussion of alternatives, the final statement should indicate the effect that operation at higher CF's would have
2.6.1
2.6.4(6) on the environmental aspects of each alternative discharge system. This should include a prediction of plume characteristics, mixing zone dimensions and other important aspects of each discharge system.

The draft statement indicates that intermittent chlorination will be used for biological control. No information is given, however, as to the frequency of application, amounts to be used, or procedures to be employed for such chlorination. Since extensive residual levels
2.5.1(1) of chlorine or other biocides can be extremely damaging to the aquatic environment, it is important that biocide usage be closely regulated. EPA has recommended in the past that levels of residual chlorine in the receiving water should not exceed 0.1 mg/l for more than 30 minutes/day or 0.05 mg/l for more than 2 hours/day. In addition to chlorine, acrolein will be used periodically to control Asiatic Clams. In order to adequately protect aquatic biota from significant toxic effects, it
2.5.1(2) is recommended that discharge concentrations do not exceed ten percent of the 96 hour, TLM_{50} for indigenous species. The final statement
2.5.1(1) should specify the procedures to be used to assure that the discharges
2.5.1(2) of chlorine, acrolein, and other chemical additives are below levels that would cause significant environmental damage.

MONITORING AND SURVEILLANCE

A comprehensive monitoring and surveillance program should be developed for the environment affected by Watts Bar station. EPA will be pleased to work with Federal and state agencies in developing general guidelines which can be used by the applicant in preparing a comprehensive plan.

The following specific areas should be considered in developing the Watts Bar monitoring and surveillance plan:

2.6.2(1) 1. Water temperature monitoring. Several continuous monitoring stations, in addition to those currently proposed, will be required to document compliance with the applicable water quality standards.

2.7.2 2. Dissolved oxygen monitoring. This is necessary to ensure that receiving waters remain within applicable standards.

2.7.2 3. Biological monitoring. The developing of this plan will depend on established base-line biological data and demonstrated needs as determined by information generated by other elements of the monitoring system.

COST BENEFIT ANALYSIS

The need for the power produced from this station has not been established in the draft statement. Although projections of the energy
1.2 demand for the area should be supported, an extrapolation of current demand does not suffice to establish the power needs.

Among the issues that should be addressed in the weighing of the costs and benefits are the following:

1. The benefit of power. If the need for additional electric power from this station is established, one approach to calculating
8.1 the benefit to society is to determine the difference in the sales price to the consumer of power produced from this station compared to that produced by the least costly alternative.

2. Environmental costs. The environmental costs should be considered in view of the many alternatives including: site selection to include the projected impact at each site, trans-
8.2 mission lines and right-of-ways, alternative effluent systems for heat and radioactive materials, and the synergistic effects that may ensue from interaction with other industries and power plants existing or planned for the area.

The foregoing is considered necessary if one is to weigh the costs and benefits of the proposed action. The Watts Bar statement does not present any of the costs/benefits, therefore, no evaluation can be performed as to the necessity of the plant, nor can it be established whether adequate consideration has been given to minimize the environmental impact.

ADDITIONAL COMMENTS

During the review we noted in certain instances that the statement does not present sufficient information to substantiate the conclusions presented. We recognize that much of this information is not of major importance in evaluation the environmental impact of the Watts Bar Nuclear Plant. The cumulative effect, however, could be significant. It would, therefore, be helpful in determining the impact of the plant if the following information were included in the final statement:

Radiological Aspects

2.4.1(1)(c)
2.4.1(2)(a)

1. TVA should provide the sensitivities of the radiation monitors at the various effluent release points in terms of Ci/sec discharge rate for particulates, iodines, and noble gases. Similarly, the monitor setpoints for alarm and actuation functions should be provided.

2.4.1(1)(c)

2. The discharge path of the liquid radwaste should be described in a manner consistent with the recent changes in the PSAR.

2.5.1(10)

3. Clarification should be provided regarding the characteristics and the rate of chemical wastes passing through the radwaste system.

2.4.1(1)(a)
2.5.1(10)

4. The feasibility of treating radioactive detergent, or laundry wastes in the sewage treatment facility should be discussed.

Non-Radiological Aspects

1. Ozone is an air pollutant which has been included in the National Primary and Secondary Ambient Air Quality Standards, therefore the production of ozone by the high voltage transmission lines constructed to distribute electricity generated
2.2.5(1) at this facility should be discussed. Concentrations of ozone in the vicinity of these lines should be estimated for various atmospheric conditions, and related to potential effects on man and wildlife.

2. Additional information concerning the emissions from the auxiliary boilers utilized at this facility should be provided.
2.5.5 For example, sulfur content of fuel, stack heights , and heat input are some of the necessary parameters used to evaluate emissions from such sources.

3. A discussion should be included regarding the disposal of solid waste that would be generated by the project. Land clearing waste, construction and demolition debris, and operational non-radioactive waste could present short-term
2.2.3
2.5.6
2.8.3 adverse environmental impacts unless disposed of in accordance with state and Federal solid waste management rules and regulations. The discussion of solid waste disposal should include the consideration of solid waste generated by the construction of transmission lines.

4. The final statement should indicate the method and procedures for disposal of transformer oils. These oils contain polychlorinated
2.5.3 biphenyls which are very toxic to aquatic life and every effort should be made to prevent them from entering surface waters.

5. The draft statement indicates that backwash from the water treatment plant will be diverted to a lagoon area. This area should
2.5.1(3) be shown on the site map and information provided on size and volume of the lagoon.

6. It is noted in the draft statement that ammonia will be released from several sources. These include steam generator blow-
2.5.1(5) 2.5.1(8) down, auxiliary steam generator, and other sources. The final statement should provide information on the amounts released and the probable environmental effects.

7. Details should be provided on the weak cation-anion exchanger which will be used for waste neutralization. Elements released
2.5.1(4) from this system, regenerant solutions to be used and/or possible disposal methods should be discussed.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (AWL)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20591
PHONE: 202-426-2262

8 JUL 1971

Dr. F. E. Gartrell, Director
Environmental Research & Development
Tennessee Valley Authority
Chattanooga, Tenn. 37041

Dear Dr. Gartrell:

This is in response to memorandum type letter of 20 May 1971 addressed to Mr. Herbert R. De Simone, Assistant Secretary for Environment and Urban Systems, DOT, concerning the draft environmental impact statement for the Watts Bar Nuclear Plant to be constructed below the TVA Watts Bar Dam Reservation on the Tennessee River in Rhea County, Tennessee.

The concerned operating administrations and staff of the Department of Transportation have reviewed the draft statement. It is the determination of this Department that the impact of this project upon transportation is minimal. Noted from the Federal Railroad Administration review of the draft statement was the following observation:

> We take no general exception to the draft environmental statement. It is noted, however, that the Watts Bar Steam Plant, with a capacity of 240 MW, has been used at only 1% of its
> 1.1.3(2) capacity since 1945. The question is raised whether the projected power needs that are used to justify the building of Nuclear Units 1 and 2 might not also dictate the use of this plant. From the statement, it would appear that full capacity operation of the steam plant would materially alter the environmental impact, particularly from the standpoint of air pollution.

The Department of Transportation recommends that the project be constructed at as early a date as possible.

The opportunity for this Department to review and comment upon the draft environmental statement for the Watts Bar Nuclear Plant Units 1 and 2 is appreciated.

Sincerely,

R. Y. Edwards

R. Y. EDWARDS
Rear Admiral, U. S. Coast Guard
Chief, Office of Public and International Affairs

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (WS/83)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: (202) 426-2262

SA 0602

24 MAY 1972

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in response to your letter of 10 April 1972 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, concerning the revised draft environmental impact statement on the Watts Bar Nuclear Plant, Units 1 and 2 in Rhea County, Tennessee.

The concerned operating administrations and staff of the Department of Transportation have reviewed the revised draft. Noted in the review by the Federal Railroad Administration is the following:

> "We are pleased that considerable attention has been given to the configuration of the new transmission line network. However, no mention of possible proximity to existing railroad rights-of-way was noted. As new and higher voltage transmission lines have
> 2.2.5(2) been built, the railroad industry has experienced increasing difficulty with such technological problems as inductive interference with its signal and communication circuits. The Federal Railroad Administration suggests that the final environmental statement include a notation that either there are no railroads involved or that this problem of inductive interference has been resolved if it indeed represents a problem."

Reference is made to the Department's comments on the former draft statement as per our letter of 6 July 1971.

It remains this Department's determination that the impact of the Watts Bar Nuclear Plant upon transportation is minimal. We have no objection to the project and other than to recommend that the concern of the Federal Railroad Administration regarding possible inductive interference be addressed in the final statement, we have no further comments.

A copy of this letter is being sent to the U. S. Atomic Energy Commission as you requested.

The opportunity to review and comment on the revised draft environmental impact statement for the Watts Bar Project is appreciated.

Sincerely,

W. M. Benkert

W. M. BENKERT
Chief, Office of Marine Environment
and Systems

7.10-1

STATE OF TENNESSEE
OFFICE OF URBAN AND FEDERAL AFFAIRS
SUITE 1025
ANDREW JACKSON STATE OFFICE BUILDING
NASHVILLE 37219

LEONARD K. BRADLEY
DIRECTOR

741-2714

July 26, 1971

Mr. A. J. Gray
Tennessee Valley Authority
Knoxville, Tennessee

Dear Mr. Gray:

As you and Rick discussed in telephone conversations last week, all State agencies except The Radiological Health Division of the Department of Public Health have concluded their initial review of the Tennessee Valley Authority Environmental Impact Statement for the Watts Bar Nuclear Power Plant. Questions were raised which require our further inquiry; but hopefully, we can come up with the information necessary to formulate the State comment without going into conferences. The following is a summary of the questions and requests that our State agencies have returned to us for further exploration:

2.6.2(1) (1) The Environmental Impact Statement must contain an evaluation of the proposed 26,480 c.f.s. discharge under "instantaneous minimum stream flow" conditions. Such an evaluation for plant design purposes is required by State Water Quality Standards.

2.6 (2) Within a month, we expect the Environmental Protection Agency to arrange an instate hearing to consider whether Tennessee's present 10° standard for water temperature evaluation should be lowered to 5°. Tennessee Valley Authority should be prepared to re-evaluate the project in terms of this possible new standard.

2.7.1(6) (3) The Watts Bar Safety Analysis documents (4 volumes) place a $70,000/year value on the commercial mussel harvest in the Game and Fish Commissioner's mussel sanctuary in the 3-mile stretch below Watts Bar Dam. The Tennessee Valley Authority Environmental Impact Statement recognized that this shellfish habitat might be temporarily disturbed during the construction period. The Public Health Department fears that the disturbance (siltation and food chain alteration) could destroy the habitat permanently. It is requested that Tennessee Valley Authority furnish "substantial proof" to the contrary.

Mr. A. J. Gray
July 26, 1971
Page 2

1.1.3(10)(b) (4) The present dam and hydroplant at Watts Bar violate State water quality standards for oxygen content during the summer months. The proposed plant could worsen this situation. The Public Health Department wishes to have from Tennessee Valley Authority a correction plan and timetable for this situation.

2.6.2(2) (5) Is there a possibility that a cooling tower vapor plume could ever mix with the conventional plant's sulfur dioxides, resulting in an acidic mist (H_2SO_4) ?

2.6.2(2) (6) Will the nearly highway ever suffer obscured visibility from vapor plumes?

2.5.1 (7) The Public Health Department would like to see Tennessee Valley Authority engineering reports on facilities to be installed to process liquid effluents other than radioactive wastes.

1.1.3(7)(c) (8) A proposed Decatur-Spring City Regional Water System intake is scheduled for TRM 523.1 (eastern shore, Chickamauga Reservoir). The N-plant and subsequent industrialization could present a hazard to such an intake. Tennessee Valley Authority should work with local interests and the area Developement District to get any new water intakes sited upstream from the facility.

2.6.2(1) (9) It is requested that Tennessee Valley Authority furnish precise information on predicted temperature elevations in the river as a result of the cooling tower discharge.

Enclosed for your use is a copy of the Tennessee Department of Public Health's Water Quality Control Division's remarks on the Tennessee Valley Authority statement. The clearinghouse will endeavor to return to Tennessee Valley Authority the State Clearinghouse Comments as rapidly as possible after State agencies consider Tennessee Valley Authority responses to the points listed above.

Sincerely,

John L. Wellborn

John L. Wellborn

JLW:aw

7.10-3

Tennessee Game and Fish Commission

Ellington Agricultural Center • P. O. Box 40747 • Nashville, Tennessee 37220

DAVID M. GOODRICH, DIRECTOR
HAROLD E. WARVEL, ASS'T DIR.

June 11, 1971

Mr. John Wellborn
Office of Urban and Federal Affairs
Suite 1025
Andrew Jackson State Office Building
Nashville, Tennessee 37219

Dear Mr. Wellborn:

The TVA Environmental Impact Statement on the proposed Watts Bar Nuclear Plants has been reviewed by our staff. We find no significant problems in this plan and are pleased that cooling towers are planned for these plants (they are not planned for the Sequoyah plant downstream). Although it is stated that the plant's effluent will stay well within the Stream Pollution Control Board proposed thermal standards, no anticipated specific information is given in the report as to what temperature elevations will occur in the Tennessee River. We would be interested in some figures on this especially since Tennessee's proposed thermal stand-
2.6.2(1) ards have not been approved by the Environmental Protection Agency and are almost certain to be upgraded before approval.

The Tennessee Game and Fish Commission continues to prefer nuclear power plant installations to fossil fuel plants where adequate measures are taken to prevent thermal and radioactive pollution. We appreciate the opportunity to comment on this statement.

Very truly yours,

TENNESSEE GAME AND FISH COMMISSION

David M. Goodrich

David M. Goodrich
Director

DMG/DMS/jk

cc: Mr. Harold Warvel
Mr. Hudson Nichols
Mr. Robert Hatcher

MEMBERS OF COMMISSION

[illegible]

Winfield Dunn
Governor
William L. Jenkins
Commissioner
William H. Russell
Assistant Commissioner

TENNESSEE 7.10-4
DEPARTMENT OF

Conservation

DIVISION OF PLANNING & DEVELOPMENT
2611 WEST END AVENUE • NASHVILLE, TENNESSEE 37203
WALTER CRILEY, Director

June 21, 1971

Re: Watts Bar Nuclear Plant-Units I and II

Mr. Leonard K. Bradley, Director
Office of Urban and Federal Affairs
1025 Andrew Jackson State Office Building
Nashville, Tennessee 37219

Dear Mr. Bradley:

We have reviewed the above referenced project and are pleased to see that maximum precautionary measures against the environment and man have been considered in this proposal. The proposed nuclear plant will have no apparent effect on any present or proposed programs within the Department.

However, we would like to emphasize that special consideration and planning should be given to the Meigs County recreation area north of Watts Bar Dam,
1.1.3(8)(e) the Yellow Creek Waterfowl Management Area approximately one mile southwest, and the area known as Foochee Bend located on Watts Bar Reservoir. Mention has been made of plans to transmit this area to the state for future development as a state park.

Thank you for your consideration in this matter.

Sincerely,

Walter L. Criley

By Doug Erdman
Doug Erdman
Project Administrator
741-2164

y

7.10-5

WINFIELD DUNN
GOVERNOR

Eugene W. Fowinkle, M.D., M.P.H.
Commissioner

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
NASHVILLE 37219

July 7, 1971

Mr. John Wellborn
Office of Urban and Federal Affairs
Suite 1025
Andrew Jackson State Office Building
Nashville, Tennessee 37219

Re: Environmental Impact of Watts Bar Nuclear Plant, Units One and Two, Rhea County, Tennessee

Dear Mr. Wellborn:

The Tennessee Department of Public Health, Division of Water Quality Control, has reviewed the Tennessee Valley Authority Draft of the Environmental Impact Statement on the Watts Bar Nuclear Plant supplied by memorandum from you on June 4, 1971. The evaluation by this Division is contained in this letter. Evaluation by the Divisions of Air Pollution Control and Radiological Health are contained in separate letters.

Certain questions have arisen during the review of this TVA Draft and questions and comments are grouped under the following headings: (1) Design Criteria Proposed and Effect on State Water Quality Standards, (2) Effect of Discharge Upon Proposed and Existing Water Uses.

Design Criteria Proposed and Effect on State Water Quality Standards

The design stream flow noted throughout the Draft refers to an average discharge of 26,480 cfs. State Water Quality Standards require that minimum stream flows be used for design purposes. In the case of a regulated stream,
2.6.2(1) such as the Tennessee River below Watts Bar Dam, the instantaneous minimum flow is the river flow to be used for design purposes. The TVA Draft is deficient in its coverage of effects produced by the proposed effluent during conditions of minimum stream flows and minimum channel velocities. We request that the Tennessee Valley Authority thoroughly evaluate the effects of the discharge under minimum flow conditions.

An existing TVA facility, Watts Bar Dam and Hydro Plant, causes violation of Water Quality Standards in the Tennessee River during the summer months. Tables 13 and 14 of the TVA Draft illustrate this. The dissolved oxygen in the Tennessee River downstream from Watts Bar Dam (upper 35 miles of Chickamauga

Mr. John Wellborn
Page 2
July 7, 1971

Reservoir) does not meet State Standards for required dissolved oxygen concentrations. Releases of low dissolved oxygen water from the Hydro Plant during the summer months causes the dissolved oxygen in the Tennessee River to drop below the 5.0 mg/l limit established for State waters. The addition of heat, even in small quantities, from the proposed Nuclear Plant can serve only to
1.1.3(1)(b) aggravate the conditions which are already in violation of State Water Quality Standards. The Tennessee Valley Authority is requested to eliminate the conditions which violate existing Water Quality Standards due to discharges through the Watts Bar Dam and Hydro Plant, and additionally the Authority is requested to outline the method by which and the time schedule under which the existing discharge will be brought to comply with State Standards. Also, the Authority is requested to re-evaluate the effect which waste heat, floated upon the surface, will have upon dissolved oxygen concentrations in the Reservoir.

The temperature restrictions imposed by standards set by the State Water Quality Agency, are, "The temperature of the water shall not exceed 93° F. and the maximum rate of change shall not exceed 3° F. per hour. The maximum temperature of recognized trout streams shall not exceed 68° F. In no case shall
2.6 the maximum temperature rise be more than 10° F. above the stream temperature which shall be measured at an upstream control point." These standards still have not been approved by the Environmental Protection Agency and a public hearing is being planned within the month to discuss proposed revisions. It appears that the proposed cooling facilities will allow existing State temperature standards to be met, but the Tennessee Valley Authority is requested to re-evaluate proposed facilities with respect to any new temperature standards which may be subsequently adopted.

The chemical discharges listed on Page 38 of the Draft indicate that several effluents will be discharged which will require treatment in some form or another, in addition to cooling. The Tennessee Valley Authority is requested to provide
2.5.1 the best available treatment for all effluents, including those from the sewage treatment plant, water filtration plant, demineralizer, steam generator, cooling tower basin drains, and radiological chemical wastes. The Authority is also requested to provide additional information in the form of engineering reports and plans and specifications for such treatment projects.

Effect of Discharge Upon Proposed and Existing Water Uses

The entire reach of the Tennessee River from 460.6 (mouth of Chattanooga Creek) to mile 530.0 (Watts Bar Dam) has been classified by the State Water Quality Control Agency for the following uses: Domestic Raw Water Supply; Industrial Water Supply; Fish and Aquatic Life; Livestock Watering and Wildlife; Recreation; Irrigation; and Navigation. Additionally, the Tennessee Game and Fish Commission on April 28, 1967, adopted Proclamation No. 153 establishing a mussel sanctuary in the three mile reach of the Tennessee River below Watts Bar Dam.

Mr. John Wellborn
Page 3
July 7, 1971

The Tennessee Valley Authority Draft, on Page 12, did not acknowledge that the Decatur-Spring City Regional Water System has proposed to locate an intake
1.1.3(7)(c) at Tennessee River Mile 532 (Eastern shore of Watts Bar Reservoir) with a 16 inch submarine transmission main to Spring City crossing Chickamauga Reservoir at Tennessee River Mile 528.8 (Old Pinhook Ferry on Old Highway 68). The treatment plant would have a capacity of 7.0 MGD. An alternate to the regional water system is a Decatur independent system with an intake at Tennessee River Mile 523.1 (Eastern shore of Chickamauga Reservoir). This treatment plant would have a capacity of 4.0 MGD. The discharge from the proposed Watts Bar Nuclear Plant and subsequent industrialization of the river bank area which will be brought about as an indirect result of the plant could present a potential hazard to the alternate Decatur independent system's proposed intake at Tennessee River Mile 523.1, although the combined system's intake in Watts Bar Reservoir would not be affected by the Nuclear Plant. The Authority is requested to re-evaluate its discharge with respect to the possible effect upon the domestic water supplies not considered in the Statement and the Authority is further requested to provide assistance in the development of the Decatur-Spring City Regional Water System with the proposed intake at Tennessee River Mile 532 in order to keep the drinking water supply of area residents upstream from the discharge from the Nuclear Plant. The Authority is further requested to evaluate the effects of the 16 inch submarine transmission line to Spring City which is proposed to be located in the area of the Nuclear facility.

A mussel sanctuary has been established between Tennessee River Mile 529.9 and 526.9. Water usage by the Nuclear Plant will be in the vicinity of Tennessee River Mile 528, approximately in the center of the mussel sanctuary. There are only two major mussel sanctuaries located on the Tennessee River system: The one downstream from Watts Bar Dam and the other at Pickwick Dam. This particular sanctuary is the only one in Chickamauga Reservoir and it is of commercial importance because of harvesting downstream from the sanctuary area. No activity should be carried out which will interfere with the maintenance of the
2.7.1(6) mussel sanctuary. There appear to be many unanswered questions regarding what effect the proposed Nuclear Plant will have on the future of the mussels in this area. The TVA Draft states, on Page 42, that "Construction activity may temporarily disturb the mussel habitat in waters adjacent to the site." This State Agency questions whether mussel habitats may be temporarily disturbed (by dredging or siltation) without being permanently destroyed. The Draft states on Page 43 that "Since only a maximum of 0.5 per cent of the average river flow passing the site will be withdrawn, any planktonic forms and fish larvae killed by passage through the heat exchanger in the plant will not have a significant effect on populations of aquatic forms in the Reservoir." This State Agency believes that any alteration in the habitat may cause a drastic alteration of mussel populations. The specific fish which serve as intermediate hosts for the mussels must not be driven from the area, either through conditions of temperature of lack of food which cause avoidance reactions or conditions of temperature or abundance of food which cause competition with other fish. This State Agency requests that the Tennessee Valley Authority provide <u>substantial proof</u> that the proposed Nuclear Plant's operation will not adversely effect the mussel sanctuary established in this reach of the Tennessee River.

Mr. John Wellborn
Page 4
July 7, 1971

The Division of Water Quality Control, formerly the Division of Stream Pollution Control of the Tennessee Department of Public Health does not object to the construction and operation of the proposed Watts Bar Nuclear Plant, Units One and Two, provided that the construction and subsequent operation is carried out in accordance with the policies and requirements of the Water Quality Control Act of 1971 of the State of Tennessee and the regulations and requirements of the Tennessee Water Quality Control Board. The information requested and the questions posed by this letter must be evaluated prior to the construction of the facility and the construction should only be undertaken if the Tennessee Valley Authority can assure that State Water Quality Standards will be met and that the beneficial uses established for the stream will not be damaged.

Sincerely,

S. Leary Jones

S. Leary Jones, Director
Division of Water Quality Control

SLJ/EHH/jw

CC: Tennessee Valley Authority
CC: Mr. John R. Thoman
Environmental Protection Agency
CC: Rhea County Health Department
CC: Mr. John A. Campbell
Division of Water Quality Control
Chattanooga, Tennessee
CC: Tennessee Game & Fish Commission
CC: Division of Radiological Health
CC: Division of Air Pollution Control

7.10-9

Welborne call TVA

FROM	TO	DATE
JHC	DB	7/14
	~~[illegible]~~	
	~~JLC~~	
	John Welborne	

TENNESSEE DEPARTMENT OF PUBLIC HEALTH

OFFICE CORRESPONDENCE

DATE: July 12, 1971

TO: Mr. David Booth

FROM: James H. Cornwell

SUBJECT: AIR POLLUTION ASPECTS OF THE PROPOSED WATTS BAR NUCLEAR POWER PLANT

After studying Tennessee Valley Authority's environmental statement on its proposed Watts Bar Nuclear Plant, I feel that there could be air pollution problems associated with this installation. Two of these are as follows:

2.6.2(2) 1. Since the plant will be close to a highway, I would certainly think that there could be visibility problems resulting from the vapor plume from the cooling towers - particularly during adverse meteorological conditions.

