NUREG-0921

Draft Environmental Statement

related to the operation of Catawba Nuclear Station, Units 1 and 2

Docket Nos. 50-413 and 50-414

Duke Power Company, et al.

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

August 1982

NOTICE

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 1717 H Street, N.W.
   Washington, DC 20555

2. The NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission,
   Washington, DC 20555

3. The National Technical Information Service, Springfield, VA 22161

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC Office of Inspection and Enforcement bulletins, circulars, information notices, inspection and investigation notices; Licensee Event Reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the NRC/GPO Sales Program: formal NRC staff and contractor reports, NRC-sponsored conference proceedings, and NRC booklets and brochures. Also available are Regulatory Guides, NRC regulations in the *Code of Federal Regulations*, and *Nuclear Regulatory Commission Issuances*.

Documents available from the National Technical Information Service include NUREG series reports and technical reports prepared by other federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal and periodical articles, and transactions. *Federal Register* notices, federal and state legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free upon written request to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland, and are available there for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

NUREG-0921

Draft Environmental Statement

related to the operation of Catawba Nuclear Station, Units 1 and 2

Docket Nos. 50-413 and 50-414

Duke Power Company, et al.

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

August 1982

ABSTRACT

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of the Catawba Nuclear Station, Units 1 and 2, pursuant to the National Environmental Policy Act of 1969 (NEPA) and 10 CFR 51, as amended, of the NRC regulations. This statement examines: the affected environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Land use and terrestrial and aquatic-ecological impacts will be small. Operational impacts to historic and archeological sites will be negligible. The effects of routine operations, energy transmission, and periodic maintenance of rights-of-way and transmission facilities should not jeopardize any populations of endangered or threatened species. No significant impacts are anticipated from normal operational releases of radioactivity. The risk associated with accidental radiation exposure is very low. The net socioeconomic effects of the project will be beneficial. The action called for is the issuance of operating licenses for Catawba Nuclear Station, Units 1 and 2.

Comments should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this Draft Environmental Statement is published in the Federal Register. Further information may be obtained from:

Dr. Kahtan N. Jabbour, Project Manager
Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555
301/492-7821

SUMMARY AND CONCLUSIONS

This Draft Environmental Statement (DES) was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (staff).

(1) This action is administrative.

(2) The proposed action is the issuance of operating licenses to Duke Power Company, North Carolina Municipal Power Agency Number 1, North Carolina Electric Membership Corporation, and Saluda River Electric Cooperative, Inc. (applicant) for the startup and operation of Units 1 and 2 of Catawba Nuclear Station (NRC Docket Numbers 50-413 and 50-414), located in York County, South Carolina, approximately 9.6 km (6 mi)* north of Rock Hill and adjacent to Lake Wylie.

The two-unit Catawba Nuclear Station uses two four-loop pressurized water reactors manufactured by Westinghouse Electric Corporation. Each reactor has a rated thermal output of 3411 MWt. The 16 MWt input from the reactor coolant pumps increases the reactor coolant system gross thermal output to 3427 MWt. Inplant electrical power consumption is expected to be 57 MWe per unit, and the net electrical rating is 1145 MWe per unit.

(3) The information in this statement represents the second assessment of the environmental impacts pursuant to the guidelines of the National Environmental Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations Part 51 (10 CFR 51) of the Commission's Regulations. After receiving an application in July 1972 to construct this station, the staff carried out a review of impacts that would occur during its construction and operation. That evaluation was issued as a Final Environmental Statement--Construction Phase (FES-CP) in December 1973. After completing a safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and public hearings, the U.S. Nuclear Regulatory Commission issued Construction Permits Nos. CPPR-116 and CPPR-117 in August 1975. As of May 1982, the construction of Unit 1 was about 90% complete. The applicant estimates a fuel-loading date of October 1984 for Unit 1 and October 1986 for Unit 2. In March 1979 the applicant applied for operating licenses for the units and submitted the required safety and environmental reports in support of the application.

(4) The staff has reviewed the activities associated with the proposed operation of the station and the potential environmental impacts. The staff's conclusions are summarized as follows:

*Throughout the text of this document values are presented in both metric and English units. For the most part, measurements and calculations were originally made in English units and subsequently converted to metric. The number of significant figures given in a metric conversion is not meant to imply greater or lesser accuracy than that implied in the original English value.

(a) Catawba station will improve the ability of the applicant and the Southeastern Electric Reliability Council (SERC) to supply system load requirements. There will be a net savings in overall system production costs that will result from the operation of the station (Section 6).

(b) Permanent alteration of about 52 ha (129 acres) of land for the station has been necessary. This is not significant.

(c) The presence of the station and station operations will have negligible effect on the 100-year floodplain (Section 5.3.3).

(d) Periodic operation of the diesel generators (the predominant contributors to air pollutant discharges) should not have a significant impact on air quality (Section 5.4).

(e) Operation of Catawba station will not have an adverse impact on any Federal- or State-designated terrestrial or aquatic endangered or threatened species (Sections 5.5 and 5.6).

(f) While experimental work is still under way on the biological effects of electric fields along transmission lines, the staff has found no evidence to date to support a conclusion that the operation of the 230-kV transmission lines will have an adverse effect on the health of humans or that their operation will adversely affect plant or animal life (Section 5.2.2).

(g) Impingement and entrainment of aquatic biota are not expected to result in detrimental impacts to any species inhabiting Lake Wylie (Section 5.5.2.1).

(h) Surface water quality impacts in Lake Wylie caused by discharges from Catawba Nuclear Station will be small. Adverse impacts on aquatic species inhabiting Lake Wylie are not expected (Sections 5.3.2.2 and 5.5.2.2).

(i) The operation and maintenance of Catawba station will not adversely impact existing archeological resources or historic sites (Section 5.7).

(j) The overall socioeconomic impact of operating Catawba station will be beneficial (Section 5.8).

(k) The environmental analysis in this statement takes into account impacts from exposure to routine releases as a result of the storage of spent fuel from Catawba and the spent fuel from Oconee and McGuire that may be stored at Catawba (Section 5.9.3.1.2 and Appendix D). The environmental impacts associated with transshipment of spent fuel between Oconee, McGuire, and Catawba are discussed in Appendix G.