2.6.2(2) 2. I understand that this plant will be adjacent to their fossil fuel fired power plant presently in operation. The vapor from this plant could combine with the sulfur oxides emitted from the coal fired plant resulting in the raining of sulfuric acid in that area.

J.H.C.

/lo

cc: Mr. D. P. Roberts
Mr. E. H. Hockensmith, Stream Pollution Control

WINFIELD DUNN
GOVERNOR

Eugene W. Fowinkle, M.D., M.P.H.
Commissioner

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
NASHVILLE 37219

July 28, 1971

Mr. John Wellborn
Office of Urban and Federal Affairs
Suite 125
Andrew Jackson State Office Building
Nashville, Tennessee 37219

Dear Mr. Wellborn:

The Division of Industrial and Radiological Health, Tennessee Department of Public Health, has reviewed the Tennessee Valley Authority's draft of the Environmental Statement on the Watts Bar Nuclear Power Plant which was supplied through your office on June 4, 1971. Our evaluation is presented herewith:

The State of Tennessee Regulations for Protection Against Radiation, Appendix 1A, Part 2, contains the maximum permissible concentrations for liquids and airborne radioactive wastes in terms of specific radioisotopes.

Based on the values stated in the draft for liquid release to the holding pond (Page 54, third (3rd.) paragraph and Page 55, second (2nd.) paragraph) and the calculated annual dose for a person immediately offsite (Page 61, second (2nd.) paragraph), it appears that appropriate state limits will be met.

In our evaluation of the Environmental Statement Draft, we have taken into consideration TVA's intention of keeping radioactive effluent discharges as low as practicable as provided for in the AEC regulations 10 CFR Part 50. In view of TVA's definition of as low as practicable to mean only a few percent of 10 CFR Part 20 limits, we should like to call attention to a new proposed amendment to 10 CFR Part 50, which provides numerical guides on the design objective and limiting conditions for operation of light-water-cooled nuclear power reactors. This proposed amendment was published in the Federal Register on June 9, 1971. Should this proposed rule be adopted, it is our opinion that the Environmental Statement Draft should be modified to conform to this rule.

The impact of the aforementioned amendment will be to establish standards for release of radioactive material from light-water-cooled
2.4.2(3) power reactors based on a percentage of natural background radiation.
Table 2.4-3 The estimated percentage contribution to population exposure from operation of this plant as stated (Page 61 and Page 62) is based on a value different from that of natural background.

Date: July 28, 1971 Page 2
John Wellborn
Office of Urban and Federal Affairs
Andrew Jackson State Office Building
Nashville, Tennessee 37219

We should also like to make the following additional comments:

1. It would appear that 10 CFR Part 20 of AEC regulations, as well as Part 2 of State regulations, specifies that effluents concentration limits apply at the boundry of

2.4.3(4)(a) the restricted area. In this respect, TVA's statement on page 47 specifying a monitoring point five hundred (500) feet below the point of discharge would appear not to provide data sufficient to determine compliance with State or Federal regulations.

2. Exception is taken to TVA's statement on page 54 that Iodine-131 is the most significant radionuclide in the plant effluent. According to Appendix B of 10 CFR Part 20 of AEC regulations and Appendix 1A, Part 2 of State regulations, Strontium-90 is the most significant radionuclide

E.1 concentration-wise. The concentration limit for Iodine-131 is 3×10^{-7} microcuries per milliliter for the soluble fraction and 6×10^{-5} microcuries per milliliter for the insoluble fraction. The concentration limit for Strontium-90 is 3×10^{-7} microcuries per milliliter for the soluble fraction and 4×10^{-5} microcuries per milliliter for the insoluble fraction.

3. We question the advisability of releasing radioactive gases

2.4.1(2)(a) near the top of each reactor building as stated on page 56. The possibility of such gases regaining access to the plant buildings should be taken into consideration.

Sincerely yours,

Francis P. Jung
Director
Division of Industrial and
Radiological Health

FPJ:mf

cc: S. Leary Jones
Don P. Roberts

7.10-12

STATE OF TENNESSEE
DEPARTMENT OF HIGHWAYS
NASHVILLE 37219

July 27, 1971

WINFIELD DUNN, GOVERNOR

ROBERT F. SMITH, COMMISSIONER

MEMORANDUM

TO: Mr. Barry Vickrey

FROM: E. R. Terrell

SUBJECT: Draft Environmental Statement: Watts Bar Nuclear Plant, Units 1 and 2

We have reviewed the subject environmental statement and find that it is well organized and most thorough.

There will be some significant impacts upon the operation of the highway network, however, which were mentioned only briefly in the statement. Traffic patterns will be affected first by trips generated during construction of the project; and after completion, by trips of permanent employees and, more importantly, recreational and educational trips to the facility.

State Route (SR) 68, providing an east-west connection between major north-south traffic corridors (U.S. Highway 27, State Route 58; and, later, Interstate 75) will be the major carrier of trips generated during and after construction. State Route 68 is classified as a minor arterial route in the Statewide Highway Functional Classification Plan for 1990.

It is mentioned in the environmental statement that the Tennessee Valley Authority is exploring the feasibility of developing a demonstration mobile home project near Spring City to help alleviate the anticipated temporary shortage of adequate housing during the construction phase of the project. The percentage of the maximum construction force of 2000 employees (expected to be reached by October, 1974) which this mobile home project would be planned to accommodate was not specified in the statement. In any case, it is apparent that there will be a substantial increase in the volume of traffic moving through the SR-68 and U.S. Highway 27 (SR-29) intersection southwest of Spring City. This intersection has poor alignment and poor sight distance for

Mr. Barry Vickrey
Page 2
July 27, 1971

vehicles approaching the intersection on U.S. 27, and poor alignment for vehicles approaching on SR-68. In the years 1965-1968 (inclusive) there were thirteen (13) separate accidents on U.S. 27 in the vicinity of this intersection. These 13 accidents resulted in ten (10) injuries and one (1) death. There was also one (1) accident resulting in two (2) injuries on State Route 68 in the vicinity of the intersection during this period.

Further, it is expected that construction activities will generate an increase in rail traffic on the Southern Railroad spur line which serves the Watts Bar Reservation and crosses U.S. Highway 27 at grade just south of the SR-68 and U.S. 27 Intersection. The increased volumes of both rail and motor vehicles traffic generated during and after construction of the Watts Bar Nuclear Plant Project will create a significant increase in the safety hazards at these points of intersection. This is a direct environmental impact of the proposed project to which the Department of Highways should address itself. The Traffic Engineering Section should be consulted to develop possible engineering solutions at these problem points.

The general condition of the remainder of SR-68 between U.S. 27 and Watts Bar Dam is adequate. From Watts Bar Dam to approximately 2.0 miles east of SR-58, two-lane SR-68 has been improved to current standards. From the end of this project to the proposed location of Interstate 75, an improvement of the existing route (partially on new alignment) is currently under study. Increased traffic volumes generated by the Watts Bar Nuclear Plant Project will provide an added justification for improvements of this segment of SR-68.

ERT/vsl

7.13-14

Tennessee Game and Fish Commission

Ellington Agricultural Center • P. O. Box 40747 • Nashville, Tennessee 37220

DAVID M. GOODRICH, DIRECTOR
HAROLD E. WARVEL, ASS'T DIR

August 23, 1971

Mr. C. J. Chance
Fish and Wildlife Branch
Division of Forestry, Fisheries
and Wildlife Development
Tennessee Valley Authority
Norris, Tennessee 37828

Dear Jack:

Thank you for your response to our questions concerning the Watts Bar Nuclear Plant. We still have some question as to how
2.7 stream standards will be met with regards to temperature considering minimum flows (your letter of June 25 discussed only average river flow) from Watts Bar Dam and the probability of upgraded temperature standards. These concerns as well as questions about the potential disturbance of the significant mussel sanctuary located at the proposed plant site are well presented by the Tennessee Water Quality Control Division in their July 7 letter to the Office of Urban and Federal Affairs (cc: TVA). We will be very interested in TVA's answers to those questions found in that letter which affect the interests of the Game and Fish Commission.

Very truly yours,

TENNESSEE GAME AND FISH COMMISSION

David M Goodrich

David M. Goodrich
Director

DMG/DMS/jk

cc: Mr. Hudson Nichols
Mr. Robert Hatcher
Mr. John Wellborn
Mr. Ed Hockensmith

MEMBERS OF COMMISSION

DR. W. H. BLACKBURN — Camden
G. L. LOWE — Chattanooga
SMITH HOWARD — Pulaski
JAMES J. BEASLEY — Milan
RHEA R. BROWDER — Harriman
EDGAR W. EVINS — Alexandria
DR. WILLIAM C. [illegible] — Henderson[illegible]
DR. PERCY A. CLAYTON — Memphis
BEN [illegible] — Johnson City
WILLIAM JENKINS — Rogersville

7.10-15

TENNESSEE HISTORICAL COMMISSION

STATE LIBRARY AND ARCHIVES BUILDING
NASHVILLE, TENNESSEE 37219

ROBERT A. McGAW, CHAIRMAN
NASHVILLE
VERNON SHARP, VICE-CHAIRMAN
NASHVILLE

MICHAEL J. SMITH
EXECUTIVE DIRECTOR

April 5, 1972

Mr. John Wellborn
Office of Urban and Federal Affairs
Andrew Jackson State Office Building
Nashville, Tennessee 37219

Dear Mr. Wellborn:

Reference is made to the Tennessee Valley Authority's Environmental Statement concerning the Watts Bar Nuclear Plant, dated May 14, 1971.

We concur in the statement made in section 2.1.11 that there are no properties on the National Register of Historic Places that would be affected by the construction of the Watts Bar Nuclear Plant.

Other environmental questions are addressed and we make no attempt to concern ourselves with the adquacy of this statement in regard to them. However, we must state that the Tennessee Valley Authority apparently assumes the inevitability and "goodness" of an unspecified economic growth and increased power consumption in this area.

The Watts Bar Nuclear Plant presumably will spur that growth, but the question of the resulting cultural changes in the lives of the residents of Rhea County and the Tennessee River Valley are not considered.

That cultural environment includes physical landscape evidence of a historical link to the past in which the area was, to
1.1.3(11) quote the statement itself, the "lands of the Cherokee, Chickamauga, and Creek Indians." Sacrificing a portion of this larger historical and cultural atmosphere is sometimes essential for the economic improvement of the area and its inhabitants, but that possibility must be considered and taken into account when planning. If the Tennessee Valley Authority has studied such long range effects of this power plant it is not evident in this Environmental Statement.

Sincerely,

Herbert L. Harper

Herbert L. Harper
Director of Programs

HLH:jg

7.10-16

TENNESSEE STATE PLANNING COMMISSION

SOUTHEAST TENNESSEE OFFICE
Suite 500, 5800 Building, Brainerd Road
Chattanooga, Tennessee 37411

Winfield Dunn
Governor
Harry T. Burn
John F. Crabtree
Charles W. Crow
W. Keith McCord
King W. Rogers
Jesse Safley
D. S. Sample
M. V. Williams

Harold V. Miller
Executive Director

[Envelope addressed to Tennessee Valley Authority, Knoxville, Tennessee]

ENVIRONMENTAL IMPACT STATEMENT

TO: John Wellborn, Office of Urban and Federal Affairs
FROM: Jay H. Livingston, Principal Planner
DATE: May 18, 1972

PROJECT: Watts Bar Environmental Supplement

TVA has satisfactorily answered all questions that this office originally raised. Therefore, the Watts Bar Environmental Supplement and addition meets with the full approval of this agency.

WINFIELD DUNN
GOVERNOR

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
NASHVILLE 37219

Eugene W. Fowinkle, M.D., M.P.H.
Commissioner

June 6, 1972

Mr. John Wellborn
Office of Urban and Federal Affairs
1312 Andrew Jackson State Office Building
Nashville, Tennessee 37219

Re: Tennessee Valley Authority Draft, Environmental Impact Statement, Supplements and Additions, Watts Bar Nuclear Plant, Units 1 and 2

Dear Mr. Wellborn:

Here are our comments on the radiological aspects of the above project:

Page 2-2

2.1.2(1)(b)

There is some uncertainty concerning the form of uranium fuel. On this page, the fuel is described as "uranium dioxide pellets which have been sintered and compacted", while on Page 2-42, the fuel is described as "high density ceramic UO_2.

Pages 2-7 and 2-8

2.1.4(2)(b)

Table entitled "Normal and Accident Shipping Requirements"- Here are itemized the permissible releases of radioactive material with contaminated coolant. This table appears to be a gross over simplification of the requirements of 10 CFR Section 71.36 (a)(2)(ii). An example follows which compares this Draft with the CFR.

Draft	10 CFR Section 71.36 (a)(2)(ii)
10 Ci Iodine	10 curies of Transport Group III and 10 curies of Transport Group IV (Groups III and IV as identified in Appendix C. 10 CFR Part 71, lists other radioactive materials in addition to the isotopes of Iodine)

2.1.4(2)(b)

Also, as isotopes of iodine are fission products, it is not understood why a higher leakage quantity of iodine is stated as permissible. As may be noted in Appendix C, other fission products, as well as iodine, are listed in Transport Groups III and IV. We question iodine being singled out from other fission products for special treatment. The leakage of fission products, per se, is restricted to 0.5 curie.

2.1.4(2)(b)

In addition, subparagraph (a)(2) of Section 71.36 states that releases will not exceed values contained in items (i) or (ii). Item (i) limits releases of radioactive material, with the coolant, to "0.1 percent of the total radioactivity of the package contents". For small shipments, the requirements of item (i) may prove more restrictive than those of item (ii). In view of this possibility, it is uncertain why reference to item (i) was omitted from the Draft.

Pages 2-15 and 2-16

2.1.4(2)(c)
B.1(3) No details are given concerning the temperature or duration of the hypothetical fire accident to which the LL-60-150 cask, designed for high level solid waste, would be subjected. Unless this cask is highly insulated, it does not seem reasonable to assume under accident conditions involving a fire that the temperature of the lead shielding would be limited a maximum temperature of about 150°F below its melting point. (471.5°F)

Page 2-19 (Item 3)

In detailing shipping safeguards for fuel and radioactive waste material as per 10 CFR Section 71.35, the Draft omits certain words which may be considered significant. The words omitted in the Draft are underlined in the following quote from Section 71.35:

2.1.4(3)(a)

> 10 CFR Section 71.35 (a)(3) "There will be no mixture of gases or vapors <u>in the package</u> which could, through any credible increase of pressure or an explosion, <u>significantly</u> reduce the effectiveness of the package".

Also, in detailing requirements of 10 CFR 71.35, the Draft refers only to Paragraph (a) and subparagraph (b)(i) of this section and omits other parts of Paragraph (b) and all of Paragraph (C).

From this review of the Draft, it appears that no modifications were made in the original "Draft Environmental Statement" dated May 14, 1971, as result of comments 1, 2, and 3 of our Division of Industrial and Radiological Health's letter to you on July 28, 1971.

Very truly yours,

David H. Booth

David H. Booth
Assistant Director
Bureau of Environmental Health Services

DHB:bah

7.10-19

STATE OF TENNESSEE

OFFICE OF URBAN AND FEDERAL AFFAIRS

SUITE 1312
ANDREW JACKSON STATE OFFICE BUILDING
NASHVILLE 37219

GARY S. SASSE
DIRECTOR

615-741-2714

June 7, 1972

Mr. A. J. Gray, Chief
Regional Planning Staff
Division of Navigation
Development & Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

Dear Mr. Gray:

Enclosed are copies of State agency comments returned to us on TVA's Supplements to the Watts Bar Environmental Impact Statement. Also enclosed is the Tennessee Highway Department's memorandum of July 27, 1971, on the original TVA draft statement.

As we discussed by telephone today, the Public Health Department's Division of Water Quality and Division of Industrial and Radiological Health have not yet completed their reviews of the Supplement. They anticipate doing so within a very few days. But in order to assist you in meeting your licensing deadlines, I am sending you what we already have and will forward other comments as they arrive.

Thank you for your cooperation in extending the allowable State review period beyond the thirty day period ending May 15. I hope that by June 15 we can forward to you all relevant agency remarks still outstanding.

Sincerely,

John Wellbon

John Wellborn

JW:ks

Enclosure

6-19-72

7.10-20

STATE OF TENNESSEE
DEPARTMENT OF HIGHWAYS
NASHVILLE 37219

WINFIELD DUNN. GOVERNOR

ROBERT F. SMITH. COMMISSIONER

June 7, 1972

Mr. Gary Sasse
Director of Urban and Federal Affairs
Office of Urban and Federal Affairs
1025 Andrew Jackson Building
Nashville, Tennessee 37219

Subject: TVA Draft Environmental Impact Statement for Watts Bar Nuclear Plant, Units 1 and 2, Supplement

Dear Mr. Sasse:

We have reviewed the above subject statement which is a supplement to the Draft Environmental Impact Statement distributed on June 4, 1971.

We submitted comments to you on July 21, 1971, in which we discussed the conditions and accident data at the Intersection of U.S. 27 (State Route 29) and State Route 68 which furnishes access to the Watts Bar Reservation. We also provided information on the proposed improvements to State Route 68 from approximately 2.0 miles East of State Route 58 to near I-75.

There are two minor problems that should be recognized, these being (1) the increase of fog and ice hazards to motorists of the immediate locale, and (2) the temporary increase of traffic flows on existing streets and highways generated by the influx of construction personnel into the area. The significance of these minor problems, however, is nil in comparison to the potential importance which this plant will have on the economy of the State.

The supplement contained information on the transportation of nuclear fuel and radioactive wastes and the transmission lines proposed. We feel that the date of shipments and the routes proposed to be used should be furnished our Maintenance Engineer or Regional Engineer so that he may keep abreast of these shipments in case of an accident or other emergency.

Also, the location of transmission lines and the placement of steel towers should be located in such a way that a hazard will not exist for out-of-control vehicles and the aesthetic quality of the area will be detracted from as little as possible.

Sincerely,

E. R. TERRELL
Director of Planning and Programming

NEC:ddc

7.10-22

STATE OF TENNESSEE
OFFICE OF URBAN AND FEDERAL AFFAIRS
SUITE 1312
ANDREW JACKSON STATE OFFICE BUILDING
NASHVILLE 37219

GARY S. SASSE
DIRECTOR

615-741-2714

June 8, 1972

Mr. A. J. Gray, Chief
Regional Planning Staff
Division of Navigation
Development & Regional Studies
Tennessee Valley Authority
Knoxville, Tennessee 37902

Dear Mr. Gray:

As I promised in my letter of 7 June, enclosed are the Radiological Health Division's comments on your Watts Bar Supplement.

Sincerely,

John Wellborn

John Wellborn

JW:ks

Enclosure

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

June 7, 1972

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

The draft environmental statement for "Watts Bar Nuclear Plant - Units 1 and 2, Supplements and Additions", which accompanied your letter of April 10,1972, has been received by the Department of Commerce for review and comment.

In order to give you the benefit of the Department's analysis, the following comments are offered for your consideration.

2.7.1(5) In the draft environmental statement under section 2.1.3, Environment of the Area, page 18, it would be helpful if section 2 on "Fish and other Aquatic Life" could be expanded to include a specific listing of the organisms involved; i.e., a listing for phytoplankton and zooplankton similar to that already prepared for fish (Table 11). These tables should include specific identifications, wherever possible, to allow a complete evaluation of the flora and fauna in the area.

1.1.3(9)(b) On page 20, inasmuch as the survey that was performed indicated increased fish production during the period of 1969-70, it would be useful to include data for the commercial catch more recent than that for 1965.

2.7.1(5) With regard to section 2.3.6, Biological Impact, page 43, in view of the importance of the Watts Bar Dam tailwaters (TRM 529.9) as a fish production area, and in view of the location of the plant intake (TRM 528) 1.9 mile downstream, it would seem premature, without additional information,

to say that the intake of 0.5 percent of the average river flow and the subsequent loss of the entrained organisms
2.7.1(5) will be insignificant. It would be desirable if a study were conducted that would assess larval and fly densities in the area during different hydro settings. In addition,
2.6.4(6) it would be desirable if some method of further reducing
2.7.1(4) the intake of these organisms were investigated.
2.7.1(5)

In section 2.3.7, Radioactive Discharges, on page 59, the subject of radiation exposure to humans from external sources and food-chain pathways is treated in the statement, and the environmental radiological program (page 47) appears adequate to monitor radioactivity levels in the aquatic environment. However, the estimated radia-
5.4(2) tion doses that will be received by the aquatic biota should be discussed, including the possibility that fish eggs on the bottom of the reservoir will be exposed to radiation in excess of background levels.

Regarding section 2.3.8, Construction Effects, page 65,
2.8.1(2) the Florida Department of Transportation's "Diaper Tech-
2.8.2 nique" may help minimize the problem of siltation and turbidity referred to here.[1]

In 3.3, Environmental Effects: Damage to Life Systems on page 68, the power plant cooling requirements are listed as 0.3 and 0.5 percent of the average annual volume of the river, but the requirements during low flow periods
2.7.1(5) are not mentioned. Tables should be included that show these requirements with respect to time of year and river flow; biological productivity and concentration or organisms varies with both these factors.

In the draft environmental statement - supplements and additions, section 3.2.2, Heat Dissipation Alternatives, page 3-31, it is indicated that the blowdown from the cooling
2.6.2(1) towers will be returned to the river via a diffuser, not through the holding pool as indicated in the draft environmental statement. It would seem desirable to utilize both systems to take advantage of the additonal cooling provided by the pool.

1/ Hutt, Art. "Limits in Siltation". Florida Conservation and Engineering, 1971, pp.26-27.

On page 3-49, in the section on Cooling Tower Blowdown, information should be supplied concerning the levels of resi-
2.5.1(1) dual chlorine that are expected in the blowdown during chemical defouling of the cooling system.

The text mentions that there is low tornado frequency in the area. This is true and it is interesting to note that analysis of the tornadoes in the United States show this general area has the lowest probability east of the 100th meridian.

Since the cooling towers will be designed on patent authorization from European patent holders, the design should be well engineered. It should be indicated that recent exper-
2.6.2(1) ience in Europe indicates cases of destruction of the towers by resonance rather than high winds. If the natural draft towers should become inoperative, an overspill of excessive heat into the river may occur.

We hope these comments will be of assistance to you in the preparation of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

cc: Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

AUG 19 1971

Dr. F. E. Gartrell
Director
Environmental Research and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in reference to your letter of May 20, 1971, requesting comments of the Federal Power Commission on the Draft Environmental Statement prepared by the Tennessee Valley Authority for the proposed Watts Bar Nuclear Units Nos. 1 and 2. These comments are in accordance with the National Environmental Policy Act of 1969 and the Guidelines of the President's Council on Environmental Quality dated April 23, 1971, and are therefore limited to a review of the need for the Watts Bar Nuclear Units and the alternate sources of supply which normally might have served as substitutes for the proposed units. We understand that others will analyze the environmental aspects of the plant relating to air and water quality.

The site of the proposed plant is in Rhea County, Tennessee, adjacent to the TVA Watts Bar Dam Reservation on the west shore of the Chickamauga Lake about eight miles southeast of Spring City, Tennessee. Unit No. 1 is scheduled for service in August 1976, and Unit No. 2 in May 1977. Each unit is to have a net dependable capacity of 1,170 megawatts.

The Need for Power

According to the Draft Environmental Statement, TVA expects to have 29,765 megawatts of dependable capacity (including the No. 1 Unit and 2,060 megawatts of seasonal exchange capacity) available during the winter peaking season of 1976-1977. During this period the system peak is expected to reach 25,340 megawatts. If scheduled generating capacity and peak loads develop as projected, the TVA system would have 4,425 megawatts of capacity in excess of the winter peak load, or a reserve margin of 17.5 percent.

During the winter peaking season of 1977-1978, TVA expects to have 32,135 megawatts of dependable generating capacity (including proposed Units Nos. 1 and 2 and 2,060 megawatts of seasonal exchange capacity). During this period the peak load is expected to increase to 26,890 megawatts. If these expectations materialize, TVA would enter the 1977-1978 winter peaking season with a reserve capacity of 5,245 megawatts, or a reserve margin of 19.5 percent.

These reserve margins would be severely affected if the construction schedule of the Watts Bar Nuclear Units were to be hampered by any one or more of the types of problems which have been experienced in the construction of other nuclear units. If the No. 1 Unit were not to be available in the fall of 1976, the TVA system would enter the 1976-1977 winter peaking season with a reserve margin of 12.8 percent rather than 17.5 percent. During the winter peaking season of the following year, if the No. 1 Unit were to be available but the completion of the No. 2 Unit were to be delayed, the anticipated reserve margin would fall from 19.5 percent to 15.1 percent. If the proposed project were to have more than its share of difficulties, both units might be delayed beyond 1977. Such delays are not unprecedented in the history of the nuclear plant program. If this should occur, the TVA system would face the 1977-1978 winter peaking season with a reserve margin of 10.8 percent.

The preceding discussion is summarized in the following table:

Tennessee Valley Authority System

	Winter Peaking Season 1976-1977	Winter Peaking Season 1977-1978	
Dependable Capacity	29,765	32,135	
Peak Load	25,340	26,890	
Reserves - Megawatts	4,425	5,245	
Percent	17.5	19.5	
Assumed Delays	Unit No. 1	Unit No. 2	Both Units
Reserves - Megawatts	3,255	4,075	2,905
Percent	12.8	15.1	10.8

Based on data reported in the Draft Environmental Statement, there seems to be no doubt about the need for the Watts Bar Nuclear Units beginning in 1976 in order to provide needed reserve margins for ordinary contingencies to be expected in day-to-day operation of an electric system such as that represented by TVA.

Alternates to Proposed Units

If the Watts Bar Nuclear Units were not to be constructed, equivalent generating capacity would have to be provided from other sources. Practical considerations limit alternate sources to fossil-fuel burning plants, hydroelectric installations, and the importation of power from neighboring systems, if such systems have excess capacity to sell. A choice between these alternate sources is usually determined by environmental and economic factors and by the technical requirement of every electric utility system for a balance between base load and peaking capacity.

A review of the alternate sources of power available to the TVA system by the Commission's Bureau of Power leads to a confirmation of TVA's conclusion that there are no practical alternates to the capacity of the Watts Bar Nuclear Units. This conclusion is supported by the current fossil-fuel supply situation, the lack of hydroelectric sites suitable for base load generation, and by the particular technical requirement of the TVA system for additional base load generating capacity beginning in 1976 to maintain a practical ratio between base load and peaking capacity.

While the TVA service area contains coal deposits and has access to coal fields to the north and south, not enough low-sulfur coal at a competitive price is available to assure that any coal burning alternate generating facility would be acceptable from an economic and air quality point of view.

A natural gas fired steam plant does not appear to be a practical alternate because not enough natural gas is available in the TVA service area to supply the requirements of gas fired generating capacity equivalent to that of the Watts Bar Units. Economic considerations on the other hand appear to rule out the fuel oil steam plant as a reasonable alternate. Low-sulfur fuel oil, even if it were to be generally available in the future, would command a premium. Furthermore, transportation of such fuel oil from deepwater ports to the inland TVA service area would introduce a cost handicap which would place the fuel oil fired alternate plant beyond the competitive range of a nuclear plant.

Dr. F. E. Gartrell

Conventional and pumped storage hydroelectric sites abound in the TVA service area, but all are restricted with regard to water resources and none are suitable for the kind of base load generating capacity now needed nor large enough to serve as a substitute for the Watts Bar Nuclear Units.

The reserve margins of systems elsewhere in the SERC area do not appear to offer a practical substitute for the block of generating capacity represented by the Watts Bar Nuclear Units. Even if these reserve margins were of sufficient magnitude, the geographical dispersion of such reserves and the transmission requirements involved would prevent economical use on the TVA system. Similarly, the construction of a fossil-fuel generating station at a site outside the TVA service area would introduce problems of transmission line right-of-way costs, environmental considerations, and diminished reliability.

Sincerely,

John N. Nassikas

John N. Nassikas
Chairman

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

May 17, 1972

IN REPLY REFER TO:
PWR-ER

Dr. F. E. Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

This is in reference to your letter of April 10, 1972, requesting comments on the "Draft Environmental Statement, Watts Bar Nuclear Plant, Units 1 and 2, Supplements and Additions" dated April 7, 1972.

Comments were previously made by the Federal Power Commission's Bureau of Power on the need for the Watts Bar units in a letter dated July 17, 1971. Those comments were based on the then scheduled commercial service dates of August 1976 for Unit 1 and May 1977 for Unit 2. Since that time the commercial service dates of the two units have been delayed by nine months and are now scheduled for May 1977 and February 1978 respectively.

The following comments by the Federal Power Commission's staff of the Bureau of Power are a revision of the comments dated July 17, 1971, and take into account the new commercial service dates and the latest available estimates of load, power resources, and reserves which are expected to prevail during the summer and winter peaking seasons of the period from summer 1977 through winter 1978-1979. Our comments are based on data presented in the Draft Statement Supplements and Additions of April 7, 1972, which represent the latest information on expected load and resources for this period. The load and capacity estimates are presumed more current than those reported by the Southeastern Electric Reliability Council in its FPC Order 383-2 report dated April 1, 1972. (Information cut-off date December 31, 1971). The Council's report does not take into account the recently announced nine-month delay in the commercial service dates of the Watts Bar units.

Our comments are directed to the power supply as this is expected to develop during the critical peaking periods of 1977, 1978 and 1979 and to the unfavorable consequences with respect to quality of electric services and reliability of services to residential, commercial and industrial customers within the service area if the new commercial service dates of the Watts Bar units are further delayed one year. As requested a copy of these comments is being forwarded to the Director, of the Division of Radiological and Environmental Protection, Atomic Energy Commission.

Dr. F. E. Gartrell

The Need for Power

The importance of the Watts Bar units is indicated by the effect on the power supply situation which would result from any further delay in the commercial service dates of the two units, and by the role of the Authority as a source of emergency electric power and as a participant in firm power interchanges in the Southeast Region.

The TVA service area usually experiences its annual peak load between November and March, but because of seasonal interchange agreements, the net obligations during the summer months are only slightly less than the preceding winter peak load. As a consequence of these obligations, any power shortage on the Authority's system could directly affect about six million persons who are served by the 160 municipalities and rural cooperatives, as well as 46 industrial installations and 11 Federal installations served from the bulk power system. By virtue of the 26 interconnections with neighboring systems, TVA energy flows in any emergency in support of the other interconnected systems.

The effect of a one year further delay of each Watts Bar unit upon the projected reserve margin situation is summarized in the following table:

Power Resources, Loads and Reserves

	Summer 1977	Winter 1977-78	Summer 1978	Winter 1978-79
Watts Bar Units Available				
Dependable Resources, Megawatts	30,536	30,865	32,206	32,535
Load Served by TVA, Megawatts	25,180	25,990	26,490	27,520
Reserve Margin, Megawatts	5,356	4,875	5,716	5,015
Percent	21.3	18.8	21.6	18.2
One Year Delay in Watts Bar Units (1,170 megawatts each unit)				
Reserve Margin, Megawatts	4,186	3,705	4,546	3,845
Percent	16.6	14.3	20.9	14.0

Dr. F. E. Gartrell

The Authority indicates the acceptability of the 18.2 percent to 21.6 percent range of reserve margins if current construction scheduled are met, but states that if each unit be further delayed a year that, except for the summer of 1978, the then resulting reserve margins are inadequate to assure reasonable adequacy and reliability of service.

Electrical utility systems, in general, find it necessary to maintain a planned reserve margin within the range of 15 to 25 percent, depending on system electrical characteristics, types and size of generating facilities, capabilities of interconnections and other related system features. The staff of the Bureau of Power notes that the Authority's planned capacity additions for the period preceding the scheduled operation of the Watts Bar units includes the following large units not yet in service: Nuclear - Browns Ferry No. 1, No. 2, and No. 3 (1,065 megawatts each) Sequoyah No. 1 and No. 2 (1,125 megawatts each) Fossil - Cumberland No. 2 (1,275 megawatts). The foregoing comments relative to the 1977-1979 period and the Watts Bar units presume that the above large units, and the Cumberland No. 1 unit (1,275 megawatts) currently being brought into service, will be brought into reliable operation on schedule. The staff of the Bureau of Power agrees that the capacity of the Watts Bar units will be needed as scheduled to maintain adequate reserve margins for the loads projected by the Authority so as to insure against the contingencies which are inherent in electric system operations, to avoid potential curtailments of service, and to provide for an orderly process in the scheduling of preventive maintenance.

Transmission Lines

The Watts Bar Nuclear Plant will require six new transmission lines totaling 165 miles in length in order to integrate the plant into the existing bulk power network. We understand that there will be minimum environmental impact from these lines which are to be constructed in conformance with "Environmental Criteria for Electric Transmission Systems" established by the U. S. Department of the Interior and U. S. Department of Agricultural.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

cc: Director, of the Division of
Radiological and Environmental Protection
Atomic Energy Commission

8.0 BENEFIT-COST WEIGHING AND BALANCING

This section provides an overall assessment of the economic, technical, and other benefits of the Watts Bar 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 improve the health, education, and living conditions of the people generally.

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 upon 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. Also, electricity is of central importance in solving a vast array of environmental control problems including, for example, the disposal of sewage, recycling of wastes, and mass transit.

The addition of the Watts Bar 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 967 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 Chickamauga Reservoir from cooling tower blowdown; the consumptive use by evaporation of about 62 ft^3/s of water; minor releases of radioactivity to the air and to Chickamauga 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 Commission's draft guide 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 Watts Bar 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 and to provide evaporators for waste treatment.

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 7 percent of that received from natural background radiation and the dose commitment to the population within 50 miles of the plant in the year 2000 is projected at about 0.02 percent of the dose commitment from natural background radiation. Therefore, radiation resulting from operation of the Watts Bar 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 Tennessee water temperature standards of 5.4°F temperature change, a maximum temperature of 86.9°F, and a rate of change not to exceed 3.6°F per hour.

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 Watts Bar plant are detailed below and are summarized in Table 8.1-1.

1. Electric power produced and sold - Watts Bar 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, May 1977, and unit 2, February 1978. Since capacity is planned for on a system basis and TVA has additional generating capacity scheduled for commercial operation during this 2-year period, it is not possible to identify the specific loads which the Watts Bar 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 for F.Y. 1972:

Residential	1.413 ¢/kWh
Commercial	1.337 ¢/kWh
Industrial	0.727 ¢/kWh
Government	0.622 ¢/kWh
Other	1.023 ¢/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 Watts Bar 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 average 1972 price 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 - WATTS BAR 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	$3,414 \times 10^6$	562,000,000	48,200,000
Commercial	$2,065 \times 10^6$	322,000,000	27,600,000
Industrial	$4,419 \times 10^6$	374,000,000	32,100,000
Government	$3,277 \times 10^6$	238,000,000	20,400,000
Other	592×10^6	71,000,000	6,100,000
Total Sold	$13,767 \times 10^6$	1,567,000,000	134,400,000

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, and 1970. The effect of these rate increases has resulted in the average cost of electricity to the consumer increasing by 49.0 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 includes 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 Watts Bar 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 Watts Bar 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 Watts Bar 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 Watts Bar 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 27,500 tons, and NO_x emissions of about 16,900 tons when based on replacing coal-fired generation which meets applicable standards.

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 Watts Bar 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 Watts Bar 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 Watts Bar 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

WATTS BAR NUCLEAR PLANT - BENEFITS

Direct Benefits	
Expected Levelized Annual Generation in Kilowatt Hours	14,779,000,000
Dependable Capacity in Kilowatts	2,340,000
Proportional Distribution of Electrical Energy - Expected Levelized Annual Delivery in Kilowatt Hours:	
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	48,200,000
Commercial	27,600,000
Industrial	32,100,000
Government	20,400,000
Other	6,100,000
Annual Indirect Benefits	
In Lieu of Tax Payments (Local, State) in Dollars	5,700,000
Regional Product	See Text
Environmental Enhancement	
Recreational-Dollars	3,000
Air Quality (Potential to Reduce Pollutants in Tons)	
SO_2	27,500
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 Watts Bar 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 Table 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 $550 million (1972 dollars); a power generating cost of 2.2 mills/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 velocity through the openings of 0.4 ft/s. The maximum intake channel velocity is less than 0.1 ft/s. Larval fish mortalities are expected as a result of the passage of water through the cooling water system. Estimates of the larval fish mortalities are given 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 will not survive. Estimates of total daily quantities (by weight) were made based on concentrations taken during limited sampling in 1970 and 1972, estimates of the withdrawal volumes, the assumptions of uniform draw by the intake and uniformity of sample distributions in horizontal and vertical cross sections, and estimates of discharge quantities by the Watts Bar Hydro Plant turbines from the middle of the vertical profile in the forebay of Watts Bar Dam. Additionally, estimates of maximum phytoplankton standing crop were made by converting the number of cells to equivalent biomass.

Plankton entrainment estimates for the summer season are 456 to 1,369 pounds/day (dry weight) of phytoplankton and 66,696 pounds/day (dry weight) of zooplankton.

The inherent weaknesses 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. Communities 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. Seasonal 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 to be taken during the first or second week of the quarter. However, these 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 the closed-cycle cooling system due to the temperature rise in the condensers and to mechanical shock. An accurate assessment of the effects on larval fish populations cannot be made at this time. However, a conservative estimate of withdrawal and entrainment of larval and young fish has been made as follows:

At 60,000 GPM, 4.71×10^7 fish

At 25,000 GPM, 1.96×10^7 fish

Estimates are based, and should be viewed, upon the following considerations:

1. Estimates are for total withdrawal over a 91-day period extending from April 27 through July 27.

2. No data are available for the Watts Bar site. It is judged that larval and young fish susceptible to entrainment and condenser passage would come from two sources:
   a. those produced in the tailwater area of Watts Bar Dam, and
   b. those produced in Watts Bar Reservoir and which pass through the dam via turbines, locks, and spillways.
3. The tailwater areas are not as productive of larval fish as are shallow embayments and littoral areas; furthermore, turbine inlets draw from the deeper strata of Watts Bar Reservoir. Thus, concentrations of fish would be less than those noted for shoreline or surface locations sampled in Wheeler Reservoir.
4. Therefore, calculations were based on the average concentrations of larval fish taken in midchannel at a depth of five meters at TRM 293 and TRM 298 (Wheeler Reservoir).
5. Given (1) the absence of knowledge of larval and young fish in Watts Bar tailwater, (2) the absence of data regarding passage through the dam, and (3) the judgment that Wheeler Reservoir is one of the most productive of TVA's mainstream reservoirs, (4) the relatively low intake velocities and volumes of Watts Bar Nuclear Plant, it is judged that the estimates are conservative, i.e., they overestimate actual losses.

(3) <u>Discharge area and thermal plume</u> -

(a) <u>Physical water quality</u> - The maximum total plant heat rejection to Chickamauga Reservoir will be 2.9×10^8 Btu/h from cooling tower blowdown. An exact estimate of the mixing zone for the heated discharge can only be determined after the design of the diffuser is finalized.

(b) <u>Dissolved oxygen</u> - 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 95°F and the saturation dissolved oxygen level at this temperature is about 6.8 mg/l, no discharge of blowdown water with a dissolved oxygen concentration of less than 5 mg/l is anticipated at Watts Bar.

(c) <u>Aquatic biota</u> - It is TVA's judgment that there is no basis for assuming irretrievable loss of aquatic biota owing to thermal discharges of the plant.

(d) <u>Wildlife</u> - No effects on any area wildlife forms are anticipated from the limited thermal discharges to Chickamauga Reservoir.

(e) <u>Migratory fish</u> - 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 Watts Bar plant will be within water quality standards prior to discharge. No significant environmental costs are expected from the chemical discharges to Chickamauga Reservoir.

(5) Radionuclides discharged to water body - Doses are calculated according to the methods described in Appendix E. Doses for the alternative system are derived from the numbers listed in Tables 3, 5, and 6 of Appendix E by using the scaling factor 5.4 which corresponds to the treatment without tritium recycle. Tritium doses are included for annual releases of 100 Ci for the system with tritium recycle and 1,590 Ci without tritium recycle. 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 of benthic invertebrates living in the vicinity of the Watts Bar Nuclear Plant.

(b) People - external - The external dose rate to people involved in abovewater activities (skiing, fishing, boating), inwater activities (swimming), and shoreline activities has been calculated. The external dose to people involved in shoreline activities is expected to be very small. A precise estimate would be dependent upon a variety of factors, such as the distance a person is from the edge of the water, and would be very complex. If the simplifying assumption is made that all persons participating in shoreline activities receive the same dose rate as a person boating or skiing, the maximum dose rate to an individual present continuously is estimated to be 2.4×10^{-7} rem/yr to the skin, and the population dose is 7×10^{-4} man-rem/yr. This estimated individual dose rate exceeds the more realistic estimates for abovewater activities and inwater activities. The total population dose rate for the skin dose for abovewater activities, inwater activities, and shoreline activities is 1.7×10^{-3} man-rem/yr.

(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 62 ft^3/s (123 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 (26,480 ft^3/s). Yearly evaporative losses would be a maximum of 45,000 acre-feet.

(7) Plant construction -

(a) Physical water quality - During the construction period there will be some dredging of material in Chickamauga 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 criteria. Thus, no dilution volume in Chickamauga Reservoir 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 Chickamauga Reservoir in solutions with concentrations which meet Tennessee water quality criteria. Thus, no reservoir dilution volume is required.

(8) Other impacts - No other significant environmental effects have been identified.

(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 Chickamauga Reservoir - The construction and operation of the Watts Bar Nuclear Plant, considering the alternatives utilized to minimize environmental effects, is not expected to have any noticeable effect on Chickamauga 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 Watts Bar plant should have no effect on local ground water levels since relatively small quantities of water are withdrawn and since Chickamauga Reservoir water levels are maintained according to TVA's reservoir operating guides. Normal fluctuations in water levels in the reservoir are from elevation 675 in winter to elevation 682.5 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 for the ingestion of Tennessee River water (Table 3 of Appendix E). 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 26,000 persons between Watts Bar and Paducah, Kentucky. The maximum population dose commitment (thyroid) for an annual release of 0.92 Ci in the liquid effluent is 0.16 man-rem. This dose commitment DC_P is obtained as follows:

$$DC_P = \sum_{i=1}^{27} \frac{P_i}{A_i} \times A_i^* \times DC_i$$

where

P_i = population of county i,

A_i = county area, (mile^2),

A_i^* = county area within 0.5 mile of the Tennessee River, (mile^2),

DC_i = individual thyroid dose commitment calculated for a public water supply in or near county i, (rem).

The maximum individual dose commitment is obtained directly from Table 3 of Appendix E.

(b) <u>Plants and animals</u> -

Calculations of doses to aquatic plants and animals living in the Tennessee River near the Watts Bar Nuclear Plant are described in Appendix E. It is assumed that ground water within 0.5 mile of the Tennessee River contains 100 percent of the radioactivity concentration present in the river. Therefore, doses to plants and animals resulting from the radioactivity concentration in the ground water will not exceed those shown in Table 6 of Appendix E. The maximum annual dose of 0.3 mrad does not include the dose to benthic organisms from sedimentation which is not appropriate in this case.

(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 are not expected to have any effect on ground transportation. Closed-cycle mechanical draft towers could affect ground transportation 455 hours per year.

(b) Effects on air transportation - Analysis of Paradise power 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 about 9 miles southwest of the Watts Bar site, no interference with commercial airport operation is anticipated.

(c) Local effects on water transportation - Natural draft cooling towers have no effects on water transportation. Analyses 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 730 hours per year when operating on closed-cycle mechanical draft cooling towers.

(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 have been estimated assuming combustion of 4.8×10^6 gallons per year of fuel oil with 0.5 percent sulfur content. Resulting ambient levels for shorter averaging time periods assume a consumption rate of 727 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	0.15	25.6
Sulfur dioxide	0.06	25.1
Carbon monoxide	1.45×10^{-5}	0.1
Hydrocarbons	0.12	6.4
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 F. 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 F. 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 967 acres for the base plant. Feasible alternatives for heat dissipation do not require additional land.

(2) Plant construction -

(a) Noise effects on people - Ambient noise levels due to construction of the Watts Bar 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 - No historical sites are affected by the plant or its transmission system additions.

(c) Accessibility of archaeological sites - Areas of potential archaeological significance at the Watts Bar site were identified in a December 1970 survey by the University of Tennessee Department of Anthropology. Explorations were performed in the summer of 1971, with additional exploration planned. These explorations should prevent irretrievable loss of any items of archaeological significance. Accessibility for archaeological exploration after plant construction should not be required.

(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 Watts Bar site is estimated to be about 700 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 Chickamauga Reservoir. Additions of combined-cycle cooling facilities could be expected to contribute significantly more quantities of land erosion since the addition of diffusers would require significantly more dredging.

(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 Watts Bar 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 displacement of wildlife in the immediate site area.

(d) Flood control - The Watts Bar 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, following periods of low or no streamflow when blowdown is withheld, the concentration factor will increase to about 4. Even at this level, total dissolved solids concentrations will not exceed about 400 mg/l. At these levels the cooling water will meet Tennessee Water Quality Control Board's criteria of 500 mg/l for dissolved solids. No significant effects are expected from drift discharges from the towers.

(5) Transmission route selection -

(a) Preemption of land - The Watts Bar plant will require 165 miles of new transmission lines. New land area required for transmission line right of way is estimated to be 3,165 acres. This land is not purchased in fee and only some restrictions are imposed by the easements.

(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 Watts Bar, no visually sensitive areas or areas of high population density are to be crossed.

At this time none of the transmission line right of way easements for Watts Bar 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 damage 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 Watts Bar 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 Watts Bar, the minimum of undesirable features has been sought. Unavoidable state, U.S., and interstate highway crossings will number 17 and major river crossings will number 10. 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 presently 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 generally 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 and off the rights of way.

(8) Other land impacts - The only other impact identified is the property value effect of the addition of the plant. To ascertain the effects of the site on property values in the area the investigation has been limited to activity within a 5-mile radius of the plant site. Data for this area are relatively incomplete prior to the middle 1960's, but some real estate transactions

date back to 1963. Eighteen real estate transactions studied lie within the 5-mile radius. Fourteen of these occurred prior to plant site announcement. Because of the small amount of data no presumptive statistical evidence can be offered. However, home sites and farms have traded in the area and an analysis of all the facts of the sales indicate no measurable depreciation or appreciation has occurred subsequent to the plant site announcement.

Although no measurable impact on property values has occurred since announcement of the site location, past experience indicates that initiation of construction and the attendant influx of construction employees will probably have some effect during the construction period. This effect will probably be temporary, however, and when construction is complete, property values are expected to return to normal levels. Many of the construction workers will probably live in the nearby communities of Spring City (population 1,756), Dayton (population 4,361), and Rockwood (population 5,259). These communities also may experience minor upward movement in property values during the construction period.

In a recently completed study for Browns Ferry Nuclear Plant site, no depreciation and little appreciation was discovered after five years of activity which included the major construction period for the plant. The Browns Ferry study was based on an adequate number of transactions and a time element adequate to measure trends.

(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 Watts Bar Nuclear Plant on the land resource is the commitment of 967 acres of land for the use of power production during the plant's lifetime and the restriction on the use of 3,165 acres of transmission line rights of way during the lifetime of these lines.

5. Cross category effects -

(1) Transportation - In a normal year Watts Bar will receive about 10 truck shipments of new fuel; will make about 130 truck, or 13 by rail, shipments of spent fuel; and will make about 30 to 35 truck 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 have been divided into 9 classes by AEC. This characterization of accidents by classifications brackets the qualitative assessment of environmental

costs and benefits. Table 2.3-2 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

WATTS BAR 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
Generating Cost	Total Value (1972 dollars)	$\$929.25 \times 10^6$	$\$928.95 \times 10^6$
	Annualized	$\$ 79.73 \times 10^6$	$\$ 79.70 \times 10^6$
Environmental Effects			
1. Natural Surface Water Body	Chickamauga Reservoir		
1.1 Cooling Water Intake Structure	1.1.1 Fish Mortality	See Text	

a. Minimum system with respect to primary impact to offsite population due to plant gaseous releases.