(l) The risk to public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operations will be very small (Section 5.9.3.2).

(m) Activities off site that might adversely affect operation of the plant (nearby industrial, military, and transportation facilities that might create explosive, missile, toxic gas, or similar hazards) were evaluated. The risk to Catawba station from such hazards is negligibly small (Section 5.9.4.4(2)).

(n) The environmental risks of accidents, assuming protective action is taken, is of the same order of magnitude as the risk from normal operation, although accidents have a potential for early fatalities and economic costs not associated with normal operations. The risk of early fatality is small in comparison with the risk of early fatality from other human activities. There are no special or unique characteristics of the site and environs that would warrant requiring special accident-mitigating features (Section 5.9.4.6). A qualitative discussion of accidents involving the spent-fuel pool is in Appendix E.

(o) The environmental impact of Catawba station as a result of the uranium fuel cycle is very small when compared to the impact of natural background radiation (Section 5.10).

(p) Noise levels off site during Catawba Nuclear Station operation are predicted by the staff to be at or below the EPA-identified level for protection of public health and welfare for nearby residences. A confirmatory noise-monitoring program is recommended for the operational phase of the station (Sections 5.12 and 5.14.4).

(5) This statement assesses various impacts associated with the operation of the facility in terms of annual impacts, and balances these impacts against the anticipated annual energy production benefits. Thus, the overall assessment and conclusion would not be dependent on specific operating life. Where appropriate, however, a specific operating life of 40 years was assumed.

(6) This Draft Environmental Statement is being made available to the public, to the Environmental Protection Agency, and to other specified agencies in August 1982.

(7) On the basis of the analyses and evaluations set forth in this statement, and after weighing the environmental, economic, technical, and other benefits against environmental and economic costs and after considering available alternatives at the operating license stage, the staff concludes that the action called for under NEPA and 10 CFR 51 is to issue operating licenses for Catawba Units 1 and 2, subject to the following conditions for the protection of the environment (Section 6.1):

(a) Before engaging in additional construction or operational activities that may result in a significant adverse impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

(b) The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement, as modified and approved by the staff, and implemented in the Environmental Protection Plan and Technical Specifications that will be incorporated in the operating licenses for Catawba Units 1 and 2.

(c) If adverse environmental effects or evidence of irreversible environmental damage occurs during the operating life of the plant, the applicant shall provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
SUMMARY AND CONCLUSIONS	v
FOREWORD	xiii
1 INTRODUCTION	1-1
1.1 Administrative History	1-1
1.2 Permits and Licenses	1-1
2 PURPOSE AND NEED FOR THE ACTION	2-1
2.1 References	2-1
3 ALTERNATIVES TO THE PROPOSED ACTION	3-1
3.1 References	3-1
4 PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT	4-1
4.1 Résumé	4-1
4.2 Facility Description	4-1
4.2.1 External Appearance and Plant Layout	4-1
4.2.2 Land Use	4-2
4.2.3 Water Use and Treatment	4-2
4.2.4 Cooling System	4-4
4.2.5 Radioactive-Waste-Management Systems	4-5
4.2.6 Nonradioactive-Waste-Management Systems	4-6
4.2.7 Power Transmission System	4-8
4.3 Project-Related Environmental Descriptions	4-9
4.3.1 Hydrology	4-9
4.3.2 Water Quality	4-10
4.3.3 Meteorology	4-11
4.3.4 Ecology	4-12
4.3.5 Threatened and Endangered Species	4-15
4.3.6 Community Characteristics	4-16
4.3.7 Historic and Archeologic Sites	4-16
4.4 References	4-17
5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS	5-1
5.1 Résumé	5-1
5.2 Land Use	5-1

TABLE OF CONTENTS (continued)

		Page
	5.2.1 Plant Site	5-1
	5.2.2 Transmission Lines	5-2
5.3	Water	5-2
	5.3.1 Use	5-2
	5.3.2 Water Quality	5-3
	5.3.3 Floodplain Aspects	5-5
5.4	Air Quality	5-6
	5.4.1 Fog and Ice	5-6
	5.4.2 Other Emissions	5-7
5.5	Ecology	5-7
	5.5.1 Terrestrial Ecology	5-7
	5.5.2 Aquatic	5-8
5.6	Endangered and Threatened Species	5-11
5.7	Historic and Archeologic Impacts	5-11
5.8	Socioeconomic Impacts	5-12
5.9	Radiological Impacts	5-12
	5.9.1 Regulatory Requirements	5-12
	5.9.2 Operational Overview	5-13
	5.9.3 Radiological Impacts From Routine Operations	5-15
	5.9.4 Environmental Impacts of Postulated Accidents	5-25
5.10	Impacts From the Uranium Fuel Cycle	5-47
5.11	Decommissioning	5-48
5.12	Noise Impacts at Catawba	5-49
5.13	Emergency Planning Impacts	5-50
5.14	Environmental Monitoring	5-50
	5.14.1 Terrestrial Monitoring	5-50
	5.14.2 Aquatic Monitoring	5-50
	5.14.3 Atmospheric Monitoring	5-51
	5.14.4 Environmental Noise Monitoring	5-52
5.15	References	5-53
6	EVALUATION OF THE PROPOSED ACTION	6-1
6.1	Unavoidable Adverse Environmental Effects	6-1
6.2	Irreversible and Irretrievable Commitments of Resources	6-1
6.3	Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity	6-1

TABLE OF CONTENTS (continued)

		Page
6.4	Benefit-Cost Summary	6-2
6.4.1	Benefits	6-2
6.4.2	Costs	6-2
6.4.3	Conclusions	6-3
6.5	References	6-3
7	LIST OF CONTRIBUTORS	7-1
8	LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS ENVIRONMENTAL STATEMENT ARE BEING SENT	8-1
9	RESERVED FOR STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT	9-1