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative			Plant with Minimal Environmental Impact	Current Plant Design
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	
	1.2.2	Fish Mortality - Pounds per Year as Adults	*	*
1.3 Discharge Area and Thermal Plume	1.3.1	Physical Water Quality - Btu/h Heat Rejection	2.9×10^8	2.9×10^8
		Acre-Feet of Water Affected - 5.4°F Isotherm	See Text	See Text
	1.3.2	Oxygen Depletion - mg/l Decrease from Ambient Dissolved Oxygen Concentrations	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

*At makeup flow rate of: 60,000 gal/min - 1,552 lb/yr
25,000 gal/min - 742 lb/yr

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
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
	1.4.4 People - Lost User Recreational Days	0	0
1.5 Radionuclides Discharged to Water Body	1.5.1 Aquatic Organisms - rad/yr	0.13	0.13
	1.5.2 People, External - rem/yr man-rem/yr	2.4×10^{-7} 1.7×10^{-3}	2.4×10^{-7} 1.7×10^{-3}
	1.5.3 People, Ingestion - rem/yr man-rem/yr	5.5×10^{-5} 12	5.5×10^{-5} 12
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

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
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	
1.9 Combined or Interactive Effects		See Text	
1.10 Net Effect		See Text	
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	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	 2.0×10^{-5} 0.16	 2.0×10^{-5} 0.16
	2.3.2 Plants and Animals	See Text	
2.4 Other Impacts on on Ground Water		See Text	

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative				Plant with Minimal Environmental Impact	Current Plant Design
3. Air					
3.1	Fogging and Icing Caused by Heat Dissipation System Evaporation and Drift	3.1.1	Ground Transportation - Hours per Year	0	0
		3.1.2	Air Transportation Hours per Year	0	0
		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	See Text	
		3.2.2	Air Quality, Odor	See Text	
3.3	Radionuclides Discharged to Ambient Air	3.3.1	People, External rem/yr man-rem/yr	4.2×10^{-3} 6.2	6.6×10^{-3} 13
		3.3.2	People, Ingestion rem/yr man-rem/yr	3.3×10^{-3} 5.4	3.3×10^{-3} 5.4
		3.3.3	Plants and Animals - rad/yr	4.2×10^{-3}	6.6×10^{-3}
3.4	Other Impacts on Air			See Text	

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative				Plant with Minimal Environmental Impact	Current Plant Design
4.	Land				
4.1	Preemption of Land	4.1.1	Land, Amount, in Acres	967	967
4.2	Plant Construction	4.2.1	People, Noise	See Text	
		4.2.2	People, Accessibility of Historical Sites	See Text	
		4.2.3	People, Accessibility of Archaeological Sites	See Text	
		4.2.4	Wildlife	See Text	
		4.2.5	Land, Erosion	See Text	
4.3	Plant Operation	4.3.1	People, Noise	See Text	
		4.3.2	People, Aesthetics	See Text	
		4.3.3	Wildlife	See Text	
		4.3.4	Land, Flood Control	See Text	
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

Table 8.2-1

WATTS BAR NUCLEAR PLANT - GENERATING AND ENVIRONMENTAL COSTS
(continued)

Alternative		Plant with Minimal Environmental Impact	Current Plant Design
4.5 Transmission Route Selection	4.5.1 Land, Amount, Acres	3,165	3,165
	4.5.2 Land Use and Land Value	See Text	
	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	See Text	
4.7 Transmission Line Operation	4.7.1 Land Use	See Text	
	4.7.2 Wildlife	See Text	
4.8 Other Land Impacts - Land Value Effects		See Text	
4.9 Combined or Interactive Effects		See Text	
4.10 Net Effects		See Text	
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

WATTS BAR NUCLEAR PLANT

ALTERNATIVES FOR GASEOUS RADWASTE SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Gaseous Radwaste System	45-Day* Holdup	60-Day Holdup	Cryogenic Distillation	Gas Absorption	Hydrogen Recombiners
Incremental Generating Cost (thousands of dollars)	base	100	600	400	400
Dosage Rates to People from External Contact					
rem/yr	$7.0x10^{-3}$	$6.6x10^{-3}$	$4.2x10^{-3}$	$4.2x10^{-3}$	$6.6x10^{-3}$
man-rem/yr	14	13	6.2	6.2	13
Dosage Rates to People from Ingestion					
rem/yr	$3.3x10^{-3}$	$3.3x10^{-3}$	$3.3x10^{-3}$	$3.3x10^{-3}$	$3.3x10^{-3}$
man-rem/yr	5.4	5.4	5.4	5.4	5.4
Dosage Rate to Plants and Animals					
rad/yr	$7.0x10^{-3}$	$6.6x10^{-3}$	$4.2x10^{-3}$	$4.2x10^{-3}$	$6.6x10^{-3}$

*A 45-day radioactive gas holdup time period was originally proposed in the equipment to have been supplied with the nuclear steam supply system, but in order to minimize radioactive releases, alternative gaseous treatment systems were analyzed and 60-day holdup selected.

Table 8.2-3

WATTS BAR NUCLEAR PLANT

ALTERNATIVES FOR HEAT DISSIPATION SYSTEM

COSTS WHICH VARY FROM BASE PLANT

Alternative Heat Dissipation System*	Natural Draft Cooling Towers Closed-Cycle	Mechanical Draft Cooling Towers Closed-Cycle	Cooling Lake
Estimated Incremental Generating Cost (thousands of dollars)	41,600	42,600	**
Reservoir Heat Input (Btu/h)	2.9×10^8	2.9×10^8	1.5×10^8
Water Consumed (acre-feet/day)	123	123	62
Transportation Affected (h/yr)			
Ground	0	445	0
Water	0	730	0
Additional Land Required (acres)	0	0	>2100
Erosion (tons/yr)	700	700	1000

*Also considered were a spray canal and a once-through cooling system with a diffuser discharge. These were deemed to be infeasible early in the environmental review process.

**Considerably greater than the other alternatives. No detail cost estimates available.

8.3 <u>Weighing and Balancing of Alternative Generation, Alternative Sites, and Alternative Subsystems</u> - 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. <u>Alternative generating capacity</u> - An analysis of the alternatives for generating capacity addition in the time period when the Watts Bar plant is planned is given in section 4.1. Based on this analysis, TVA decided that the nuclear generating capacity addition was more acceptable from the standpoint of economic and environmental impacts.

2. <u>Alternative sites</u> - An analysis of alternatives to the Watts Bar site is given in section 4.2. A summary of the pertinent physical features of the sites considered is given in Table 4.2-1.

The Watts Bar PSAR has been submitted to AEC and other licensing procedures are underway and since no alternative site has been found which is more suitable than the Watts Bar site for the location of this plant TVA judges that there are no substantial environmental risks associated with the Watts Bar site. Consequently, TVA has concluded that the Watts Bar site is a suitable location for this 2-unit plant and is the site which provides the best opportunity for meeting TVA's power supply obligations in the late 1970's.

3. <u>Heat Dissipation</u> - At the outset of designing the Watts Bar plant it was realized that there was a high probability

that more stringent thermal water quality standards would be imposed than the 10°F temperature rise and 93°F maximum temperature then proposed by the State of Tennessee. Additionally, it was realized that the site's proximity to the Watts Bar Dam would result in some periods of time with zero or near zero waterflow rates past the plant. Thus a once-through cooling system with a diffuser was eliminated due to infeasibility early in the environmental review process. The other alternatives given early consideration were natural draft and mechanical draft cooling towers, a spray canal, and a cooling lake. Details on these alternatives are given in section 2.6.

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. This resulted in a complete analysis of only the cooling tower alternatives.

Estimates of environmental impacts were made as discussed above in section 8.2. The results are summarized in Table 8.2-3.

An investigation of a spray canal showed the only location to be in an area restricted by a high ridge which would adversely affect performance, thus it was concluded that the spray canal could only be effectively utilized to augment a cooling lake.

The cooling lake concept required remote location from the plant, which would have resulted in high environmental costs. Thus this design concept was considered environmentally unacceptable.

A comparison of the closed-cycle natural draft and mechanical draft cooling tower alternatives was made. The principal disadvantages of the mechanical draft cooling towers when compared to natural draft cooling towers are the possible higher frequency for fogging and icing and higher noise levels and the additional cost of one million dollars. Since construction is to be concurrent with the remainder of the plant, the shorter construction time of mechanical draft towers was not a significant factor in the decision as to type of tower to be utilized. Thus TVA concluded that the natural draft cooling towers offer the best alternative for heat dissipation at Watts Bar.

4. Gaseous radwaste system - As discussed in section 2.4, the initial nuclear steam supply system design concept for the gaseous radwaste treatment system was to provide a 45-day holdup period to permit decay of radioactive gases. It was realized that there were potentials for reducing expected dose rates by a change in design concept. Thus during the environmental review process the following alternatives were evaluated:

1. 45-day holdup
2. 60-day holdup
3. Cryogenic distillation
4. Gas absorption
5. Hydrogen recombiners

Table 8.2-2 presents an evaluation of these alternatives. As shown in the table, the 60-day holdup system, at a cost of $100,000 over the 45-day holdup system, assuming 0.25 percent fuel defects, results in an external annual dose rate to people of 6.6 mrem, a reduction of 0.4 mrem from that of the 45-day holdup system. The use of a cryogenic distillation system at a cost of $600,000, or of gas absorption or hydrogen recombiner systems at $400,000 each, would result in dose rates of 4.2, 4.2, and 6.6 mrem, respectively. Neither the cryogenic distillation or gas absorption systems has demonstrated performance and reliability in nuclear plant service. The cryogenic distillation system, while proven for industrial applications, is a complex system which 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. The hydrogen recombiner system, as indicated above, gives no significant reduction in dose rates over the 60-day holdup.

Based on this analysis TVA has concluded that the 60-day holdup alternative, which results in a dose rate of 6.6 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" of 6.6 mrem per year is less than the numerical guidance provided by the proposed Appendix I to 10 CFR Part 50. It also represents only about 5 percent of the naturally occurring background dose.

5. Liquid radwaste treatment - As indicated in section 2.4, the use of tritium recycle and extended treatment of

steam generator blowdown will hold release of radioactive liquids to the lowest practicable level. Table 8.3-1 indicates the different doses expected as a result of either recycling or not recycling tritiated water. As indicated in section 2.4, TVA is continuing the analysis of tritium recycle and its potential for producing the minimum environmental effect.

Table 8.3-1

LIQUID RADWASTE SYSTEM ALTERNATIVES

	Radwaste System	
	Without Tritium Recycle	With Tritium Recycle
Annual Doses from Radionuclides Discharged to the Tennessee River		
Humans (external)		
rem	2.7×10^{-7}	5.0×10^{-8}
man-rem	5.4×10^{-3}	1.0×10^{-3}
Humans (ingestion)		
rem	3.0×10^{-4}	5.5×10^{-5}
man-rem	69	12
Aquatic Organisms		
rad	0.70	0.13
Annual Doses from Radionuclide Contamination of Ground Water		
Humans (ingestion)		
rem	1.1×10^{-4}	2.0×10^{-5}
man-rem	0.93	0.16

9.0 CONCLUSION

This environmental statement reflects the manner in which TVA has incorporated environmental considerations into the decision-making process for the Watts Bar 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 Chickamauga 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 changes have been made in 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 Watts Bar 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 Watts Bar Nuclear Plant.

Appendix A

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.

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. 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

$$DR = \frac{I\, e^{-\mu r}\, B(E, Z, \mu r)}{R^2}, \tag{1}$$

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}), $= 2.5 \times 10^{-3}\ \text{ft}^{-1}$,

$B(E, Z, \mu r)$ = 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 A-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 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,

$$D(d) = \frac{2I}{v} \int_{o}^{\infty} \frac{e^{-\mu r}}{r^2} B(E, Z, \mu r) dx \quad , \qquad (4)$$

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),

$B(E, Z, \mu r)$ 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. 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.

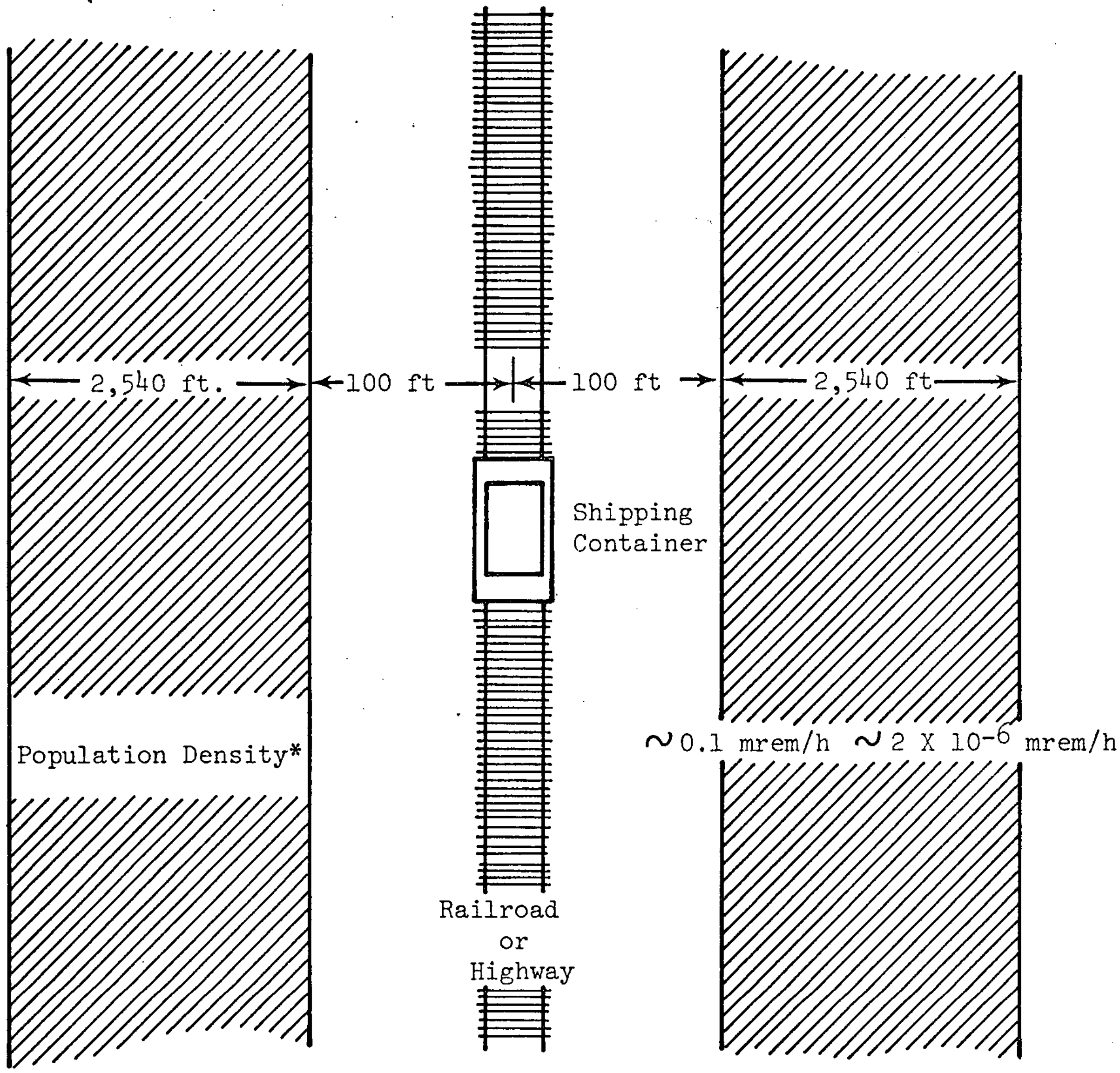
2. Transportation accident - The principal potential environmental effects from an accident involving irradiated fuel are those from direct radiation resulting from increased radiation levels and from gaseous release of noble gases and iodine.

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 A-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 A-4. These dose curves represent the envelope of the doses for Pasquill stability conditions A through F with a wind speed of 1 m/sec. For a specific accident (with a wind speed of 1 m/sec and for one particular Pasquill stability condition) the maximum doses would be equal to the "plateau" doses shown in figure A-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/sec the doses would be lower than shown in figure A-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 millirems 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 A-3.

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 Ci/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 260 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 A-5, and at 600 feet is 10 mrem. Figure A-5 has been prepared assuming Pasquill stability condition F and a wind speed of 1 m/sec. For Pasquill stability condition A through E and wind speeds of 1 m/sec, the dose at 50 feet from the cask will be about the same as shown in figure A-5 (260 mrem) but the doses at downwind distances beyond 50 feet would be lower than shown in the figure. For wind speeds above 1 m/sec, doses may be predicted by multiplying the doses calculated for a wind speed of 1 m/sec 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 0.050 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 A-1
Spent Fuel and Radioactive Waste Shipments Population Exposure Distribution

WATTS BAR NUCLEAR PLANT

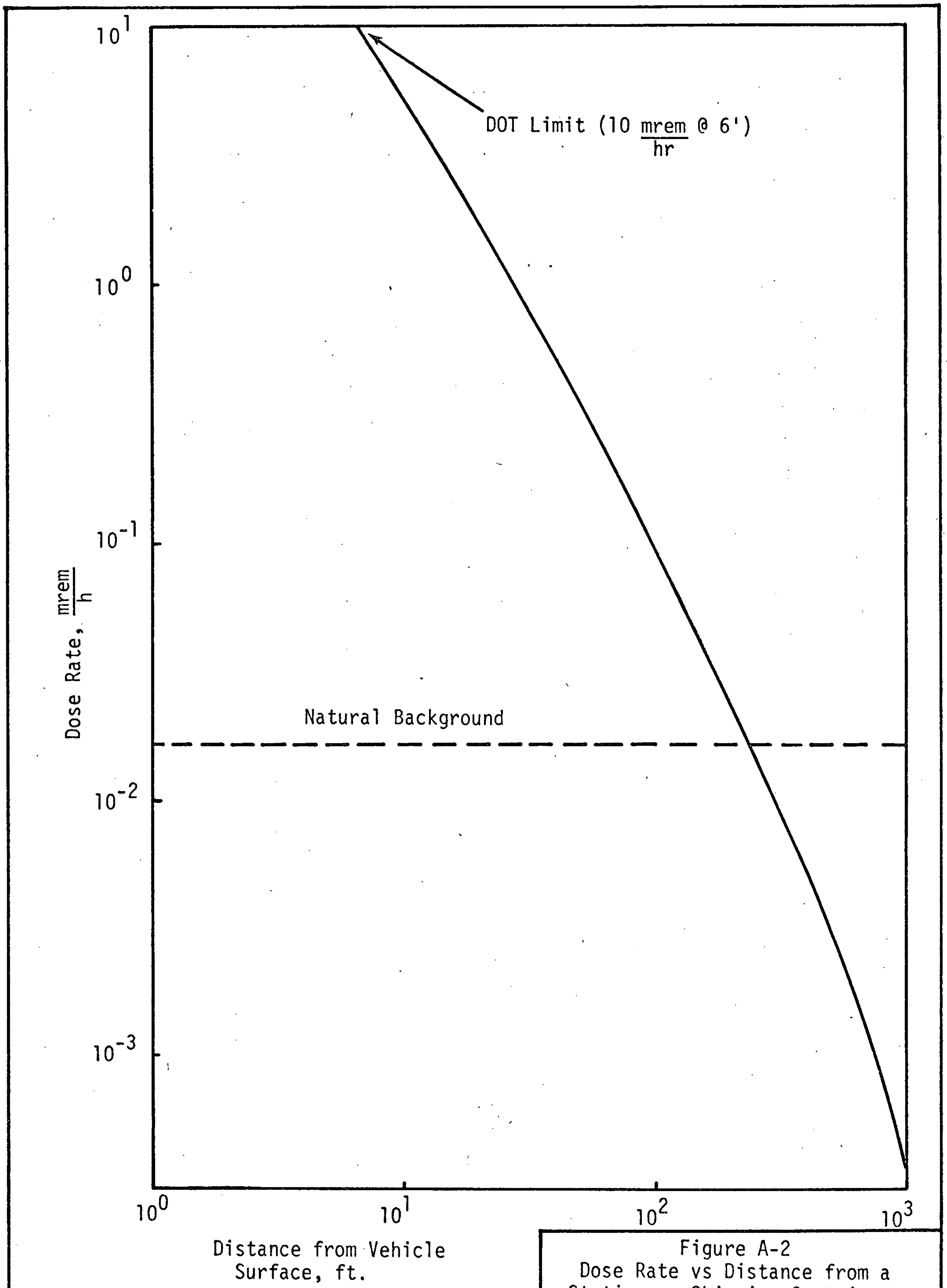


Figure A-2
Dose Rate vs Distance from a Stationary Shipping Container, Normal Conditions
WATTS BAR NUCLEAR PLANT

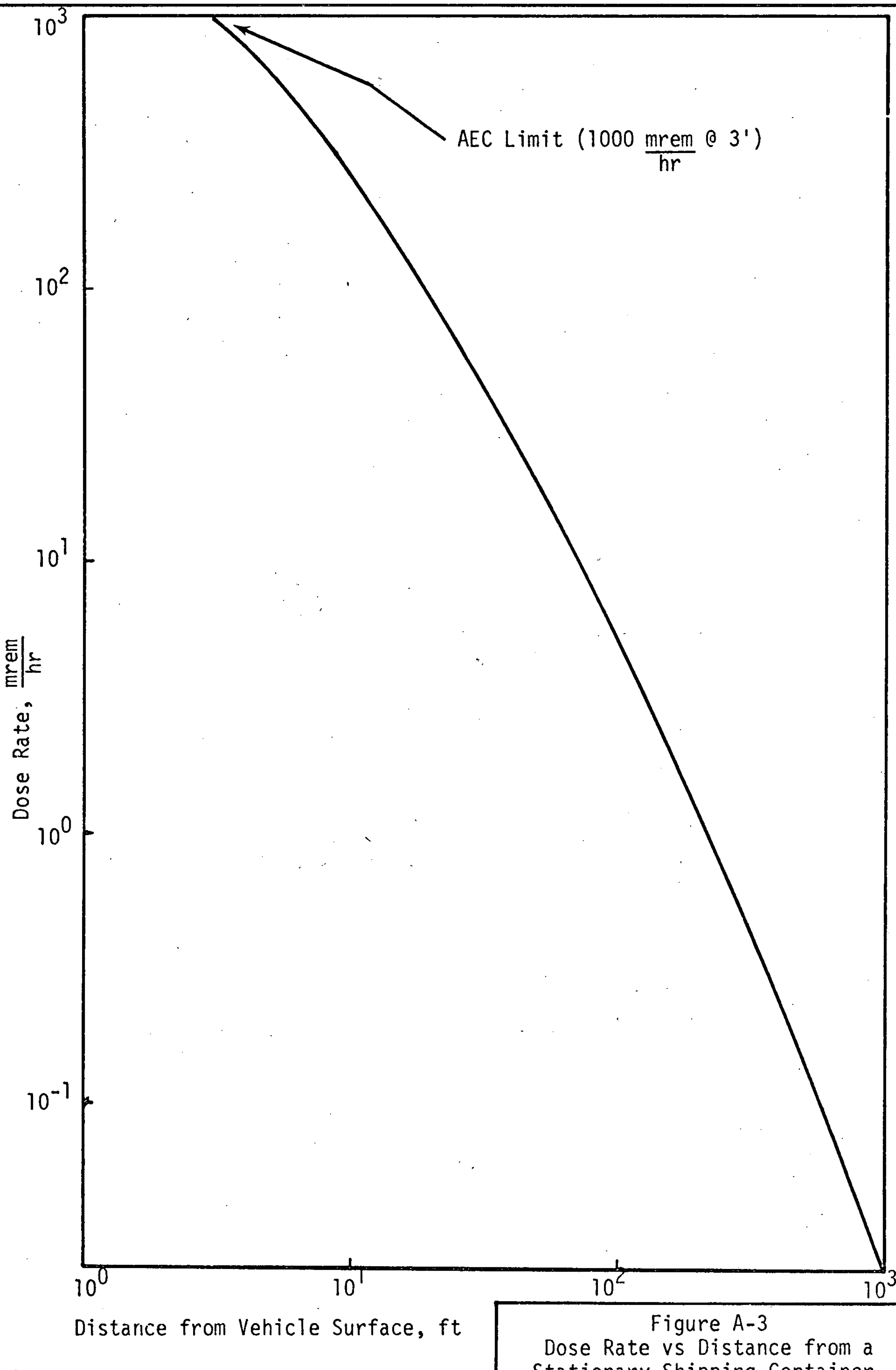


Figure A-3
Dose Rate vs Distance from a Stationary Shipping Container, Accident Conditions

WATTS BAR NUCLEAR PLANT

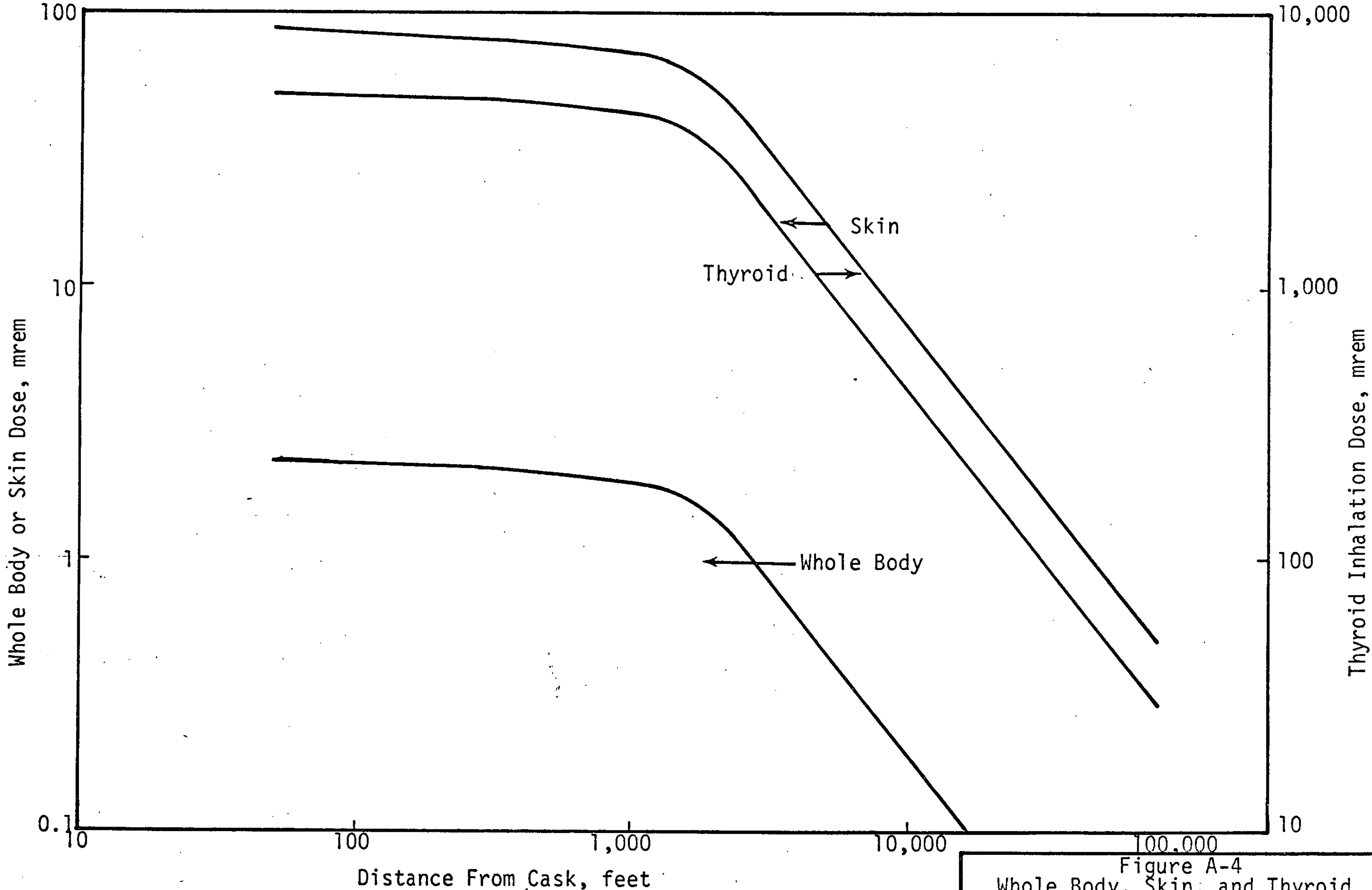


Figure A-4
Whole Body, Skin, and Thyroid Inhalation Doses vs Distance for Release of 1000 Ci of Noble Gases and 10 Ci of I-131 During a Spent Fuel Transportation Accident

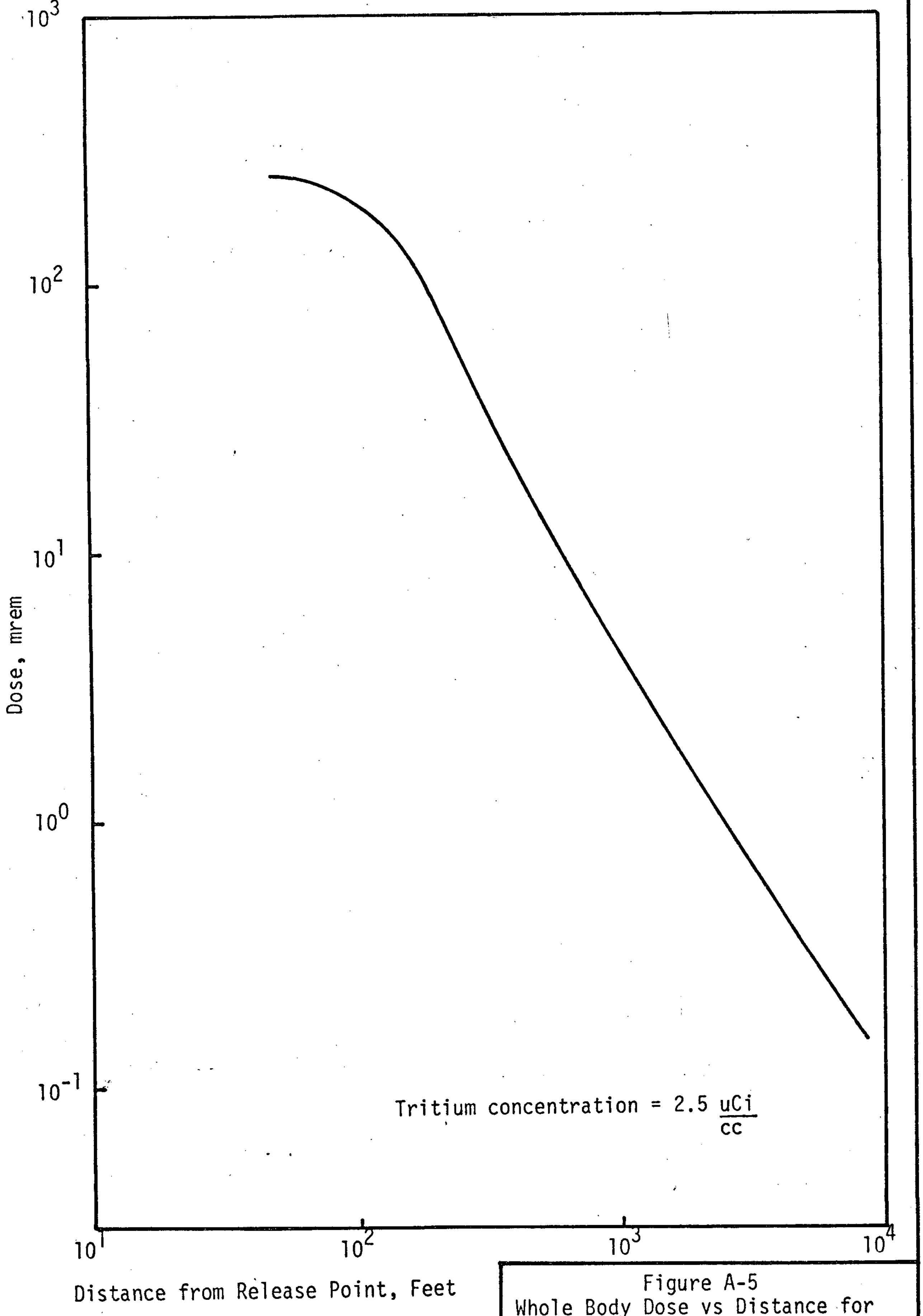


Figure A-5
Whole Body Dose vs Distance for Release of 3,700 Gallons of Tritiated Water During Transportation Accident

Appendix B

RELATION OF 10 CFR PART 71 ACCIDENT REQUIREMENTS TO ACTUAL SHIPPING ENVIRONMENT

1. Performance requirements of 10 CFR Section 71.36 - The .omestic 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 question has been raised as to the adequacy of the 10 CFR Part 71 accident requirements in simulating the actual conditions to which a container might be subjected as a result of an accident under transport 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 in the test.

(1) <u>30-foot free fall</u> - 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) upon impact within a distance of 2 to 8 inches. 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 B-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 upon striking an unyielding surface.

As indicated in the table, a 45,000-lb 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-lb cask, which is equivalent to the IF-300, would generate about 7,800,000 pounds of force. A loaded truck, weighing 75,000 lb 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-lb cask as a result of the 30-foot free fall. Likewise, a 5,000-lb 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 generate 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 B-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 by 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. As evidenced from pictures of large fires, 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.

Table B-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 C

OZONE PRODUCTION AND ITS POTENTIAL EFFECTS

This report 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 of 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 C-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 C-2 and C-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 C-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. Ozone generation by transmission facilities and other potential sources - Ozone may be generated by any corona or electrical discharge in air or other oxygen medium. Quantities produced are dependent on the severity of the discharge and 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, appliances, 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 C-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 (including any significant increase in chromosome aberrations) 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 levels of

ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum voltage), either resulting from normal transmission operations 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.

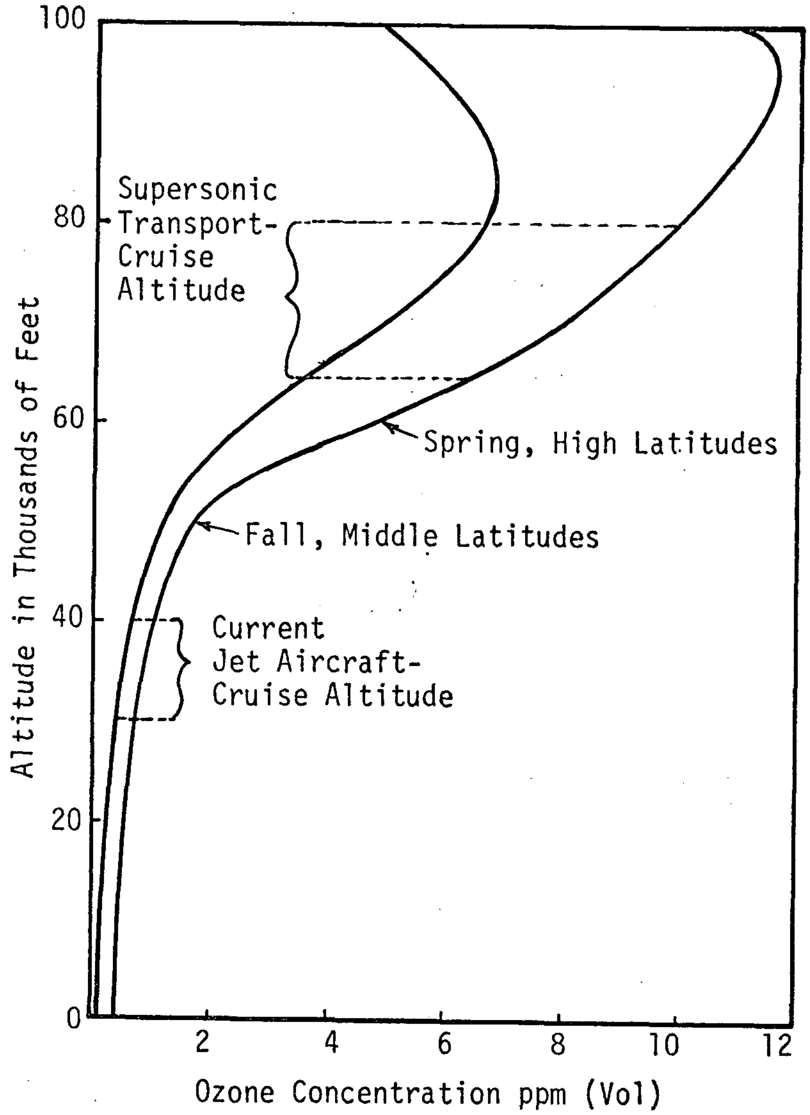


Figure C-1

Ozone Distribution
Northern Hemisphere

WATTS BAR NUCLEAR PLANT

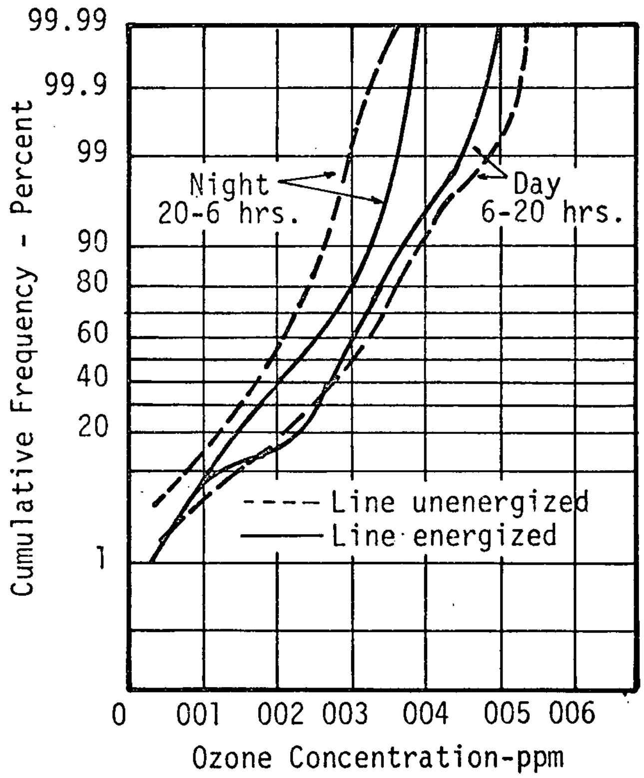


Figure C-2
Ozone Statistic obtained near UHV Test Line during 8 days of Energization and 10 days without Energization

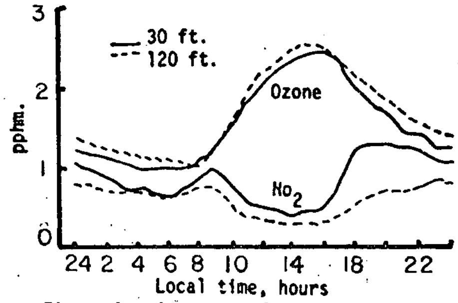


Figure 1. Averages of ozone and nitrogen dioxide for five months(Sept. 1966-Jan. 1967)

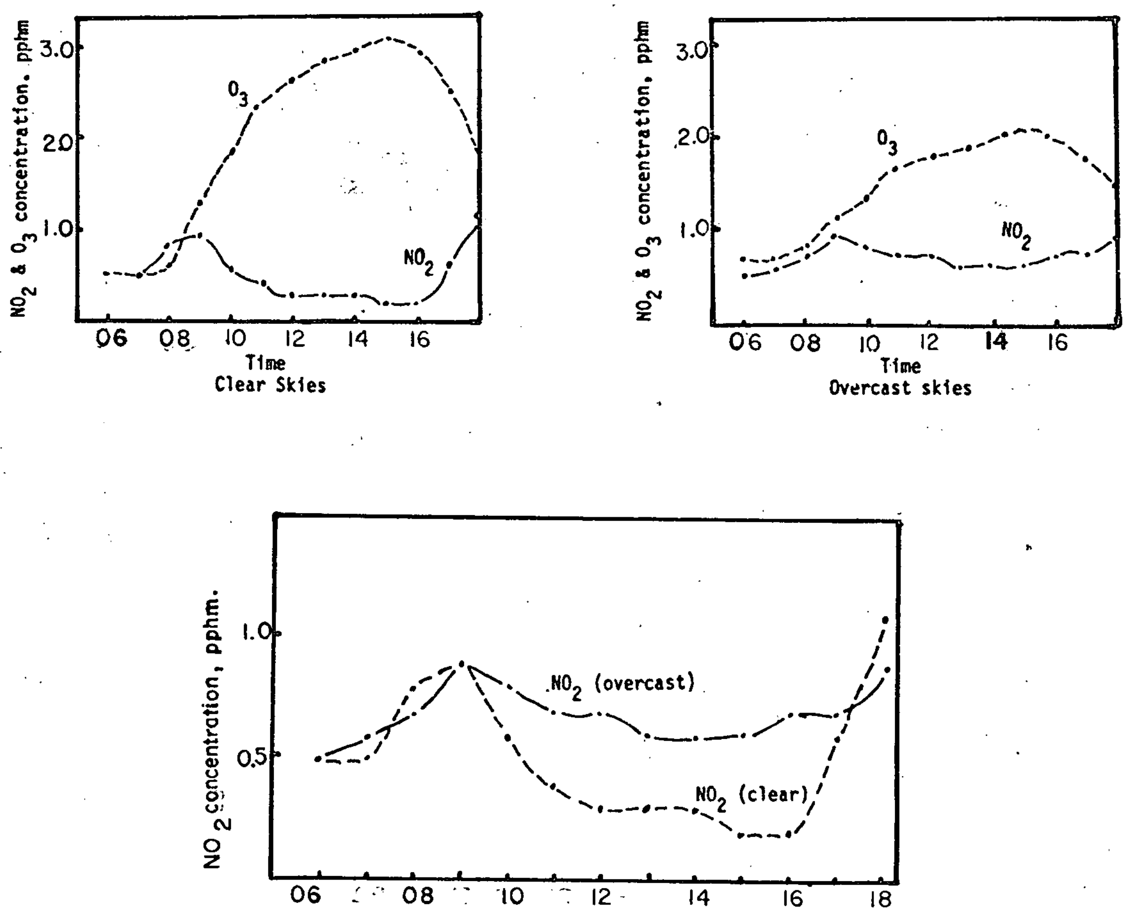


Figure 2. Nitrogen dioxide on clear and overcast days (Sept. 1966-Jan. 1967)

Figure C-3

Functional Relationships of Ozone and Nitrogen Dioxide

WATTS BAR NUCLEAR PLANT

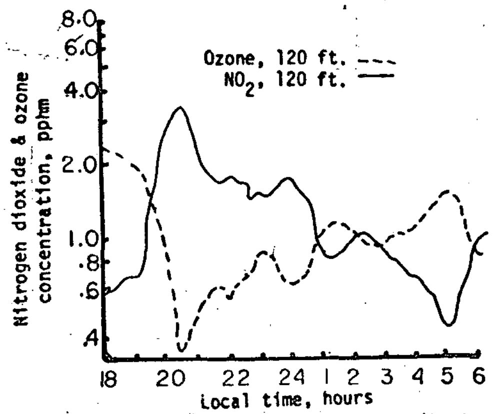


Figure 3. Nitrogen dioxide and ozone (1800-0600 hr on 11/24/66).

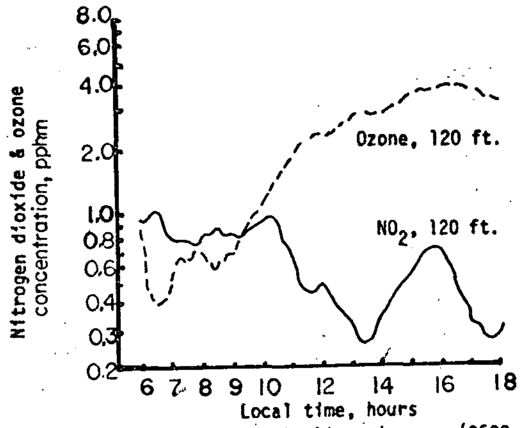


Figure 4. Nitrogen dioxide and ozone (0600 1800 hr on 11/25/66).

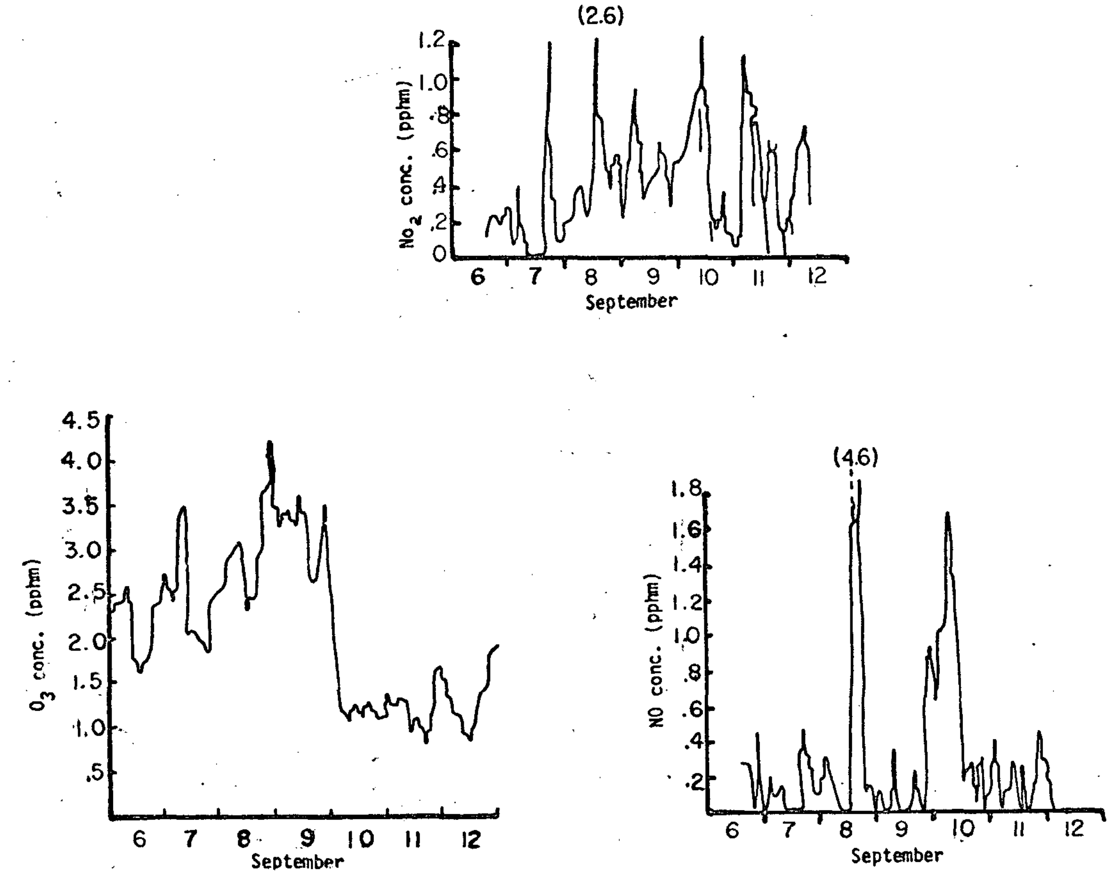


Figure 5. Diurnal averages for nitrogen dioxide and ozone at Green Knob. N. C. (Sept. 1965).

Figure C-3 (Cont'd)

Functional Relationships of Ozone and Nitrogen Dioxide

WATTS BAR NUCLEAR PLANT

Appendix D

OUTLINE OF ACCIDENT ANALYSES

1. Introduction - This appendix describes the evaluation of the environmental impact of postulated occurrences and accidents for the Watts Bar 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 the AEC for the consideration of accidents in December 1971. As shown in Table D-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 description of critical equipment and structures is provided in the preliminary safety analysis report (as amended), which also contains descriptions of very conservative analyses of many of these same events.

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 chemical and volume control 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 or gaseous waste 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 28,000 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 floor and equipment drain sump and pumps which are located in the containment buildings.

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.

The above notwithstanding, an unplanned release of 1 curie of radioactive material (having the same isotopic distribution as the normal liquid releases) was assumed to be released inadvertantly 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 at Yankee-Rowe and Saxton 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 1-curie liquid release.

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 nine 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. Analysis of Class 4 events - 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 a conservative 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 not be exceeded. Therefore, the fuel will not be damaged, and no activity will be released to the primary coolant as a result of an abnormal operating transient.

---

*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.

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. With the exception of the steam generator blowdown, 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:

1. 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.