APPENDIX A RESERVED FOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT
APPENDIX B NEPA POPULATION-DOSE ASSESSMENT
APPENDIX C IMPACTS OF THE URANIUM FUEL CYCLE
APPENDIX D EXAMPLES OF SITE-SPECIFIC DOSE-ASSESSMENT CALCULATIONS
APPENDIX E REBASELINING OF THE RSS RESULTS FOR PWRs
APPENDIX F CONSEQUENCE MODELING CONSIDERATIONS
APPENDIX G ENVIRONMENTAL IMPACT APPRAISAL FOR TRANSSHIPMENT OF SPENT FUEL FROM OCONEE AND McGUIRE TO CATAWBA NUCLEAR STATION
APPENDIX H LETTERS FROM STATE ARCHEOLOGIST, UNIVERSITY OF SOUTH CAROLINA, AND STATE HISTORIC PRESERVATION OFFICER, SOUTH CAROLINA DEPARTMENT OF ARCHIVES AND HISTORY
APPENDIX I PRELIMINARY DRAFT NPDES PERMIT

LIST OF FIGURES

4.1	Perspective Drawing, Catawba Nuclear Station	4-19
4.2	Station Water Use, Catawba Nuclear Station	4-20
4.3	Nonradiological Release Points	4-21
4.4	Low-Pressure Service Water Discharge Structure	4-22
4.5	Modification of the Existing Transmission System	4-23
4.6	Major Hydraulic Features of the Catawba River Drainage Basin, Catawba Nuclear Station	4-24
5.1	Potentially Meaningful Exposure Pathways to Individuals	5-57
5.2	Schematic Outline of Atmospheric Pathway Consequence Model	5-58
5.3	Probability Distributions of Individual Dose Impacts	5-59
5.4	Probability Distributions of Population Exposures	5-60
5.5	Probability Distributions of Cancer Fatalities	5-61
5.6	Probability Distributions of Early Fatalities	5-62
5.7	Probability Distribution of Mitigation Measures Cost	5-63
5.8	Individual Risk of Dose as a Function of Distance	5-64

TABLE OF CONTENTS (continued)

Page

5.9 Isopleths of Risk of Latent Cancer Fatality per Reactor-Year to an Individual 5-65
5.10 Catawba Nuclear Station Site Area With Noise Assessment Locations (A-E) and (1-11) 5-66

LIST OF TABLES

4.1 Catawba Nuclear Station Water Use 4-25
4.2 Lake Wylie Intake Structure Areas and Water Velocities for Catawba Nuclear Station 4-27
4.3 Data on Circular Mechanical Draft Cooling Towers for Catawba Nuclear Station 4-27
4.4 Catawba Nuclear Station Waste Water Discharge.......... 4-28
4.5 Catawba Nuclear Station Conventional Waste Water Treatment System Effluent Analysis 4-29
4.6 Catawba Nuclear Station Transmission Line Additions 4-30

5.1 Surface Water Use as a Percentage of Average River Flows, Catawba River-Lake Wylie 5-67
5.2 Consumptive Water Use as a Percentage of 7-Day 10-Year Low Flow, Catawba River-Lake Wylie 5-67
5.3 Maximum Thermal Plume Extent Under Average and Worst-Case Conditions for the Four Seasons 5-68
5.4 (Summary Table S-3) Uranium Fuel-Cycle Environmental Data 5-69
5.5 (Summary Table S-4) Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor 5-71
5.6 Incidence of Job-Related Mortalities 5-72
5.7 Preoperational Radiological Environmental Monitoring Program Summary 5-73
5.8 Activity of Radionuclides in a Catawba Reactor Core at 3565 MWt . 5-76
5.9 Realistic Estimates of 2-Hour Radiation Doses from Design-Basis Accidents at Exclusion Area Boundary 5-78
5.10 Summary of Atmospheric Releases in Hypothetical Accident Sequences in a PWR (Rebaselined) 5-79
5.11 Summary of Environmental Impacts and Probabilities 5-80
5.12 Summary of Early Fatalities and Probabilities 5-81
5.13 Average Values of Environmental Risks Resulting From Accidents per Reactor-Year 5-81
5.14 Noise Level Predictions at Receptor Locations Shown in Figure 5.10 Resulting From the Operation of Catawba Nuclear Station Only 5-82

6.1 Benefit-Cost Summary for the Catawba Plant 6-4

FOREWORD

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

This environmental review deals with the impacts of operation of the Catawba Nuclear Station, Units 1 and 2. Assessments relating to operation that are presented in this statement augment and update those described in the Final Environmental Statement-Construction Phase (FES-CP) that was issued in December 1973 in support to issuance of construction permits for Catawba Units 1 and 2.

The information to be found in various sections of this statement updates the FES-CP in four ways by

(1) evaluating changes in facility design and operation that will result in different environmental effects of operation (including those which would enhance as well as degrade the environment) than those projected during the preconstruction review

(2) reporting the results of relevant new information that has become available subsequent to the issuance of the FES-CP

(3) factoring into the statement new environmental policies and statutes that have a bearing on the licensing action

(4) identifying unresolved environmental issues or surveillance needs which are to be resolved by means of license conditions (no unresolved environmental issues or surveillance needs have been identified in this statement for the case of Catawba Units 1 and 2).

Introductions (Résumés) in appropriate sections of this statement summarize both the extent of updating and the degree to which the staff considers the subject to be adequately reviewed.

Copies of this statement and the FES-CP (1973) are available for inspection at the Commission's Public Document Room, 1717 H Street NW, Washington, DC, and at the York County Library, 325 South Oakland Avenue, Rock Hill, SC 29730. The documents may be reproduced for a fee at either location. Copies of this statement may be obtained by writing to sources indicated on the inside front cover.

Comments should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this Draft Environmental Statement is published in the Federal Register.

Dr. Kahtan N. Jabbour is the NRC Project Manager for the environmental review of this project. Should there be any questions regarding the content of this statement, Dr. Jabbour may be contacted by telephoning 301/492-7821 or by writing to the following address:

Dr. Kahtan N. Jabbour, Project Manager
Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

1 INTRODUCTION

The proposed action is the issuance of operating licenses to Duke Power Company, North Carolina Municipal Power Agency Number 1, North Carolina Electric Membership Corporation, and Saluda River Electric Cooperative, Inc. (the applicant) for the operation of the Catawba Nuclear Station (the station), Units 1 and 2 located on a peninsula about 7.2 km northwest of Wylie Dam, York County, South Carolina.

The two-unit Catawba Nuclear Station uses two four-loop pressurized water reactors manufactured by Westinghouse Electric Corporation. The rated thermal output of each reactor is 3411 MWt. The 16-MWt input from the reactor coolant pumps increases the reactor coolant system (RCS) gross thermal output to 3427 MWt. Reactor heat absorbed by the RCS produces steam in four steam generators sufficient to drive a turbine generator unit with a net electrical rating of 1145 MWe. The turbine generator unit is manufactured by the General Electric Company. Inplant electrical power consumption is expected to be 57 MWe per unit.

1.1 Administrative History

In July 1972, Duke Power Company filed an application with the Atomic Energy Commission (AEC), now the Nuclear Regulatory Commission (NRC), for permits to construct Catawba Units 1 and 2. The conclusions resulting from the staff's environmental review were issued as a Final Environmental Statement--Construction Phase (FES-CP) in December 1973. Following reviews by the AEC regulatory staff and its Advisory Committee on Reactor Safeguards, public hearings were held before an Atomic Safety and Licensing Board. Construction permits for Units 1 and 2 were issued on August 7, 1975.

In March 1979 the applicant submitted applications for operating licenses for the Catawba Units 1 and 2. As of May 23, 1982, construction of Unit 1 was 90% complete and that of Unit 2 was 43% complete. The applicant estimates that Unit 1 will be ready for fuel loading in October 1984.

1.2 Permits and Licenses

The applicant has provided in Section 12 of the Environmental Report-Operating License Stage (ER-OL) a status listing of environmentally related permits, approvals, and licenses required from Federal and state agencies in connection with the proposed project. The staff has reviewed the listing and other information and is not aware of any potential non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the plant. The issuance of a water quality certification, or waiver therefore, pursuant to Section 401 of the Clean Water Act of 1977 by the South Carolina Department of Health and Environmental Control (SCDHEC) is a necessary prerequisite for the issuance of an operating license by the Nuclear Regulatory Commission. This certification was received by the applicant on December 27, 1974. The SCDHEC issued a National Pollutant Discharge Elimination System (NPDES) permit, pursuant to Section 402 of the Clean Water Act of 1977 to the applicant on June 29, 1981 (Appendix I). This permit has expired, but has been administratively extended by the State of South Carolina until further action is taken.

2 PURPOSE AND NEED FOR THE ACTION

The Commission has amended 10 CFR 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," effective April 26, 1982, to provide that need for power issues will not be considered in ongoing and future operating license proceedings for nuclear power plants unless a showing of "special circumstances" is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). Need for power issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications. (See 10 CFR 51.21, 51.23(e), and 51.53(c).)

This policy has been determined by the Commission to be justified even in situations where, because of reduced capacity requirements on the applicant's system, the additional capacity to be provided by the nuclear facility is not needed to meet the applicant's load responsibility. The Commission has taken this action because the issue of need for power is correctly considered at the construction permit (CP) stage of the regulatory review where a finding of insufficient need could factor into denial of issuance of a license. At the operating license (OL) review stage, the proposed plant is substantially constructed and a finding of insufficient need would not, in itself, result in denial of the operating license.

Substantial information exists which supports the contention that nuclear plants are lower in operating costs than conventional fossil plants. If conservation, or other factors, lowers anticipated demand, utilities remove generating facilities from service according to their costs of operation, with the most expensive facilities removed first. Thus, a completed nuclear plant would serve to substitute for less economical generating capacity. (See 46 FR 39440, August 3, 1981 and 47 FR 12940, March 26, 1982).

Accordingly, this statement does not consider "need for power." Section 6 does, however, consider the savings associated with the operation of the nuclear plant.

2.1 References

Federal Register Notice, 46 FR 39440, "Need for Power and Alternative Energy Issues in Operating License Proceedings," Proposed Rule, U.S. Nuclear Regulatory Commission, August 3, 1981.

---, 47 FR 12940, "Need for Power and Alternative Energy Issues in Operating License Proceedings," Final Rule, U.S. Nuclear Regulatory Commission, March 26, 1982.

3 ALTERNATIVES TO THE PROPOSED ACTION

The Commission has amended its regulations in 10 CFR 51 effective April 26, 1982, to provide that issues related to alternative energy sources will not be considered in ongoing and future operating license proceedings for nuclear power plants unless a showing of special circumstances is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). In addition, these issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications. (See 10 CFR 51.21, 51.23(e), and 51.53(c).)

The Commission has concluded that alternative energy source issues are resolved at the construction permit (CP) stage and the CP is granted only after a finding that, on balance, no superior alternative to the proposed nuclear facility exists. In addition, this conclusion is unlikely to change even if an alternative is shown to be marginally environmentally superior in comparison to operation of the nuclear facility because of the economic advantage that operation of the nuclear plant would have over available alternative sources. (See 46 FR 39440, August 3, 1981 and 47 FR 12940, March 26, 1982.) By earlier Amendment (46 FR 28630, May 28, 1981), the Commission also stated that alternative sites will not be considered at the operating license stage, except under special circumstances in accordance with 10 CFR 2.758. Accordingly, this statement does not consider alternative energy sources or alternative sites.

3.1 References

Federal Register Notice, 46 FR 28630, "Alternative Site Issues in Operating License Proceedings," Final Rule, U.S. Nuclear Regulatory Commission, May 28, 1981.

---, 46 FR 39440, "Need for Power and Alternative Energy Issues in Operating License Proceedings," Proposed Rule, U.S. Nuclear Regulatory Commission, August 3, 1981.

---, 47 FR 12940, "Need for Power and Alternative Energy Issues in Operating License Proceedings," Final Rule, U.S. Nuclear Regulatory Commission, March 26, 1982.

4 PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT

4.1 Résumé

This résumé highlights changes in the design of and operating procedures for Catawba station, as well as new information on the local environment gained since the FES-CP was issued in 1973.