2. The steam generator blowdown samples are monitored and when a predetermined activity level is reached, the blowdown valves are closed automatically.

If a subsequent chemical analysis indicates that a steam generator is indeed contaminated, the blowdown is then directed into the radwaste disposal system for processing. Processing of steam generator blowdown is discussed in more detail in section 2.4. 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. No credit was taken for filtration of condenser air ejection releases.

The steam generator tube rupture accident is defined as a complete severance of one steam generator tube. The accident results in an increase in the contamination of the secondary (steam) system.

The operator must identify and isolate the faulty steam generator in order to reduce the release of radioactivity to the atmosphere. The following characteristics of a tube rupture will enable the operator to rapidly identify the accident:

1. The pressurizer low-pressure and low-level alarms are actuated, and prior to the plant trip, charging pump flow increases in an attempt to maintain pressurizer level.
2. A steam flow/feedwater flow mismatch will exist as feedwater flow to the affected steam generator will be reduced.
3. The steam generator blowdown liquid monitor and the vacuum pump radiation monitor will alarm indicating a sharp increase in radioactivity in the secondary system, and the blowdown valves will close.

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 auxiliary 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 side of the steam generator. The activity in the secondary system before rupture of the tube is based on a primary to secondary leak rate of 20 gallons per day per unit and a blowdown rate of 10 gal/min 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 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 several times during the plant lifetime, and therefore, it is included as part of the routine radioactive releases.

6. Analysis of Class 6 events - 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, as well as ensuring 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 occurrence which might damage a fuel assembly. Administrative procedures will ensure that the integrity of the equipment is maintained.

Detailed refueling procedures 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 are given in the Watts Bar 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 upon 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 assumption 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.

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 drop 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. In fact, in over 50 reactor years of industry operating experience with Westinghouse PWR's, there has not been a single fuel-handling incident in which either a new or spent fuel rod has sustained a cladding rupture. This is a result of conscientious fuel transport procedures and thorough engineering design of the fuel-handling equipment and facilities, such as:

1. The fuel pit 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 pit 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 pit area 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 off fuel storage rack, and (3) fuel cask drop accident. 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, nor is fuel damage a likely result of a 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.

With the exception discussed above, events in this class are expected to have the same probability as those discussed for Class 6.

8. <u>Class 8 accidents</u> - 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) <u>Loss-of-coolant accident</u> - 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 includes several safety features designed to minimize the effects of a loss-of-coolant accident. These features include:

1. A free-standing steel primary containment vessel surrounded by a concrete shield building to prevent the leakage of fission products (double containment).

2. The ice condenser system which prevents a high pressure in the containment and thus reduces the potential for the escape of fission products from the containment. The ice melt, which contains sodium borate, also removes iodines from the primary containment atmosphere.

3. The emergency core cooling system which provides core cooling following the accident to minimize fuel element failure.

4. The emergency gas treatment system which filters the leakage from the primary containment before releasing it to the plant vent.

5. The auxiliary building gas treatment system which filters any leakage to the auxiliary building before release to the atmosphere.

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 countermeasures 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 four accumulator tanks pressurized with nitrogen which rapidly discharge their borated water to the RCS when the RCS pressure decreases below the accumulator 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 and ice condenser 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 ice bed and melt water.

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 filters of the emergency gas treatment system to atmosphere. The assumptions specified in Reference 1 were used to estimate releases.

(2) Control rod ejection accident - The design basis reactivity transient is the postulated ejection of a rod control cluster assembly (RCCA). Such an ejection could result from a complete rupture of a control rod mechanism housing. The possibility of such an ejection is minimized by:

1. Shop testing each housing at 4,100 lb_f/in^2 and again at 3,750 lb_f/in^2 upon installation. (Normal primary system pressure is 2,250 lb_f/in^2.)
2. The housings are designed to withstand plant transients and the design basis earthquake.

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. Some iodines are removed from the containment by melted ice in the ice condenser and by the containment spray water. The airborne and gaseous fission products, along with the remaining iodines, may leak into the secondary containment (shield building) after which they are exhausted via the emergency gas treatment system where further 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.

(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: (a) primary to secondary leak in a steam generator, and (b) 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, and a 10 gal/min per unit blowdown rate. The guidance given in Reference 1 is followed in the analysis. However, since the halogen reduction factor for releases from the primary system is taken to be 0.5 for both the "large" and "small" break, the two accidents yield identical calculated results.

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. Dispersion conditions - TVA has a site meteorological investigation program under way at the Watts Bar site. The data, taken over about a 1-year period, has been analyzed and is reported in an amendment to the PSAR. This data shows that dispersion conditions more severe than a Pasquil type G and a wind speed of 0.25 meters per second occur less than 5 percent of the time. This dispersion condition (which results in dispersion values about 10 times higher than those given in AEC Safety Guide No. 4 (Reference 4)) is used to calculate

design basis accident doses for the PSAR (see Amendment 11). Reference 1 suggests that dispersion values a factor of 10 lower than those in the Safety Guide No. 4 be used to assess the environmental effect of accidents. As a result of the meteorological investigations at the site, TVA has concluded that use of the Safety Guide No. 4 dispersion conditions[2] without any modifying factor is an appropriate basis for estimating environmental effects and is consistent with the approach used by the Atomic Energy Commission and others.

Figure D-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 2. Table D-2 gives the wind direction frequencies used in the analysis. Figure 1.1-2 is a map of the site area with the minimum exclusion distance of 1,200 meters shown.

11. Population densities - The population exposures from each postulated event have been estimated using projected population information for the year 2000. The population distribution used is shown in Table D-3. 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 D-1 for the principle accidents analyzed. The analysis of this information shows that no accident or class of accidents are environmentally significant.

Table D-1

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	INDIVIDUAL DOSES AT THE SITE BOUNDARY (rem)					DOSE COMMITMENT TO POPULATION[a] (man-rem)			
		Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	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	$2.2x10^{-2}$	$5.9x10^{-2}$	$8.0x10^{-2}$	NEG	$1.6x10^{-2}$	$2.6x10^{0}$	$7.0x10^{0}$	NEG	$9.6x10^{0}$
3.2	Release of waste gas storage tank contents	$8.8x10^{-2}$	$2.3x10^{-1}$	$3.2x10^{-1}$	NEG	$6.4x10^{-2}$	$1.0x10^{+1}$	$2.8x10^{+1}$	NEG	$3.8x10^{+1}$
3.3	Release of liquid waste storage tank contents	---	---	---	---	$1.3x10^{-2}$	---	---	---	$9.0x10^{-1}$
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 steam generator leaks	*	*	*	*	*	*	*	*	*

Table D-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
5.2	Offdesign transients that induce fuel failure above those expected and steam generator leak	6.5×10^{-4}	1.3×10^{-3}	1.9×10^{-3}	1.6×10^{-3}	5.0×10^{-3}	7.8×10^{-2}	1.6×10^{-1}	1.9×10^{-1}	4.3×10^{-1}
5.3	Steam generator tube rupture	5.2×10^{-2}	7.3×10^{-2}	1.2×10^{-1}	2.1×10^{-2}	2.6×10^{-1}	6.2×10^{0}	8.7×10^{0}	2.5×10^{0}	$1.7 \times 10^{+1}$
6.0	Refueling accidents									
6.1	Fuel bundle drop	1.2×10^{-3}	2.6×10^{-3}	3.8×10^{-3}	5.6×10^{-4}	8.0×10^{-3}	1.4×10^{-1}	3.2×10^{-1}	6.7×10^{-2}	5.2×10^{-1}
6.2	Heavy object drop onto fuel in core	2.5×10^{-2}	5.7×10^{-2}	8.2×10^{-2}	1.1×10^{-2}	1.7×10^{-1}	3.0×10^{0}	6.8×10^{0}	1.3×10^{0}	$1.1 \times 10^{+1}$
7.0	Spent fuel handling accident									
7.1	Fuel assembly drop in fuel storage pool	1.2×10^{-3}	2.6×10^{-3}	3.8×10^{-3}	5.6×10^{-4}	8.0×10^{-3}	1.4×10^{-1}	3.2×10^{-1}	6.7×10^{-2}	5.2×10^{-1}
7.2	Heavy object drop onto fuel rack	8.7×10^{-4}	3.2×10^{-3}	4.1×10^{-3}	1.2×10^{-3}	8.9×10^{-3}	1.0×10^{-1}	3.8×10^{-1}	1.4×10^{-1}	6.2×10^{-1}
7.3	Fuel cask drop[d]	1.2×10^{-5}	1.2×10^{-3}	1.2×10^{-3}	2.4×10^{-4}	2.7×10^{-3}	1.4×10^{-3}	1.5×10^{-1}	2.9×10^{-2}	1.8×10^{-1}
8.0	Accident initiation events considered in design basis evaluation in safety analysis report									

Table D-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

		INDIVIDUAL DOSES AT THE SITE BOUNDARY (rem)					DOSE COMMITMENT TO POPULATION[a] (man-rem)			
Class	Event	Gamma Radiation	Beta Radiation	Gamma Plus Beta	Iodine Inhalation	Fraction of Limit[b]	Gamma Radiation	Beta Radiation	Iodine Inhalation	Total
8.1	Small loss-of-coolant	6.3×10^{-5}	1.6×10^{-4}	2.3×10^{-4}	1.1×10^{-4}	5.3×10^{-4}	1.9×10^{-2}	5.1×10^{-2}	1.5×10^{-2}	8.6×10^{-2}
8.1	Large loss-of-coolant	1.9×10^{-2}	2.1×10^{-2}	4.0×10^{-2}	6.0×10^{-1}	4.8×10^{-1}	3.6×10^{0}	5.6×10^{0}	$8.0 \times 10^{+1}$	$8.9 \times 10^{+1}$
8.1a	Instrument line break	NA	NA	NA	NA	NA	NA	NA	NA	NA
8.2(a)	Rod ejection accident	2.0×10^{-3}	2.3×10^{-3}	4.2×10^{-3}	6.1×10^{-2}	5.2×10^{-2}	3.8×10^{-1}	6.0×10^{-1}	8.0×10^{0}	9.0×10^{0}
8.3(a)	Small MSLR	2.7×10^{-5}	3.3×10^{-5}	6.0×10^{-5}	4.4×10^{-3}	3.0×10^{-3}	3.2×10^{-3}	4.0×10^{-3}	5.2×10^{-1}	5.3×10^{-1}
8.3(a)	Large MSLR	2.7×10^{-5}	3.3×10^{-5}	6.0×10^{-5}	4.4×10^{-3}	3.0×10^{-3}	3.2×10^{-3}	4.0×10^{-3}	5.2×10^{-1}	5.3×10^{-1}

*Evaluated as routine releases in Section 2.4, Radioactive Discharges
NA Not Applicable
NEG 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 D-2

Annual Wind Direction Frequency

Wind Direction	Percent of Time Wind Blows From Direction Indicated
N	6.71
NNE	6.94
NE	11.29
ENE	6.23
E	2.36
ESE	1.96
SE	2.85
SSE	3.41
S	8.13
SSW	10.52
SW	7.18
WSW	4.00
W	5.25
WNW	5.17
NW	8.91
NNW	9.27

Table D-3

POPULATION DISTRIBUTION

(Year 2000, Estimated)

Direction	0-1	1-2	2-3	3-4	4-5	5-7	7-10	10-20	20-30	30-40	40-50
	Distance Downwind (miles)										
N	5	0	0	0	0	85	490	5592	1808	1805	3092
NNE	0	0	50	20	10	0	100	2995	8649	14661	30545
NE	0	20	45	75	40	385	205	398	15490	27518	57995
ENE	0	35	0	80	95	55	210	3150	18604	24720	45799
E	0	30	25	30	30	120	325	5902	21718	21922	33600
ESE	10	20	10	25	50	135	335	8145	15333	12072	20235
SE	5	0	20	40	25	145	310	10388	8948	2222	6870
SSE	0	0	20	50	35	105	385	6139	16064	11287	10285
S	5	5	25	50	60	745	190	1888	23180	20352	13700
SSW	0	20	15	45	50	140	160	4305	14881	36441	68371
SW	0	0	10	25	0	60	245	6722	6582	52530	123042
WSW	0	15	75	55	25	210	725	3942	4585	27550	63421
W	0	5	20	30	50	265	275	1162	2588	2570	3800
WNW	10	35	45	75	55	155	20	926	4892	3476	8161
NW	0	10	50	55	120	760	1350	690	7195	4382	12522
NNW	0	0	5	45	20	140	1155	3141	4502	3093	7807

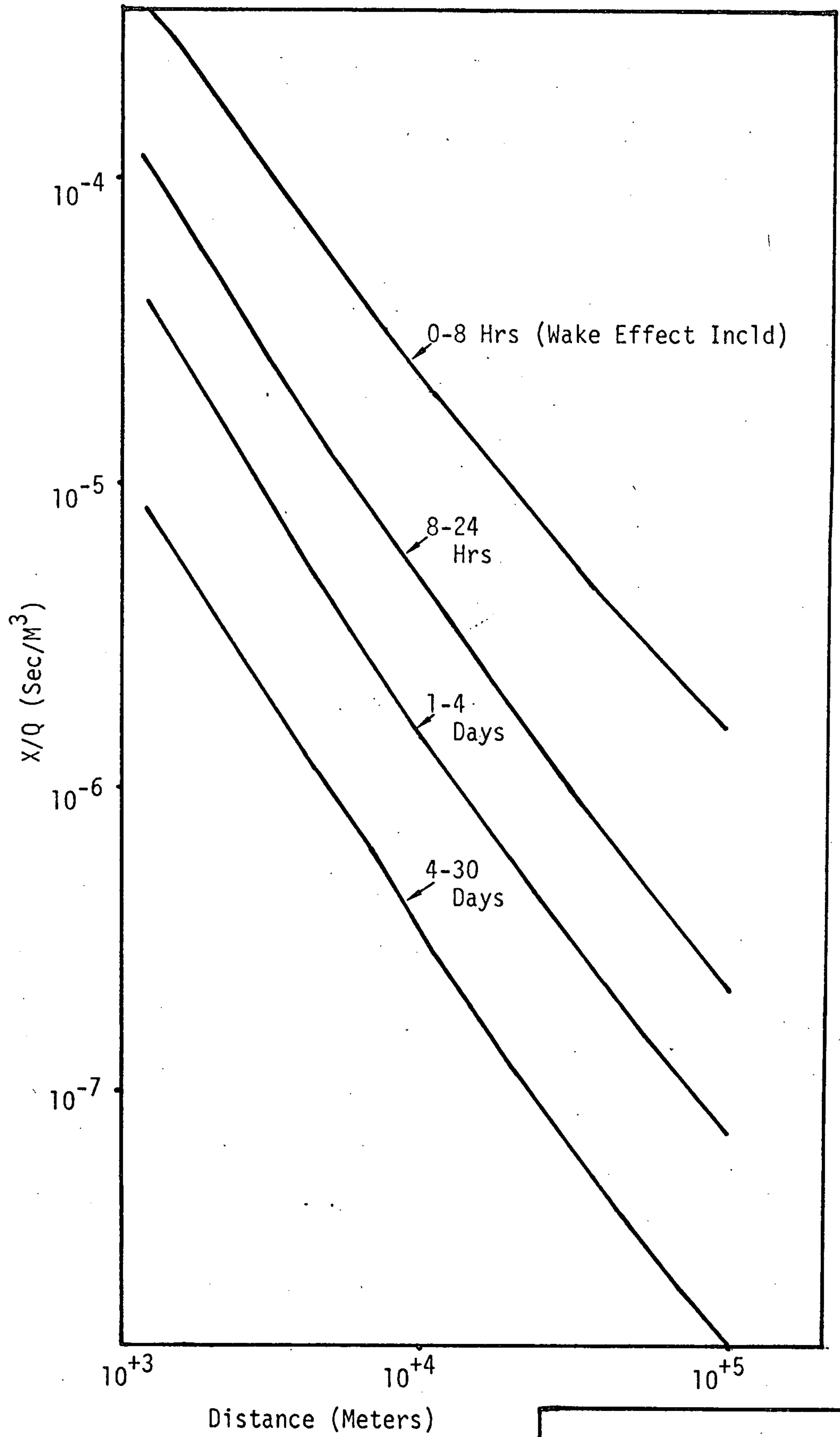


Figure D-1
X/Q VERSUS DISTANCE

APPENDIX E

RADIOLOGICAL IMPACT OF LIQUID EFFLUENTS

The calculation of radiation doses to organisms that are exposed in a natural or incompletely controlled environment is a difficult task. Because of the complexity of biological functions and the interrelationship between organisms and their environments, it is necessary to develop simplified dose models that can predict the more important characteristics of the system under analysis. It is further necessary to apply assumptions that are descriptive of average behavior and average conditions of the ecosystems. 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 are calculated for the radionuclides listed in Table E-1 which are expected to be released during normal operation of the Watts Bar 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 2000 based on the current populations multiplied by 1.5. The factor 1.5 is the projected increase for a 125-county area in the Tennessee River basin.

1. Doses to man from the ingestion of water - Calculations of dose commitments from the consumption of Tennessee River water use data for the public and industrial water systems listed in Table E-2. It is assumed that the plant effluent is mixed with the entire riverflow within the 24-mile reach between the nuclear plant site and the first water supply intake.

Dilution is calculated using average annual flow data for the Tennessee River as measured during 1899-1968. The average flow ranges from approximately 28,000 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 within the reach from the nuclear plant site to the mouth of the river. 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 adsorption 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 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 were derived from data given in the references listed[1,2,3,4] and are defined in units of (mrem/μCi) by the equation

$$(DCF)_{ij} = \frac{51.2 \times 10^3 \; f_{wij} \; \varepsilon_{ij} \; (1-\exp(-\lambda_{ij}T))}{m_j \; \lambda_{ij}}, \tag{2}$$

where $51.2 \times 10^3 = \left(\frac{\text{g rad}}{\text{Mev}}\right) \left(\frac{\text{disintegrations}}{\mu\text{Ci-day}}\right) \left(\frac{\text{mrem}}{\text{rem}}\right)$

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] The maximum dose from a single radionuclide is the thyroid dose due to Iodine-131 ingestion. Tables E-3 and E-4 show a detailed breakdown of the dose commitments at each public water supply intake.

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 28,000 gal/min which corresponds to the minimum effluent flow rate. Average annual concentrations of radionuclides in the liquid effluent can be obtained by dividing the releases shown in Table E-1 by the annual discharge flow.

Doses to humans from ingestion of Tennessee River water affected by slug releases can be estimated using the data in section A of Tables E-3 and E-4 provided (1) the distribution of activity is essentially the same as that given in Table 1, (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.

2. <u>Doses to man from the consumption of fish</u> - 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 23 lb/acre sport fish and 20 lb/acre commercial fish in the year 2000. The Tennessee River is segmented into 17 reaches in order to facilitate the calculations of fish harvests and radioactivity concentrations. 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.[8,9] 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 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 E-3 and E-4.

Calculations indicate that there would be no significant radiological impact from human utilization of shellfish. Shellfish are not now 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,

$$R_i = 51.2 \times 10^3\ C_{wi} \left(\overline{E}_\beta/2 + E_\gamma\right)_i\ \frac{\text{mrem}}{\text{day}} \tag{3}$$

For the dose rate to the total body,

$$R_i = 51.2 \times 10^3\ C_{wi}\ E_{\gamma i}\ \frac{\text{mrem}}{\text{day}} \tag{4}$$

where 51.2×10^3 = (see equation 1),

C_{wi} = water concentration for the i^{th} radionuclide, (μCi/g),

$E_{\gamma i}$ or $(\overline{E}_\beta/2 + E_\gamma)i$ = average effective energy emitted by the i^{th} radionuclide per disintegration, (MeV-rem/dis-rad).

Dose rates for those activities such as boating are assumed to be given by equations 3 and 4 divided by 2. Water concentrations are calculated for 17 reaches between the nuclear plant site and Kentucky Dam (TRM 22.4). Doses to the population are calculated using estimates for abovewater visits and inwater visits for the respective reaches based on current information given in reference 9 multiplied by the predicted population growth factor of 1.5.

The maximum individual doses for abovewater 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 inwater 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 Watts Bar site. In order to estimate the maximum possible tritium dose to a swimmer, continuous immersion in the Tennessee River just below the Watts Bar 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 radioecology fields, a decision was made by TVA to restrict the analyses to those organisms living on or near the Watts Bar 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 than 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 Watts Bar 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, an effective radius of 10 cm, and consumes 333 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 conservative because, in general, warm-blooded vertebrates that are smaller than man exhibit more rapid elimination rates. Equation 5 is a combination of the above assumptions with equations 1 and 2.

$$D_i = 51.2 \times 10^3 \ I_i \ f_{wi} \ \varepsilon_i \ (1-\exp(-\lambda_i T))/\lambda_i m \quad \text{mrad} \qquad (5)$$

where

$I_i = 333 \frac{g}{d} \times C_{wi} \ F_{pi} \times 365 \frac{d}{y}$, ($\mu$Ci/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.

Table E-5 shows the estimates of the doses to a duck or muskrat.

(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 complete mixing, 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:

$$D_i = 51.2 \times 10^3 \, C_{fi} \, \varepsilon_i \times 365 \quad \text{mrad} \tag{6}$$

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 physiochemical factors including mineralogy, particle size, exchangeable calcium in the sediment, channel geometry, waterflow patterns, and the chemical form of the radiocompounds. 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.

1. Two-tenths of the activity in the liquid effluent is deposited uniformly in a sediment bed having dimensions of 10 cm x 100 m x 10 km.
2. The radioactivity concentration in the sediment is calculated assuming a buildup over the plant life of 35 years at a constant rate of deposition.
3. Beta doses are based on a 4-π geometry and gamma doses assume a 2-π geometry.

The doses calculated using these assumptions are probably overestimated. Table E-6 lists the dose estimates for these organisms.