Site appearance and layout have been modified as a result of selection of closed cycle circular mechanical draft towers and various additions and changes to buildings (see Section 4.2.1). Volumetric flow rates for various water systems at Catawba station have been revised as discussed in Section 4.2.3.2 of this statement. Sodium hypochlorite to control biofouling in the cooling tower portion of the condenser circulating water system will be used instead of gaseous chlorine; other water treatments are slightly modified as well (see Section 4.2.3.4). The Catawba station intake structure has been modified by the addition of a fourth pump bay, pump, and associated trashrack and screen as discussed in Section 4.2.4.2. The discharge structure design has been revised to consist of two pipes instead of four pipes as discussed in Section 4.2.4.5. The design and capacity of the sanitary-waste-treatment system have been changed from those presented in the FES-CP (see Section 4.2.6.4). There also have been slight changes in the power transmission system, such as the final routing of transmission lines and the removal from service of some existing lines (see Section 4.2.7).

New and updated information relevant to the operational phase of Catawba Units 1 and 2 also is provided in this section. An updated summary is presented of land use and of site boundaries in Section 4.2.2. Updated water quality data are given in Section 4.3.2; new information on severe weather and site atmospheric dispersion characteristics is provided in Section 4.3.3; and new information concerning threatened and endangered species is discussed in Section 4.3.5. Community characteristics of the site area are updated in Section 4.3.6, and the most recent archeologic information is discussed in Section 4.3.7.

4.2 Facility Description

4.2.1 External Appearance and Plant Layout

These topic areas are discussed in Sections 2.1, 2.2, and 3.1 of the FES-CP. Since that analysis, the major appearance and layout change has been in the selection of the cooling tower design by the applicant. Of the three options presented in the FES-CP, the closed cycle circular mechanical draft towers were selected, as shown in Figure 4.1. The towers are approximately 21 m (77 ft) high and are about 83 m (272 ft) in diameter. Other changes include the construction of a three story office building, designating Construction Warehouse 3 as permanent, and making additions to the Steam Production Warehouse, the Administrative Building, the Auxiliary Service Building, and the Service Building Machine Shop (response to ER-OL - Review Question (RQ) 310.1).

4.2.2 Land Use

The station property line encompasses 419 ha (1036 acres) of which 158 ha (391 acres) are within the site boundary. The exclusion area boundary is a 762 m (2500 ft) radius circle centered on the center line between the reactor buildings. Permanent station facilities are contained within the 52 ha (129 acres) boundary. However, there are two areas within the exclusion boundary that are devoted to nonstation operation activities. The first is the Concord Cemetery 0.4 ha (1 acre), which is used only for visitations and memorial and burial services. The cemetery has a small number of visitors who gain access by contacting the station's security personnel. The second is the visitors' overlook area 0.8 ha (2 acres), which is a sight-seeing and limited-use picnic area. It has been averaging 27 visits per day (response to ER-OL RQ 310.4). There are no other significant changes from the descriptions in FES-CP Sections 2.1, 2.2, and 3.1.

4.2.3 Water Use and Treatment

4.2.3.1 General

The overall water use scheme by Catawba Nuclear Station has not changed since the FES-CP was issued. That is, the station is equipped with a closed cycle cooling system that uses circular mechanical draft cooling towers in the condenser circulating water system, once through cooling for the low pressure service water system and the nuclear service water system, and closed loop cooling through the standby nuclear service water pond for the station's essential service water system during other-than-normal operation. The water supply for the Catawba station remains as described in the FES-CP. Lake Wylie, an onstream impoundment of the Catawba River, will supply all of the station water uses and will receive all liquid station discharges.

4.2.3.2 Surface Water Use

The volumetric flow rates for the various water systems of the Catawba Nuclear Station have been revised since the FES-CP was issued because of a greater degree of completion in the design of the station's water use systems and a change in the design of the station's cooling towers.

Intake from Lake Wylie is projected to occur at an average of 5.2 m^3/sec (184 ft^3/sec) with a maximum withdrawal of 10.7 m^3/sec (379 ft^3/sec), compared to a projected 10.1 m^3/sec (358 ft^3/sec) in the FES-CP. From this withdrawal, up to 4.3 m^3/sec (152 ft^3/sec) would be used in the nuclear service water system, down from an estimated 7.8 m^3/sec (275 ft^3/sec) for this use in the FES-CP. The remainder will serve the condenser circulating water system and the filtered water system. The estimated station makeup and blowdown rates for the condenser circulating water system have changed since the FES-CP as a result of the change in cooling tower design from linear mechanical draft towers to circular mechanical draft towers. These values are now estimated as follows for 100% station load:

	Makeup	Blowdown
Average	2.0 m^3/sec (69 ft^3/sec)	0.3 m^3/sec (9.7 ft^3/sec)
Maximum	3.5 m^3/sec (125 ft^3/sec)	1.8 m^3/sec (62 ft^3/sec)

The station will consume water primarily through evaporation from the circulating and nonessential water systems. The average evaporative loss is estimated at 1.7 m^3/sec (59 ft^3/sec). Monthly maximum evaporative loss is estimated to range from 1.6 m^3/sec (55 ft^3/sec) for the month of January to 1.8 m^3/sec (62 ft^3/sec) for the month of September. Water loss from drift from the station cooling towers will be very low, estimated at less than 0.01 m^3/sec (0.25 ft^3/sec) maximum. The Catawba Nuclear Station's water use is shown in Table 4.1 and in Figure 4.2. At 100% station load, the water use rates given above represent an average concentration factor of about 7.1 with a maximum of about 10, which is the same as was anticipated in the FES-CP.

The nuclear essential service water system will be supplied by the standby nuclear service water pond, as described in the FES-CP. The as-built size of the pond, 18.6 ha (46 acres), is slightly smaller than the previously planned 19.4 ha (48 acres). Maximum water flow rate between the pond and the station is estimated at 4.1 m^3/sec (151.5 ft^3/sec). During normal operation, this flow rate is zero.

4.2.3.3 Groundwater Use

As stated in the FES-CP, there will be no withdrawal from or discharge to groundwater by the Catawba Nuclear Station.