Table E-1

ESTIMATED ANNUAL RELEASES OF NUCLIDES IN LIQUID EFFLUENTS[a]

Nuclide	Release (microcuries)
Cr-51	6.7 (2)[b]
Mn-54	7.5 (2)
Mn-56	1.5 (2)
Fe-55	6.7 (2)
Fe-59	8.3 (2)
Co-58	2.2 (4)
Co-60	8.5 (2)
Br-84	1.3 (1)
Rb-88	6.0 (2)
Rb-89	1.4 (1)
Sr-89	7.7 (2)
Sr-90	3.4 (1)
Sr-91	1.0 (1)
Sr-92	1.1 (0)
Y-90	5.4 (0)
Y-91	1.3 (3)
Y-92	1.4 (0)
Zr-95	1.9 (2)
Nb-95	2.2 (2)
Mo-99	1.8 (5)
Te-132	1.0 (4)
Te-134	1.2 (1)
I-131	2.3 (5)
I-132	1.1 (3)
I-133	4.3 (4)
I-134	9.0 (2)
I-135	7.5 (3)
Cs-134	6.5 (4)
Cs-136	2.1 (4)
Cs-137	3.3 (5)
Cs-138	2.8 (2)
Ba-140	5.3 (2)
La-140	2.8 (1)
Ce-141	1.2 (1)
Ce-144	1.4 (2)
Pr-144	9.9 (-2)
Total	9.2×10^5 µCi

a. Releases of 0.46 Ci in steam generator blowdown due to a primary-to-secondary leakage of 20 gallons per day in each unit are included. Tritium releases are not included.

b. 6.7×10^2

Table E-2

TENNESSEE RIVER DRINKING WATER SUPPLY INTAKES

DOWNSTREAM FROM THE WATTS BAR NUCLEAR PLANT

System	Location (TRM)	Distance (miles)	Populations Served 1970	2000
Watts Bar Nuclear Plant	528.0	0.0	0	0
Dayton	503.8	24.2	4500	6700
Savannah Utility District	484.6	43.4	1600	2400
Atlas Chemical Industries	473.0	55.0	2000	3000
Farmers Chemical Corp.	473.0	55.0	230	340
E. I. DuPont	470.5	57.5	3000	4500
Chattanooga	465.3	62.7	290000	430000
South Pittsburg	418.0	110.0	5600	8300
Bridgeport	413.6	114.4	3100	4600
Widows Creek Steam Plant	407.6	120.4	460	690
Scottsboro	385.8	142.2	11000	16000
Sand Mountain Water Authority	382.1	145.9	8200	12000
Christian Youth Camp	368.2	159.8	130	190
Guntersville	358.0	170.0	6600	9800
N. E. Morgan Co. Water and Fire	334.4	193.6	3600	5400
Huntsville	334.2	193.8	150000	220000
Decatur	306.0	222.0	41000	61000
U.S. Plywood - Champion Papers	283.0	245.0	500	750
Wheeler Dam	274.9	253.1	50	74
Reynolds Metals	260.0	268.0	5000	7500
Muscle Shoals	259.6	268.4	7500	11000
Wilson Dam	259.5	268.5	2500	3700
Sheffield	254.3	273.7	14000	21000
Colbert Steam Plant	245.0	283.0	350	520
Cherokee	239.3	288.7	2700	4000
Tri-County Utility District	193.5	334.5	1700	2500
Clifton	158.0	370.0	1000	1500
New Johnsonville	100.5	427.5	950	1400
Camden	100.4	427.6	3100	4500
Foote Mineral	100.0	428.0	170	250
Johnsonville Steam Plant	100.0	428.0	380	560
Bass Bay Resort	79.5	448.5	120	180
Paris Landing State Park	66.3	461.7	100	150
Grand Rivers	24.0	504.0	640	950
Paducah	0.1	527.9	63000	94000

Table E-3

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
Watts Bar Site (for comparison)	1.2 (-3)[d]	1.3 (-3)	2.0 (-2)	6.6 (-4) mrem
Dayton	1.2 (-3)	1.1 (-3)	1.7 (-2)	6.5 (-4) mrem
	7.7 (-3)	7.6 (-3)	1.2 (-1)	4.3 (-3) man-rem
Savannah Utility District	9.5 (-4)	8.5 (-4)	1.3 (-2)	5.3 (-4) mrem
	2.3 (-3)	2.0 (-3)	3.0 (-2)	1.3 (-3) man-rem
Atlas Chemical Industries	9.4 (-4)	7.8 (-4)	1.1 (-2)	5.2 (-4) mrem
	2.8 (-3)	2.3 (-3)	3.4 (-2)	1.6 (-3) man-rem
Farmers Chemical Corp.	9.4 (-4)	7.8 (-4)	1.1 (-2)	5.2 (-4) mrem
	3.2 (-4)	2.6 (-4)	3.8 (-3)	1.8 (-4) man-rem
E. I. DuPont	9.4 (-4)	7.7 (-4)	1.1 (-2)	5.2 (-4) mrem
	4.2 (-3)	3.4 (-3)	4.9 (-2)	2.3 (-3) man-rem
Chattanooga	9.2 (-4)	7.5 (-4)	1.1 (-2)	5.1 (-4) mrem
	4.0 (-1)	3.2 (-1)	4.6 (0)	2.2 (-1) man-rem
South Pittsburg	8.7 (-4)	6.3 (-4)	8.0 (-3)	4.8 (-4) mrem
	7.2 (-3)	5.3 (-3)	6.7 (-2)	4.0 (-3) man-rem
Bridgeport	8.6 (-4)	6.2 (-4)	7.9 (-3)	4.8 (-4) mrem
	4.0 (-3)	2.9 (-3)	3.6 (-2)	2.2 (-3) man-rem
Widows Creek Steam Plant	8.6 (-4)	6.2 (-4)	7.7 (-3)	4.7 (-4) mrem
	5.9 (-4)	4.2 (-4)	5.3 (-3)	3.3 (-4) man-rem
Scottsboro	8.4 (-4)	5.8 (-4)	6.7 (-3)	4.6 (-4) mrem
	1.4 (-2)	9.5 (-3)	1.1 (-1)	7.6 (-3) man-rem
Sand Mountain Water Authority	8.4 (-4)	5.8 (-4)	6.5 (-3)	4.6 (-4) mrem
	1.0 (-2)	7.0 (-3)	8.0 (-2)	5.7 (-3) man-rem
Christian Youth Camp	8.3 (-4)	5.5 (-4)	5.9 (-3)	4.6 (-4) mrem
	1.5 (-4)	1.0 (-4)	1.1 (-3)	8.5 (-5) man-rem
Guntersville	8.0 (-4)	5.3 (-4)	5.3 (-3)	4.4 (-4) mrem
	7.9 (-3)	5.2 (-3)	5.2 (-2)	4.4 (-3) man-rem
N. E. Morgan Co. Water and Fire	7.6 (-4)	4.9 (-4)	4.5 (-3)	4.2 (-4) mrem
	4.1 (-3)	2.6 (-3)	2.4 (-2)	2.3 (-3) man-rem
Huntsville	7.6 (-4)	4.9 (-4)	4.5 (-3)	4.2 (-4) mrem
	1.7 (-1)	1.1 (-1)	1.0 (0)	9.2 (-2) man-rem
Decatur	7.4 (-4)	4.7 (-4)	4.0 (-3)	4.1 (-4) mrem
	4.5 (-2)	2.9 (-2)	2.5 (-1)	2.5 (-2) man-rem
U.S. Plywood - Champion Papers	6.6 (-4)	4.1 (-4)	3.1 (-3)	3.6 (-4) mrem
	4.9 (-4)	3.1 (-4)	2.3 (-3)	2.7 (-4) man-rem
Wheeler Dam	6.6 (-4)	4.0 (-4)	2.5 (-3)	3.6 (-4) mrem
	4.8 (-5)	2.9 (-5)	1.9 (-4)	2.7 (-5) man-rem
Reynolds Metals	6.3 (-4)	3.8 (-4)	1.9 (-3)	3.5 (-4) mrem
	4.7 (-3)	2.8 (-3)	1.4 (-2)	2.6 (-3) 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 2000.
d. 1.2×10^{-3}

Table E-3 (continued)

Location	Bone	G.I. Tract	Thyroid	Total Body
Muscle Shoals	6.3 (-4)	3.7 (-4)	1.9 (-3)	3.5 (-4) mrem
	7.1 (-3)	4.2 (-3)	2.1 (-2)	3.9 (-3) man-rem
Wilson Dam	6.3 (-4)	3.7 (-4)	1.9 (-3)	3.5 (-4) mrem
	2.4 (-3)	1.4 (-3)	6.9 (-3)	1.3 (-3) man-rem
Sheffield	6.3 (-4)	3.7 (-4)	1.8 (-3)	3.5 (-4) mrem
	1.3 (-2)	7.8 (-3)	3.8 (-2)	7.2 (-3) man-rem
Colbert Steam Plant	6.3 (-4)	3.7 (-4)	1.8 (-3)	3.4 (-4) mrem
	3.3 (-4)	1.9 (-4)	9.3 (-4)	1.8 (-4) man-rem
Cherokee	6.3 (-4)	3.7 (-4)	1.7 (-3)	3.4 (-4) mrem
	2.5 (-3)	1.5 (-3)	7.0 (-3)	1.4 (-3) man-rem
Tri-County Utility District	6.0 (-4)	3.5 (-4)	1.3 (-3)	3.3 (-4) mrem
	1.5 (-3)	8.5 (-4)	3.2 (-3)	8.0 (-4) man-rem
Clifton	5.9 (-4)	3.4 (-4)	1.2 (-3)	3.2 (-4) mrem
	8.7 (-4)	5.0 (-4)	1.8 (-3)	4.8 (-4) man-rem
New Johnsonville	5.2 (-4)	3.0 (-4)	9.6 (-4)	2.8 (-4) mrem
	7.4 (-4)	4.2 (-4)	1.4 (-3)	4.0 (-4) man-rem
Camden	5.2 (-4)	3.0 (-4)	9.6 (-4)	2.8 (-4) mrem
	2.4 (-3)	1.4 (-3)	4.4 (-3)	1.3 (-3) man-rem
Foote Mineral	5.2 (-4)	3.0 (-4)	9.5 (-4)	2.8 (-4) mrem
	1.3 (-4)	7.3 (-5)	2.3 (-4)	6.9 (-5) man-rem
Johnsonville Steam Plant	5.2 (-4)	3.0 (-4)	9.5 (-4)	2.8 (-4) mrem
	2.9 (-4)	1.7 (-4)	5.3 (-4)	1.6 (-4) man-rem
Bass Bay Resort	5.2 (-4)	2.9 (-4)	8.6 (-4)	2.8 (-4) mrem
	9.2 (-5)	5.2 (-5)	1.5 (-4)	5.0 (-5) man-rem
Paris Landing State Park	5.1 (-4)	2.9 (-4)	7.9 (-4)	2.8 (-4) mrem
	7.6 (-5)	4.3 (-5)	1.2 (-4)	4.1 (-5) man-rem
Grand Rivers	5.0 (-4)	2.8 (-4)	5.3 (-4)	2.7 (-4) mrem
	4.8 (-4)	2.7 (-4)	5.1 (-4)	2.6 (-4) man-rem
Paducah	5.0 (-4)	2.8 (-4)	5.0 (-4)	2.7 (-4) mrem
	4.7 (-2)	2.6 (-2)	4.7 (-2)	2.5 (-2) man-rem
Total Population Dose Commitments	7.6 (-1)	5.6 (-1)	6.6 (0)	4.2 (-1) man rems

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body
Indidividual Dose Commitments	0.54	0.59	9.0	0.30 mrem

C. Eating Fish Taken from the Tennessee River

	Bone	G.I. Tract	Thyroid	Total Body
Maximum Individual Dose Commitment	2.8 (-2)	1.7 (-2)	3.5 (-2)	1.6 (-2) mrem
Population Dose Commitment	6.5	3.8	5.2	3.7 man-rem

e. Assuming a continuous discharge of 28,000 GPM.

Table E-3 (continued)

D. Use of the Tennessee River for Water Sports

	Above Water[f]		In Water[g]		
	Skin	Total Body	Skin	Total Body	
Maximum Individual Dose	4.0 (-5)	3.3 (-5)	5.0 (-5)	4.1 (-5)	mrem
Population Dose	7.9 (-4)	6.8 (-4)	3.0 (-4)	2.6 (-4)	man-rem

f. Boating and fishing, for example
g. Swimming and water skiing, for example

Table E-4

DOSES[a] TO HUMANS FROM WATER CONTAINING TRITIUM[b]

A. Ingestion of Tennessee River Water[c]

	Individual (mrem)	Population (man-rem)
Watts Bar Nuclear Plant (for comparison)	3.6 (-6)[d]	-
Dayton	3.5 (-6)	2.4 (-5)
Savannah Utility District	2.9 (-6)	7.0 (-6)
Atlas Chemical Industries	2.9 (-6)	8.6 (-6)
Farmers Chemical Corp.	2.9 (-6)	9.6 (-7)
E. I. DuPont	2.9 (-6)	1.3 (-5)
Chattanooga	2.8 (-6)	1.2 (-3)
South Pittsburg	2.7 (-6)	2.2 (-5)
Bridgeport	2.6 (-6)	1.2 (-5)
Widows Creek Steam Plant	2.6 (-6)	1.8 (-6)
Scottsboro	2.6 (-6)	4.2 (-5)
Sand Mountain Water Authority	2.6 (-6)	3.2 (-5)
Christian Youth Camp	2.6 (-6)	4.7 (-7)
Guntersville	2.5 (-6)	2.4 (-5)
N. E. Morgan Co. Water and Fire	2.4 (-6)	1.3 (-5)
Huntsville	2.4 (-6)	5.1 (-4)
Decatur	2.3 (-6)	1.4 (-4)
U.S. Plywood - Champion Papers	2.1 (-6)	1.5 (-6)
Wheeler Dam	2.0 (-6)	1.5 (-7)
Reynolds Metals	2.0 (-6)	1.5 (-5)
Muscle Shoals	2.0 (-6)	2.2 (-5)
Wilson Dam	2.0 (-6)	7.3 (-6)
Sheffield	2.0 (-6)	4.1 (-5)
Colbert Steam Plant	2.0 (-6)	1.0 (-6)
Cherokee	1.9 (-6)	7.8 (-6)
Tri-County Utility District	1.9 (-6)	4.6 (-6)
Clifton	1.8 (-6)	2.7 (-6)
New Johnsonville	1.6 (-6)	2.3 (-6)
Camden	1.6 (-6)	7.4 (-6)
Foote Mineral	1.6 (-6)	4.0 (-7)
Johnsonville Steam Plant	1.6 (-6)	9.0 (-7)
Bass Bay Resort	1.6 (-6)	2.9 (-7)
Paris Landing State Park	1.6 (-6)	2.4 (-7)
Grand Rivers	1.6 (-6)	1.5 (-6)
Paducah	1.6 (-6)	1.5 (-4)
Population Total		2.3 (-3) man-rems

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 2000
d. 3.6×10^{-6}

Table E-4 (continued)

B. Ingestion of Nuclear Plant Effluent[e] Prior to Dilution in the Tennessee River	
Individual Dose Commitment	1.6 (-3) mrem
C. Eating Fish Taken from the Tennessee River	
Maximum Individual Dose Commitment	8.3 (-8) mrem
Population Dose Commitment	1.9 (-5) man-rem
D. Use of the Tennessee River for Water Sports	
Maximum Individual Dose[f]	7.9 (-6) mrem

e. Assuming a continuous discharge of 28,000 GPM
f. Assuming continuous immersion

Table E-5

DOSES[a] TO DUCKS AND MUSKRATS LIVING NEAR THE WATTS BAR NUCLEAR PLANT

	0.92 Ci Mixture	1.0 Ci Tritium
Internal	1.1 mrad	3.5 (-5)[b] mrad
External	2.4 (-4) mrad	0
Total	1.1 mrad	3.5 (-5) mrad

a. Internal dose commitments for each annual intake and external doses from each annual exposure

b. 3.5×10^{-5}

Table E-6

DOSES TO AQUATIC ORGANISMS LIVING IN THE TENNESSEE RIVER

NEAR THE WATTS BAR NUCLEAR PLANT

A. Doses from an Annual Release of a 0.92 Ci Radionuclide Mixture[a]

	Internal (mrad)		External (mrad)
	3-cm	30-cm	
Plants	0.041	0.093	4.8 (-4)[b]
Invertebrates	0.12	0.27	4.8 (-4) suspended 130 benthic
Fish	0.11	0.25	4.8 (-4)

B. Doses from an Annual Release of 1.0 Ci Tritium

Plants, invertebrates, and fish	7.3 (-6) mrad (internal)

a. Excluding tritium
b. 4.8×10^{-4}

APPENDIX F

RADIOLOGICAL IMPACT OF GASEOUS EFFLUENTS

Estimation of doses due to gaseous effluents from the Watts Bar 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 F-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 which appear in Tables F-2 through F-4 are calculated assuming operation of two units for one year at full power with 0.25 percent failed fuel.

Radionuclides will be released from the Watts Bar 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 is used (equation 1). It is assumed that the gaseous effluents are initially diluted in the turbulent wake downwind of the building.

$$\chi_{km} = \sum_{i=1}^{3} \sum_{j=1}^{6} \frac{\sqrt{2\pi}\, \sigma_{yim}\, Q f_{ijk}}{(\pi \sigma_{yim} \sigma_{zim} + cA) u_j \theta x_m} \exp\left(\frac{-\lambda x_m}{u_j}\right), \qquad (1)$$

where

χ_{km} = average annual, ground level concentration of a radionuclide in sector k at distance x_m, (Ci/m^3),

f_{ijk} = fraction of the release period during which the wind blows in direction k, with speed j, and atmospheric stability condition i,

Q = release rate of a particular radionuclide, (Ci/sec),

σ_{yim} = horizontal standard deviation of the plume for stability condition i at distance x_m, (m),

σ_{zim} = vertical standard deviation of the plume 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 pressure 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/sec),

θ = sector width, (radians),

λ = radioactive decay constant for a particular nuclide, (sec^{-1}).

Equation 1 is used to predict the average annual, ground level concentration of the radionuclides across a 22.5° sector. In equation 1, c is assumed to be 0.5 and A is assumed to be 1,630 m^2 which is the minimum cross-sectional area of the reactor building.

For these calculations Pasquill plume standard deviations,[1] σ_{yim} and σ_{zim}, are used. The frequencies, f_{ijk}, in equation 1 are determined by TVA meteorologists using data collected at the Watts Bar site. The data are grouped for seven stability conditions (Pasquill stability conditions A through G) and for seven wind speed ranges (0.0.5, 0.6-3.4, 3.5-7.4, 7.5-12.4, 12.5-18.4, 18.5-24.4, >24.5 mph). The meteorological data are collected at a point where relatively high frequencies of stable atmospheric conditions with calms and low-wind speeds are measured. TVA meteorologists believe that the data collected at this particular point portrays a more restrictive dispersion regime than will exist at the reactor complex. Consequently, it is believed that the radiation doses and iodine concentrations presented in this appendix are higher than would be experienced during reactor operation.

1. External beta doses - Beta doses to individuals are computed using an immersion dose model described by the equation:

$$D_\beta = 4.64 \times 10^9 \, \overline{E}_\beta \, \chi, \qquad (2)$$

where

D_β = external beta dose due to immersion in a cloud, (mrem/yr),

4.64×10^9 = a constant used in calculating external beta dose, $\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$,

$\overline{E}_\beta$ = average beta energy of nuclide being considered, (MeV/dis),

χ = average-annual, ground-level radionuclide concentration as calculated by equation 1, $\left(\frac{\text{Ci}}{\text{m}^3}\right)$.

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 2.

In computing the beta dose to the population within 50 miles of the Watts Bar Nuclear Plant, the area is divided into 16 directional sectors and 11 concentric rings, i.e., 176 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 2000 is used in calculating population dose.

For each source of gaseous effluents, the annual releases of the radionuclides are listed in Table F-1. The corresponding individual and population external beta doses are reported in Table F-2.

2. External gamma doses - Gamma doses to individuals are computed using an immersion dose model described by the equation:

$$D_\gamma = 7.21 \times 10^9 \, \overline{E}_\gamma \, \chi, \qquad (3)$$

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, $\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$,

$\overline{E}_\gamma$ = 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 2.

The total population gamma dose within 50 miles of the Watts Bar Nuclear Plant is calculated using the method described for the population beta dose. The annual individual and population external gamma doses for each source of gaseous effluents are reported in Table F-2.

3. Thyroid doses due to iodine inhalation - The equation used in calculating inhalation doses for routine releases of radioiodine from the Watts Bar Nuclear Plant is:

$$D = 8.76 \times 10^3 \chi \text{ (BR) (DCF)}, \qquad (4)$$

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/hr),

DCF = dose commitment factor for iodine inhalation, (mrem/Ci inhaled).

Maximum individual thyroid dose due to intake of radioiodine are calculated for a one-year-old child in accordance with the recommendations of the Federal Radiation Council.[3] Population doses are calculated using adult parameters and the same method described for calculating population beta doses.

The breathing rate assumed for a one-year-old child is 0.29 m^3/hr [4] and for an adult is 0.83 m^3/hr.[5] The iodine inhalation dose commitment factors for the one-year-old child and for the adult are obtained from reference 6.

The calculated annual individual and population iodine inhalation doses for each source of gaseous effluents are reported in Table F-3.

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/sec),

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 one-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 (1.2 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 Watts Bar Nuclear Plant is consumed within this area, and cows are assumed to graze the pastures during the entire year. County milk production data for the year 1969 is used in computing milk ingestion population doses. The numerical values used for the parameters v_g, M, CR, and DCF are taken from references 6,7,8, and 9.

The individual and population milk ingestion doses are reported in Table F-3.

5. Maximum average-annual radioiodine concentration - The maximum average-annual radioiodine concentration occurs in the SW sector at the site boundary (790 m). The maximum concentrations for each iodine isotope and for each source of gaseous release are calculated using equation 1 and are reported in Table F-4.

Table F-1

ESTIMATED ANNUAL RELEASES OF NUCLIDES IN GASEOUS EFFLUENTS[a]

	Source of Release							
	Routine Release Sources				Alternate Waste Treatment Systems			
Isotope	Auxiliary[b] Building Release (Ci/yr)	Vacuum Pump[c] Release (Ci/yr)	Steam[c,d] Leakage (Ci/yr)	Purge[e] Release (Ci/yr)	Waste Treatment 60-day Holdup (Ci/yr)	Waste Treatment Recombiners (Ci/yr)	Waste Treatment 45-day Holdup (Ci/yr)	Waste Treatment Gas Removal Systems (Ci/yr)
I-131	1.6 (-4)[f]	1.8 (-3)	3.3 (-3)	3.5 (-5)	1.1 (-5)		4.0 (-5)	
I-132	3.5 (-5)	2.3 (-5)	4.3 (-5)	2.6 (-9)				
I-133	2.3 (-4)	9.8 (-4)	1.8 (-3)	3.8 (-6)				
I-134	2.5 (-5)	6.5 (-6)	1.2 (-5)					
I-135	1.1 (-4)	1.9 (-4)	3.6 (-4)	2.5 (-7)				
Kr-83m	1.8	3.2		6.6 (-4)				
Kr-85m	1.3 (+1)	2.4 (+1)		1.5 (-2)				
Kr-85	2.4 (+1)	4.2 (+1)		1.8 (+1)	2.8 (+3)	2.8 (+3)	2.8 (+3)	
Kr-87	7.1	1.3 (+1)		2.4 (-3)				
Kr-88	2.1 (+1)	3.7 (+1)		1.5 (-2)				
Kr-89	4.9 (-1)	8.8 (-1)		6.8 (-6)				
Xe-131m	1.4 (+1)	2.5 (+1)		1.1	5.2 (+1)		1.3 (+2)	
Xe-133m	1.7 (+1)	3.1 (+1)		2.5 (-1)	3.0 (-5)		3.0 (-3)	
Xe-133	1.4 (+3)	2.6 (+3)		4.7 (+1)	6.5 (+1)		4.7 (+2)	
Xe-135m	9.2 (-1)	1.6		6.1 (-5)				
Xe-135	1.1 (+2)	2.0 (+2)		2.7 (-1)				
Xe-137	7.7 (-1)	1.4		1.3 (-5)				
Xe-138	3.1	5.6		2.3 (-4)				

a. For operation of two units at full power with 0.25 percent failed fuel.
b. Based on leakage of 10 gallons per day per unit.
c. Based on primary to secondary leakage of 20 gallons per day per unit and a 6-gallon per minute blowdown rate per unit.
d. Includes the effect of venting tanks which contain blowdown.
e. Based on two full purges per year per unit and primary coolant leakage of 50 pounds per day per unit.
f. 1.6×10^{-4}.

Table F-2

ESTIMATED ANNUAL EXTERNAL GAMMA AND BETA DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS[a]

	Source of Release							
	Routine Release Sources					Alternate Waste Treatment Systems		
	Auxiliary Building Release	Vacuum Pump Release	Steam Leakage	Purge Release	Waste Treatment 60-Day Holdup	Waste Treatment Recombiners	Waste Treatment 45-Day Holdup	Waste Treatment Gas Removal Systems
Maximum Individual Gamma Dose at Site Boundary (mrem)	7.1 (-1)[b]	1.3	1.6 (-5)	1.3 (-2)	5.5 (-2)	3.1 (-2)	1.7 (-1)	
Maximum Individual Beta Dose at Site Boundary (mrem)	7.8 (-1)	1.4	5.3 (-6)	3.5 (-2)	2.4	2.3	2.6	
Total Population Gamma Dose Within 50 miles (man-rem)	8.7 (-1)	1.6	2.1 (-5)	2.7 (-2)	1.4 (-1)	9.0 (-2)	3.8 (-1)	
Total Population Beta Dose Within 50 miles (man-rem)	1.3	2.4	7.4 (-6)	8.5 (-2)	6.9	6.8	7.3	

a. For operation of two units at full power with 0.25 percent failed fuel.

b. 7.1×10^{-1}

Table F-3

ESTIMATED ANNUAL THYROID DOSE COMMITMENTS FROM RADIOIODINE

RELEASED IN GASEOUS EFFLUENTS[a]

	Source of Release							
	Routine Release Sources					Alternate Waste Treatment Systems		
	Auxiliary Building Release	Vacuum Pump Release	Steam Leakage	Purge Release	Waste Treatment 60-day Holdup	Waste Treatment Recombiners	Waste Treatment 45-day Holdup	Waste Treatment Gas Removal Systems
Iodine Inhalation								
Maximum Individual Thyroid Dose at Site Boundary (mrem)	5.3 (-3)[b]	4.2 (-2)	7.8 (-2)	6.9 (-4)	2.1 (-4)		7.4 (-4)	
Total Population Thyroid Dose Within 50 miles (man-rem)	4.4 (-3)	4.4 (-2)	8.2 (-2)	8.5 (-4)	2.6 (-4)		9.5 (-4)	
Iodine Ingestion via Milk								
Maximum Individual Thyroid Dose at Nearest Dairy Farm (mrem)	1.0 (-1)	1.1	2.1	2.2 (-2)	6.9 (-3)		2.5 (-2)	
Total Population Thyroid Dose Within 50 miles (man-rem)	1.7 (-1)	1.8	3.4	3.6 (-2)	1.1 (-2)		4.1 (-2)	

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 5.3×10^{-3}

Table F-4

ESTIMATED MAXIMUM ANNUAL IODINE CONCENTRATIONS FROM RELEASES IN GASEOUS EFFLUENTS[a]

	Source of Release								
	Routine Release Sources						Alternate Waste Treatment Systems		
	Auxiliary Building Release	Vacuum Pump Release	Steam Leakage	Purge Release	Waste Treatment 60-day Holdup	Total, All Routine Sources	Waste Treatment Recombiners	Waste Treatment 45-day Holdup	Waste Treatment Gas Removal Systems
Max. Annual Conc. of I-131, µCi/cc	1.2 (-16)[b]	1.2 (-15)	2.4 (-15)	2.6 (-17)	8.2 (-18)	3.8 (-15)		3.0 (-17)	
Max. Annual Conc. of I-132, µCi/cc	1.9 (-17)	1.2 (-17)	2.3 (-17)	1.4 (-21)		5.4 (-17)			
Max. Annual Conc. of I-133, µCi/cc	1.6 (-16)	7.0 (-16)	1.3 (-15)	2.7 (-18)		2.2 (-15)			
Max. Annual Conc. of I-134, µCi/cc	8.7 (-18)	2.2 (-18)	4.2 (-18)			1.5 (-17)			
Max. Annual Conc. of I-135, µCi/cc	7.3 (-17)	1.3 (-16)	2.4 (-16)	1.7 (-19)		4.3 (-16)			

a. For operation of two units at full power with 0.25 percent failed fuel.
b. 1.2×10^{-16}

APPENDIX G

RADIOLOGICAL IMPACT OF EXTERNAL DOSE FROM REFUELING AND PRIMARY MAKEUP WATER STORAGE TANKS

The direct gamma radiation dose rate at the site boundary from two refueling water storage tanks and two primary makeup water 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 iron slab.
2. The physical dimensions and volume of the tanks are: Refueling Water Storage Tank: 43'6" dia. x 32'0" high, 350,000 gallons/tank; Primary Makeup Water Storage Tank: 32'6" dia. x 30'9" high, 187,000 gallons/tank
3. The tank is filled with pure water.
4. The isotopic distribution of the radioactivity in each tank is shown in Table G-1. The specific activity in each tank is 0.0011 μCi/ml. The total activity, exclusive of tritium, in each refueling water storage tank is 1.52 Ci and in each primary makeup water storage tank is 0.81 Ci.
5. Decay of the isotopes is not considered in the calculation.
6. The isotopic mixture is considered uniformly distributed in the tank.
7. Only those gamma rays of significant energy and intensity (number per disintegration) were used in the calculations.

8. The average gamma energy and number of gammas per disintegration for the mixture of isotopes given in Table G-1 are calculated to be 0.56 MeV and 0.87 respectively.
9. The contribution from each nuclide to the total dose rate is weighted according to its fraction of the total activity.
10. Attenuation and buildup factors for 790 meters of air, for the 5/16-inch steel tank wall, and for the water in the tanks are considered in the calculations. Self-absorbtion due to the water is considered.
11. No credit for the air-earth interface scattering and absorbtion effect is taken in the calculations.

Using these assumptions, the direct gamma dose rate at the site boundary (790 m) from activity contained in each refueling water storage tank is calculated to be 0.011 mrem/yr. For each primary makeup water storage tank, the direct gamma dose rate is 0.014 mrem/yr. The total direct gamma dose rate at the site boundary from the two refueling water storage tanks and the two primary makeup water storage tanks is calculated to be 0.050 mrem/yr.

Table G-1

ISOTOPIC DISTRIBUTION OF ACTIVITY IN REFUELING AND PRIMARY MAKEUP WATER STORAGE TANKS[a]

Isotope	Refueling Water Storage Tank Contents, Curie	Primary Makeup Water Storage Tank Contents, Curie	Fraction of Total Activity for Each Tank
Sr-89	2.17×10^{-3}	1.16×10^{-3}	1.41×10^{-3}
Zr-95	4.74×10^{-4}	2.54×10^{-4}	3.11×10^{-4}
Nb-95	3.89×10^{-4}	2.09×10^{-4}	2.56×10^{-4}
Mo-99	5.91×10^{-2}	3.17×10^{-2}	3.90×10^{-2}
I-131	4.44×10^{-1}	2.38×10^{-1}	2.91×10^{-1}
Cs-134	1.58×10^{-1}	8.48×10^{-2}	1.04×10^{-1}
Cs-136	3.88×10^{-2}	2.08×10^{-2}	2.55×10^{-2}
Cs-137	8.00×10^{-1}	4.29×10^{-1}	5.27×10^{-1}
Ba-140	3.88×10^{-4}	2.08×10^{-4}	2.55×10^{-4}
Ce-144	2.08×10^{-4}	1.12×10^{-4}	1.37×10^{-4}
Mn-54	4.98×10^{-4}	2.67×10^{-4}	3.28×10^{-4}
Co-58	1.42×10^{-2}	7.62×10^{-3}	9.35×10^{-3}
Co-60	4.89×10^{-4}	2.62×10^{-4}	3.23×10^{-4}
Fe-59	5.49×10^{-4}	2.94×10^{-4}	3.61×10^{-4}
Total	1.51	0.81	

a. Exclusive of tritium.

Appendix H

CUMULATIVE RADIOLOGICAL IMPACT FROM OPERATION OF WATTS BAR AND SEQUOYAH NUCLEAR PLANTS

TVA has calculated the expected cumulative radiation doses to man and species other than man resulting from radionuclides in liquid effluents released by the Watts Bar and Sequoyah Nuclear Plants to Chickamauga Reservoir. A summary of these calculations is given in Tables H-1 and H-2. Estimated doses for the radionuclides released from the Watts Bar and Sequoyah Nuclear Plants are listed for individual drinking water supplies as far as Chattanooga. Estimates of the doses from these releases are less for supplies farther downstream.

Doses are calculated using the models and assumptions described in Appendix E. The distribution of radionuclides released in liquid effluents from the Sequoyah Nuclear Plant is expected to be the same as that for the Watts Bar Nuclear Plant, but the activities are estimated to be 25 percent greater than the releases shown in Table E-1 of Appendix E. The maximum dose[a] to an individual from the cumulative releases of radionuclides in liquid effluents is calculated to be 0.15 mrem per year which is only 0.1 percent of the total dose that an individual receives from natural background radiation. The calculated doses for the nuclear plants are much less than the variations in the doses from naturally occurring background radiation.

It is concluded that the combined doses resulting from the normal operation of the Watts Bar and Sequoyah Nuclear Plants will present no significant risk to the health and safety of the public.

---

a. Excluding the doses from tritium.

Table H-1

RADIOLOGICAL IMPACT OF THE LIQUID EFFLUENTS[a] FROM THE

WATTS BAR AND SEQUOYAH NUCLEAR PLANTS

	Watts Bar	Sequoyah	Total	
Activity Released Annually	0.92 Ci	1.2 Ci	2.1 Ci	
A. Doses to Humans				
Ingestion of Tennessee River water (thyroid dose commitment)				
Atlas Chemical Industries				
1. individual	1.1 (-2)[b]	3.5 (-2)	4.6 (-2)	mrem
2. population	3.4 (-2)	1.0 (-1)	1.3 (-1)	man-r
Farmers Chemical Corp.	3.8 (-3)	1.2 (-2)	1.6 (-2)	man-r
E. I. DuPont	4.9 (-2)	7.7 (-2)	1.3 (-1)	man-r
Chattanooga	4.6	7.1	12	man-r
Eating Fish Taken from the Tennessee River				
Chickamauga Lake below the Sequoyah Nuclear Plant				
1. maximum individual	2.6 (-2)	7.2 (-2)	9.8 (-1)	mrem
2. population	3.5 (-1)	9.8 (-1)	1.3	man-r
Use of the Tennessee River for Water Sports				
Chickamauga Lake below the Sequoyah Nuclear Plant (skin doses)				
1. above water	1.0 (-4)	3.0 (-4)	4.0 (-4)	man-r
2. in water	4.0 (-5)	1.1 (-4)	1.5 (-4)	man-r
B. Doses to Organisms Living near the Sequoyah Nuclear Plant Site				
Terrestrial vertebrates	8.5 (-1)	2.1	3.0	mrad
Aquatic organisms[c]				
1. plants	6.8 (-2)	1.9 (-1)	2.6 (-1)	mrad
2. invertebrates	2.1 (-1)	5.6 (-1)	7.7 (-1)	mrad
3. fish	1.9 (-1)	5.1 (-1)	7.0 (-1)	mrad

a. Excluding tritium.
b. 1.1×10^{-2}
c. Excluding doses from activity accumulated in sediment.

Table H-2

RADIOLOGICAL IMPACT OF TRITIUM[a] IN THE LIQUID EFFLUENTS

FROM THE WATTS BAR AND SEQUOYAH NUCLEAR PLANT

	Watts Bar	Sequoyah	Total
A. Doses to Humans			
Ingestion of Tennessee River Water			
Atlas Chemical Industries			
1. individual	2.9 (-6)[b]	5.8 (-6)	8.7 (-6) mrem
2. population	8.6 (-6)	1.7 (-5)	2.6 (-5) man-re
Farmers Chemical Corp.	9.6 (-7)	1.9 (-6)	2.9 (-6) man-re
E. I. DuPont	1.3 (-5)	1.3 (-5)	2.6 (-5) man-re
Chattanooga	1.2 (-3)	1.2 (-3)	2.4 (-3) man-re
Eating Fish Taken from the Tennessee River			
Chickamauga Lake below the Sequoyah Nuclear Plant			
1. maximum individual	6.8 (-8)	1.4 (-7)	2.1 (-7) mrem
2. population	9.2 (-7)	1.9 (-6)	2.8 (-6) man-re
B. Doses to Organisms Living near the Sequoyah Nuclear Plant			
Terrestrial vertebrates	2.9 (-5)	5.7 (-5)	8.6 (-5) mrad
Aquatic organisms	5.9 (-6)	1.2 (-5)	1.8 (-5) mrad

a. Normalized to 1.0 Ci
b. 2.9×10^{-6}

APPENDIX I

WATTS BAR SITE - TERRESTRIAL ECOSYSTEM

SURVEY AND ANALYSIS OF THE VEGETATION

1. Objectives - The objectives of this survey of the the vegetation of the plant site are:

1. To provide factual information on the present species distribution, frequency, percent cover, and vigor of trees, shrubs, and ground cover in the impact area;

2. To determine the presence of any rare or endangered plants or plant communities; and

3. To provide a system for monitoring future changes in the vegetative cover and related wildlife food and habitat effects.

2. Plan - The vegetative survey plan includes: mapping the area, designing a sampling system, laying out the field procedures, and data processing and analysis.

(1) Mapping the Area - Before critical vegetation data of the proposed nuclear power plant site is gathered, a land use map of the area will be made. Mapping the site serves two main purposes. First, it provides a base of information for evaluating the results of a future monitoring program. By having an accurate picture of prenuclear plant vegetation, TVA will be in a position to judge whether any vegetation changes taking place are a result of the nuclear plant itself or of other manmade or natural causes. Second, a map will provide a scale for determining the adequacy and scope of the ground plot sampling system. For example, using a grid plot sampling design (see below), the number of plots will be fewer and farther apart

in a survey area of a few, large, poorly interspersed vegetation types than in an area of many, small, well-interspersed vegetation types. By superimposing grids over the land use map of the sampling area, the most satisfactory grid size can be chosen.

Mapping the area will proceed in three steps. First, from aerial photos the broad land use categories will be delineated in five major categories as follows:

1. Cultivated land (row crops, small grains, and cultivated pasture)
2. Old fields or native grassland
3. Forest
4. Water
5. Other (e.g., roads, residential areas, parking lots, buildings)

Because it may be difficult or impossible to separate old fields from cultivated pasture by aerial photos, each field will be delineated on the map so that questionable areas can be checked on the ground. The aerial photo study will not be limited strictly to categorizing the broad land use areas, however. The photos will be gleaned for as much pertinent land use data as they will release. In the final map, following the collection of plot data, some of the broad land use categories will be subdivided, and any of those subdivisions which are readily recognizable on aerial photos will be included on the preliminary map.

The ground check is the second step in the mapping procedure. By spending one or two days in the field, questionable area classifications and boundaries will be resolved and the aerial photo data brought up to date. A quick field survey will give the field crew an overview of the area so that potential problems and particular aspects may be anticipated. Thus, the project leader may be able to alter the sampling design slightly for greater efficiency.

Step 3 in the mapping process will come after the plot data have been gathered. During this stage the final details of the map will be added.

The old field category will be subdivided into the following:

1. Grassland and forbs
2. Vine thickets
3. Shrubland
4. Savanna (open area with scattered trees but less than 10 percent crown cover or fewer than 100 seedlings and saplings per acre)

Similarly, the forest category will be broken down into U.S. Forest Service types.

From the final vegetation map the total area of each vegetation type in the impact area will be planimetered and tabulated.

(2) <u>Sampling Design</u> - There are no hard rules for determining the kind or amount of sampling needed for an adequate picture of the nuclear plant site vegetation. In many ways every vegetation survey is unique, and the various usable techniques must be weighed against the available resources before choosing what course to follow. This problem is certainly unique, and the approach chosen will be flexible. The sampling system will be adequate enough to give a reasonable picture of the understory and ground cover vegetation but will not be so time consuming that the cost is prohibitive.

(3) Field Procedures - Permanent plots will be established as specified in TVA's forest inventory manual.[1] The chief advantage of permanent plots is that they allow for an exact measure of the potential environmental impact of the proposed facility rather than a statistically estimated measure of that impact. Pole, sawtimber, and reproduction data will be recorded (ignoring the 1/20-acre subplots in nonforested areas). In the four 1/100-acre subplots (see Figure I-1) around the periphery of the 1/5-acre plot, all small trees (less than 1 inch DBH but more than 18 inches tall) and shrubs will be noted, recording the percent cover for each species and the general condition of the dominant species collectively. Beginning at the four cardinal points and moving toward the center of each plot lay out four quadrats 10.75 feet long by 1 foot wide (see Figure I-1). The linear shape of the quadrat allows greater sampling efficiency than a round or more nearly square shape. The quadrat size is equivalent to 1 square meter. Thus the data can be easily handled in either English or metric units.

The percent cover for each species present and the general condition of all species will be recorded for each quadrat. Any rare or endangered species will be noted. If such species are discovered anywhere in the survey area but do not happen to be in a designated plot, they will be noted at the time of discovery and recorded for the next plot with a short description of location.

(4) Data Processing and Analysis - Using the data on frequency and basal area for trees and frequency and percent

cover for shrubs and herbs, an important value index for each species in the nuclear plant site area will be computed. The species and its importance value will then be presented in a species list which will give a readily visible index of change in species composition when compared with similar lists tallied throughout the surveillance program.

Through the use of multivariate techniques[2,3,4] the data on presence and absence of species will be analyzed by computer to segregate species associates at the understory (or shrub in nonforested areas) and ground cover levels. The forest type will then be combined with the understory and ground cover types to give a full description of the community structure.

The data will also have other applications such as developing site indices for shrub and ground species, recognition of indicator species, and studying the direction and rates of succession.

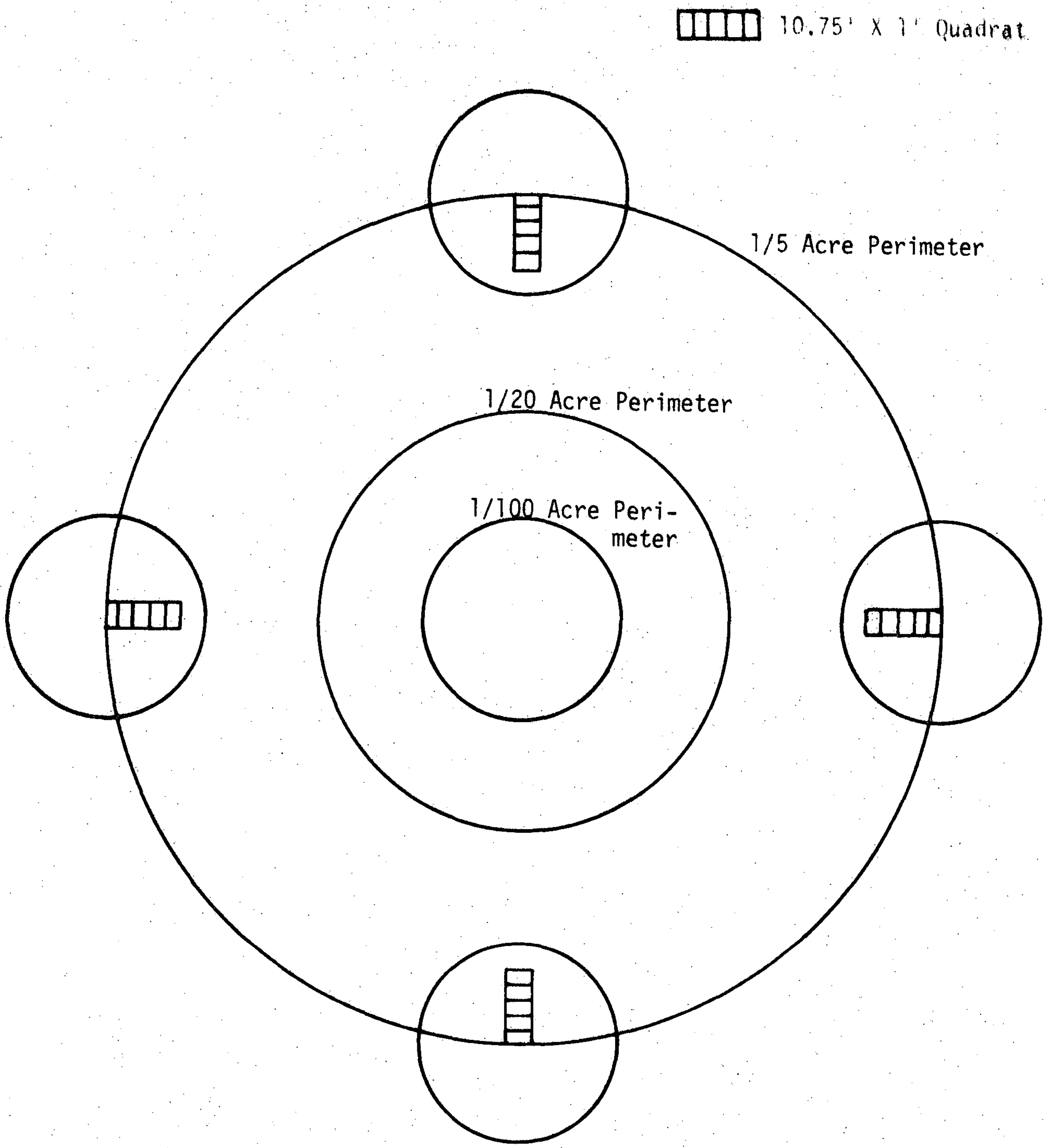


Figure I-1

Plot Layout for Sampling Overstory, Understory, and Ground Vegetation
WATTS BAR NUCLEAR PLANT

REFERENCES FOR SECTION 1.1

1. U. S. Department of Health, Education and Welfare, Public Health Service. "Synoptic Climatology of Stagnating Anticyclones East of the Rocky Mountains in the United States for the period 1936-56," Technical Report A60-7.

2. Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife Development; Fisheries and Waterfowl Resources Branch. The Mussel Resource of the Tennessee River. 1966.

3. Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife Development; Fisheries and Waterfowl Resources Branch. Fish Inventory Data. Chickamauga Reservoir, February 1971.

4. Tennessee Valley Authority, Division of Health and Safety; Environmental Hygiene Branch. Quality of the Water in Chickamauga Reservoir, July 1964.

REFERENCES FOR SECTION 2.1

1. Tennessee Valley Authority. Preliminary Safety Analysis Report - Watts Bar Nuclear Plant, Volumes 1-4.

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

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

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

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

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

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

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

9. Atomic Energy Commission. License for Delivery of Radioactive Material to a Carrier for Transport, Special Nuclear Material License -- SNM-338, Docket No. 70-337, Amendments 71-37 and 71-38 -- Westinghouse Electric Corporation.

10. Atomic Energy Commission, 10 CFR Section 71.36.

11. Tennessee Valley Authority. Final Environmental Statement, Volume 1, Section 2.1.3 - Browns Ferry Nuclear Plant.

12. Applicant's Environmental Report, Supplement 1, Section III, 6.0 - Morris Fuel Recovery Plant - General Electric Company.

13. 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.

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

15. Tennessee Valley Authority, TVA Radiological Emergency Plan.

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. 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.

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

REFERENCES FOR SECTION 2.4

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

REFERENCES FOR SECTION 2.5

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

2. Personal Communication, John F. Walko, Betz Laboratories, Inc., to Tennessee Valley Authority, July 25, 1972.

REFERENCES FOR SECTION 2.6

1. Prediction and Verification of Visible Plume Behavior Associated with Wet Plume Discharges - F. B. Kaylor, J. L. Petrillo, Y. J. Tsai, Stone and Webster Engineering Corporation.

2. The Application of Meteorology in Determining the Environmental Effects of Evaporative Heat Dissipation Systems - P. M. Altomare, NUS Corporation.

REFERENCES FOR SECTION 2.7

1. Isom, B. G., "The Mussel Resource in the Tennessee River," American Midland Naturalist. 1969.

2. Garner, J. M., Jr., and Oscar W. Kochtitzky. "Radioactive Sediments in the Tennessee River System," Journal of the Sanitary Engineering Division, August 1956, Paper 1051, pp. 1-20.

3. Yokley, P., Jr., "Life History of Pleurobema Cordatum (Rafinesque 1820) (Bivalvia: Unionacea) Malacologia 1972," 11(2). 1972. pp. 351-364.

4. Ellis, M. M., "Some Factors Affecting the Replacement of the Commercial Freshwater Mussels," U.S. Bureau Commercial Fisheries, Circ. 7, 1931, pp. 1-10.

REFERENCES FOR APPENDIX B

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.

REFERENCES FOR APPENDIX C

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. E. Bolch, 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 TlS-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 TlS-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," Air Pollution Control Association Journal, Volume 20, No. 9 (September 1970), pp. 589-592.

REFERENCES FOR APPENDIX D

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. 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.

REFERENCES FOR APPENDIX E

1. Lederer, C. M., et al., Table of Isotopes, New York, John Wiley & Sons, 1968.

2. ICRP Publication 2, New York, Pergaman 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 1979).

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.

REFERENCES FOR APPENDIX F

1. D. H. Slade, "Meteorology and Atomic Energy, 1968," AEC Report, TID-24190, July 1968.

2. C. M. Lederer, et al., Table of Isotopes, Sixth Edition, John Wiley and Sons, New York, 1968.

3. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council Report No. 2, September 1961.

4. 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.

5. "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.

6. 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.

7. T. J. Burnett, "A Derivation of the 'Factor of 700' for ^{131}I," Health Physics, Vol. 18, pp. 73-75, 1970.

8. 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.

9. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council Report No. 5, July 1964.

REFERENCES FOR APPENDIX I

1. TVA Forest Inventory Field Manual for County Units and Watersheds in the Tennessee Valley. 1971. TVA Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

2. Crawford, R. M. M. and Wishart, D. 1967. A rapid multivariate method for the detection and classification of groups of ecologically related species. J. Ecol. 55:505-524.

3. Gittins, R. 1965. Multivariate approaches to a limestone grassland community. III. A comparative study of ordination and association analysis. J. Ecol. 53:411-425.

4. Lambert, J. M. and Williams, W. T. 1962. Multivariate methods in plant ecology. IV. Nodal analysis. J. Ecol. 50:775-802.

RETURN TO REGULATORY CENTRAL FILES
ROOM 016

RETURN TO REGULATORY CENTRAL FILES
ROOM 016