4.2.3.4 Water Treatment

The planned treatment of water for use in the Catawba Nuclear Station remains the same in concept as proposed in the FES-CP. That is, water for the station condenser cooling will be treated with biocides to control biofouling, with sulfuric acid to control scaling, and with a dispersant to control sediment deposition within the system. Water for the remainder of the conventional low pressure service water system (the filtered water system which supplies the station sanitary and potable water and the demineralized water system) will be filtered, disinfected, and, as appropriate, demineralized . The estimated amounts of chemicals to be used have changed from those indicated in the FES-CP as described below.

The applicant plans to use sodium hypochlorite to control biofouling in the cooling tower portion of the condenser circulating water system instead of gaseous chlorine, as indicated in the FES-CP. The planned application rate of biocide is 272 kg/unit/day (600 lb/unit/day) instead of 136 kg/unit/day (300 lb/unit/day), as estimated in the FES-CP. However, because of the change in the form of chlorine to be applied, the proposed application rate will cause the same average 1.0 mg/l free available chlorine to exist in the cooling water as was anticipated in the FES-CP. This residual is expected to vary between 1.5 mg/l in the summer and 0.5 mg/l in the winter, based on a 3-4 mg/l chlorine demand.

Other condenser circulating water treatments proposed are (1) continuous sulfuric acid addition at 612 kg/unit/day (1350 lb/unit/day) instead of 453 kg/unit/day (1000 lb/unit/day) as proposed in the FES-CP and (2) possible intermittent use of aminomethylenephosphonate (AMP), a dispersant, and a yet-to-be-determined EPA-approved organic biocide for chlorine resistant organisms (for example, Corbicula sp.) should they become a problem. The frequency and rate of application of the latter treatments have not been finalized and may differ from those presented in the FES-CP.

4.2.4 Cooling System

4.2.4.1 General

Although the station will employ closed cycle cooling, the type and arrangement of the components in the Catawba Nuclear Station cooling system have changed since the FES-CP was issued. The most obvious change that has occurred is the selection and construction of circular mechanical draft cooling towers for station heat rejection. Linear mechanical draft cooling towers had been indicated as the chosen design in the FES-CP. These and other changes are discussed below.

4.2.4.2 Intake

The Catawba Nuclear Station intake structure has been modified slightly since the FES-CP was issued. The modification consists of the addition of a fourth pump bay, pump, and associated trashrack and screen. This change has been made to accommodate the fire protection system. Revised estimates of the water velocities at various locations in the intake structure are given in Table 4.2 for average flow rates at 100% power level operation for the station. Based on an approximate 50% increase in flow rates for the maximum water demand condition, the flow rates would increase accordingly to about 0.11 m/sec (0.36 ft/sec) through the pump bay gross opening at Lake Wylie full pond or 0.17 m/sec (0.57 ft/sec) at the same location for the Lake Wylie maximum drawdown of 3 m (10 ft).

4.2.4.3 Condenser Circulating Water System

The as-built design of the cooling tower portion of this system has been changed since the FES-CP was issued. Circular mechanical draft cooling towers have been constructed instead of the linear mechanical draft towers indicated in the FES-CP. Data on the new towers are presented in Table 4.3. The cooling towers are designed to dissipate 8.33×10^{12} J/hr (7.9×10^{9} Btu/hr) per unit instead of 8.65×10^{12} J/hr (8.2×10^{12} Btu/hr) per unit, as stated in the FES-CP. The projected condenser transit time for the cooling water at design conditions is about 16 sec. The expected rise in cooling water temperature across the condenser at the design heat rejection rate and a cooling water flow rate of 5000 m^3/min (1.32×10^{6} gpm) is 13.3C° (24F°). As stated in the FES-CP, the stainless steel condenser tubes will be mechanically cleaned while in operation by a system using sponge rubber balls passing through the tubes. These balls will be strained out of the cooling water after condenser passage and will be held for recycle.

4.2.4.4 Service Water System

This system was designated in the FES-CP as a portion of the "Conventional Service Water System." This system supplies cooling water to the secondary side of the Catawba Nuclear Station, such as the turbine oil coolers and the generator coolers. The temperature rise of this water as it passes through the station is 8.3C° (15F°) under winter design conditions. There have been no changes noted for this system since the FES-CP was issued.

4.2.4.5 Nuclear Service Water System

This system supplies cooling water to both the primary and secondary sides of the Catawba Nuclear Station. The temperature rise of this water as it passes through the station is 4.97C° (8.95F°). There have been no changes noted for this system since the FES-CP was issued.

The location of the station discharge structure is shown on Figure 4.3 and is in essentially the same location as was indicated in the FES-CP. The low pressure service water, cooling tower blowdown, nuclear service water, liquid radwaste, and sanitary wastes will pass through this structure.

The design of the discharge structure has changed since the FES-CP was issued. The revised design (as shown in Figure 4.4) consists of two pipes, each with a diameter of 1.37 m (54 in.), instead of the four pipes, each with a diameter of 1.07 m (42 in.) as shown in the FES-CP. The new discharge structure pipe cross sectional area is 83% of the area indicated in the FES-CP. The discharge velocity at the pipe exit for the average discharge flow would be about 1.2 m/sec (3.9 ft/sec) and for the maximum flow would be about 3.0 m/sec (9.7 ft/sec). The discharge flow rate for the conditions given in the FES-CP was 2.3 m/sec (7.7 ft/sec). The centerline of the discharge pipes is located at el 555.4 ft mean sea level (MSL), 4.3 m (14 ft) below the normal full-pond water surface of Lake Wylie.

4.2.5 Radioactive-Waste-Management Systems

10 CFR 50.34a requires an applicant for a permit to construct a nuclear power reactor to include a preliminary description of the design of equipment to be installed for keeping levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable (ALARA). The term ALARA takes into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and other societal and socioeconomic considerations and in relation to the utilization of atomic energy in the public interest. Appendix I to 10 CFR 50 provides numerical guidance on design objectives for light-water-cooled nuclear power reactors to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept ALARA.

To comply with the requirements of 10 CFR 50.34a, the applicant has provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents to unrestricted areas ALARA within the requirements of Appendix I to 10 CFR 50. In addition, the applicant has provided an estimate of the quantity of each principal radionuclide expected to be released annually to unrestricted areas in liquid and gaseous effluents produced from normal operation, including anticipated operational occurrences.

The staff's detailed evaluation of the radwaste system and the capability of this system to meet the requirements of Appendix I will be presented in Section 11 of the Safety Evaluation Report (SER). The quantities of radioactive material calculated by the staff to be released from the plant will also be presented in SER Section 11 and in Section 5.9 of this Environmental Statement with the calculated doses to individuals and the population that will result from these effluent quantities.

At the time of the operating license, the applicant will be required to submit Technical Specifications, which will establish release rates for radioactive material in liquid and gaseous effluents and which will provide the routine monitoring and measurement of all principal release points to ensure that the facility operates in conformance with the requirements of Appendix I to 10 CFR 50.

4.2.6 Nonradioactive-Waste-Management Systems

4.2.6.1 General

The nonradioactive effluents will result from operation of the evaporative cooling system, the water treatment systems, and the wastewater treatment system. There have been changes in the systems producing these effluents as well as changes in the volume and character of the effluents themselves since the FES-CP was issued. These changes are discussed below.

4.2.6.2 Cooling Water System

The operation of the closed cycle cooling system for the station will result in the discharge of water of different composition than that withdrawn from Lake Wylie. As indicated in Section 4.2.3 of this report, the evaporative loss from the circular mechanical draft cooling towers will result in a concentration of the physical and chemical constituents in the makeup water. The expected average concentration of the constituents, based on average Lake Wylie water quality data collected since the FES-CP was issued through 1978, is shown in Table 4.4. These data are based on a projected annual average concentration factor in the system of 7 (ER-OL Section 3.6.2). Concentration factors as high as 10 may be experienced, however, and would likely represent the maximum constituent discharge values from this system. These values also are shown in the table. Cooling system discharge concentration values for a concentration factor of 10 were presented in the FES-CP. The values projected in this review differ only slightly from those presented in the FES-CP, based on updated analyses of Lake Wylie intake water (see Section 4.3.2).

Also affecting the composition of the blowdown from the cooling water system are the chemical additions to the makeup water to control biofouling, scales, sediment deposition and pH (see Section 4.2.3.4). These additions will noticeably affect the total dissolved solids, sulfate, and alkalinity concentrations, and, to a lesser extent, the chloride concentration in the blowdown.

Sodium hypochlorite additions for biofouling control in the cooling tower loop of the low pressure service water system will result in the discharge of combined residual chlorine, as indicated in the FES-CP. However, the amount and concentration expected in the station discharge differs from that indicated in the FES-CP. The applicant will control the discharge concentration of total residual chlorine in the cooling tower blowdown by interrupting system blowdown during the time of application of biocide, and for some time afterward, until sampling indicates that the total residual chlorine concentration in the system has fallen to about 0.1 mg/l. Blowdown will be restored at this time (ER-OL Section 3.6.1) so that, upon mixing with the nuclear service water system and the remainder of the low pressure service water system discharges, the total residual chlorine concentration in the cooling system discharge will be below 0.1 mg/l.

A final plan for cleaning the cooling water systems outside of the condenser-cooling tower system has not been decided upon by the applicant. The applicant's preliminary plans are as follows: (1) The nuclear service water system is equipped with strainers on the system intake to prevent entry of debris and large organisms (for example, adult Corbicula sp.). Redundant heat exhangers in the system will allow for removal from service, inspection, and cleaning without interruption to station operation, and isolation of cleaning wastes for control and treatment, if needed, before disposal. (2) The fire protection system uses chlorinated filtered water as input. It also has strainers for large object exclusion and the system can be isolated for inspection and cleaning. (3) The low pressure service water system outside of the condenser cooling tower loop will be maintained by inspections and operational controls (for example, backflushing thermal treatment or mechanical cleaning) in a clean condition (ER-OL Section 3.4). Use of a biocide such as sodium hypochlorite in these systems in a manner that would result in its discharge is not planned at this time.

The estimated amount of dissolved solids expected to escape from the station's cooling towers in the drift has changed from the estimate given in the FES-CP. Based on an estimated maximum drift rate of 0.008% of the circulating water flow rate and a maximum total dissolved solids concentration of about 860 mg/l (the same as the maximum circulating water concentration at 10 cycles of the concentration) about 495 kg/day (1090 lb/day) could be dispersed in the drift. Under average conditions, this value is not expected to exceed 345 kg/day (760 lb/day). The value estimated in the FES-CP was 468 kg/day (1030 lb/day) based on a 650 mg/l drift total dissolved solids concentration and the then estimated 0.01% drift loss figure.

4.2.6.3 Conventional Waste-Water-Treatment System

Waste and spent process waters from the fire protection system and the filtered water system through the demineralized water system and the sanitary/potable water (nonsewage wastes only) are routed to and treated before discharge in the conventional waste-water-treatment system (CWWTS). This system replaces the wastewater collection basin described in the FES-CP. The CWWTS provides physical and chemical treatment to the nonradioactive station wastes listed in ER-OL Table 3.6.1-3. The CWWTS consists of an initial holdup pond for wastewater flow equalization and sedimentation, two parallel stream settling ponds, and a final holdup pond for aeration and final stabilization of the treated wastewater before discharge. Treatment of wastes will employ coagulant aids and pH adjustment in the intermediate settling ponds, with provision for recirculation of wastes between ponds if the desired level of treatment has not been attained. Additional system description is presented in ER-OL Section 3.6.1.

Expected effluent characteristics of the CWWTS discharge based on the system design are given in Table 4.5. The expected characteristics of the CWWTS discharge, based on station chemical usage and on analyses of influent waters, are presented in Table 4.4.

Discharge from the CWWTS will be through a separate structure located in the discharge cove. The discharge flow rate will be small, compared to the other station discharges to Lake Wylie, and will average about 760 l/min (200 gpm). Other losses from the CWWTS are expected to be negligible because the initial holdup pond is lined with concrete, the two settling ponds are lined with tamped clay, and the final holdup pond is lined with impermeable hypalon (ER-OL Section 3.6.1).

4.2.6.4 Sanitary-Waste-Treatment System

The design and capacity of the sanitary-waste-treatment system to be used during the operational phase of the Catawba Nuclear Station have been changed from those presented in the FES-CP. The estimated volume of waste influent to the system has increased from 1.9 X 10^4 l/day (5000 gal/day) as presented in the FES-CP to 6.4 X 10^4 l/day (17,000 gal/day). The capacity of the treatment system has been increased accordingly.

Instead of treatment via septic tank, sand filtration, and chlorination followed by disposal to a wastewater collection basin and then discharge to Lake Wylie, the system will employ a four chamber aerated facultative lagoon and an effluent polishing basin followed by discharge to Lake Wylie. The aerobic biological treatment accomplished in the lagoon provides about a 26-day retention time for the wastes at the rated capacity. The effluent polishing basin is designed as a tertiary aquaculture system that uses aquatic macrophytes, animals (such as, zooplankton and fish) and final aeration in three main compartments to reduce suspended solids, nitrogen and phosphorus concentrations through biological assimilation. The assimilated materials can then be harvested and disposed of without disposal to Lake Wylie. This system effluent will not be chlorinated, as opposed to the treatment scheme presented in the FES-CP. Further description of the system is presented in the ER-OL and in a January 5, 1977 letter from L. C. Dail, Duke Power Company. The design, construction, and proposed operation of this system has been approved by the State of South Carolina. The operation of the system will be under the supervision of an operator certified by the State (ER-OL Section 3.7.2).

4.2.7 Power Transmission System

The procedures planned for connecting Catawba with Duke's existing transmission system consist of constructing two new 230 kV lines and connecting three existing 230 kV lines to the Catawba Switching Station. The FES-CP described a Catawba station to Shelby station tap 230 kV line. This line has been slightly modified and is called the Catawba-Ripp 230 kV line. The other important changes from the FES-CP are: (1) removal from service of the existing section of line from point B (as shown in Figure 4.5) to Allison Creek tap and (2) removal from service of the existing section of Catawba-Newport "Allison Creek B&W" 230 kV line from Allison Creek tap to point C (Figure 4.5), and (3) removal of Allison Creek tap from service after energizing the Catawba-Newport, Catawba-Pacolet, and Catawba-Allen 230 kV lines from Catawba Switching. Only minor differences exist between the final routing of the other transmission lines as given in the ER-OL and that proposed in the FES-CP. All the pertinent information concerning the land use aspects of the transmission lines are presented in Table 4.6.

4.3 Project-Related Environmental Descriptions

4.3.1 Hydrology

4.3.1.1 Surface Water

The surface water descriptions presented in Sections 2.5.1 and 3.4.3 of the FES-CP are still valid, as supplemented by the following discussion. In addition, Section 5.3.3 of this Draft Environmental Statement contains a discussion of the hydrologic effects of alterations in the floodplain, in compliance with the guidelines for implementing Executive Order 11988 on floodplain management (43 FR 6030, February 10, 1978). Major hydrologic features of the Catawba River are shown in Figure 4.6.

The Catawba Nuclear Station is located at Lake Wylie on the Catawba River in northeastern South Carolina. The site is on a peninsula bounded by Beaver Dam Creek to the north, Big Allison Creek to the south, and Lake Wylie to the east.

Water inflow to Lake Wylie is from Mountain Island Lake, South Fork Catawba River and tributary creeks. The Federal Energy Regulatory Commission (FERC) license for the Catawba-Wateree Project (No. 2232) requires a minimum average daily release of 8.9 m^3/sec (314 cfs) from Mountain Island Dam and 11.6 m^3/sec (411 cfs) from Wylie Dam.

The applicant estimated the 7-day once-in-10-year low flow entering Lake Wylie to be 14.6 m^3/sec (516 cfs). This estimate was based on the minimum average daily release from Mountain Island Dam and the 7-day once-in-10-year low flow per square mile from the South Fork Catawba River for the remainder of the basin.

With operation of the Catawba Nuclear Station, the maximum drawdown which will be allowed by the FERC License is 3 m (10 ft) or an elevation of 559.4 ft MSL. During the 30-year period, 1950-1980, the level of Lake Wylie has never fallen below this elevation. The lowest level of record was el 559.9 ft MSL on October 23, 1952. However, the lake was intentionally lowered at this time to permit work to be done at the Allen Steam Plant.

In addition to Lake Wylie, the only major water impoundment at the Catawba Nuclear Station is the standby nuclear service water pond (SNSWP), located at the north end of the site. The SNSWP is to be used as a source of water for emergency shutdown of the station. At full pond elevation of 571.0 ft MSL, the pond has a surface area of 19 ha (46 acres) and a volume of 6.9 x 10^5 m^3 (560 acre-ft).

4.3.1.2 Groundwater

The groundwater descriptions presented in Section 2.5.2 of the FES-CP are still valid with the following additions.

In the site area, groundwater is generally encountered under water table conditions in weathered rock and saprolite soils that overlie less weathered rocks. Observations of groundwater levels at about 60 locations in the immediate vicinity of the site indicate that the water table varies from 3 m (10 ft) to 12 m (40 ft) below natural ground surface near the location of the reactors, and it approaches the surface elevation of Lake Wylie near the lake shore. Groundwater movement is from the plant area towards the lake coves, which cut into the peninsula to the north and south of the site.

A permanant safety-related groundwater drainage system has been installed to maintain a normal groundwater level near the base of the foundation mat and basement walls of the auxiliary and reactor buildings. The drainage system will decrease the groundwater gradient, and groundwater movement away from the site will be decreased.

4.3.2 Water Quality

Data on the surface water quality of Lake Wylie were presented in the FES-CP, as part of the applicant's baseline water quality monitoring program for the period of September 1973 through August 1974. This information has been supplemented by the applicant with the Water Quality Interim Study, beginning in September 1974 and projected to continue until the Second-Year Preoperational Study is initiated. This program is the second 1-year-long study of preoperational ecological conditions in the site vicinity and it is expected to commence one full year before fuel loading of Unit 1. The interim water quality study initially collected data from 12 locations and later from 8 locations on Lake Wylie. The applicant's analysis of the data from this study indicates (1) that Lake Wylie is a seasonally stratified lake system typical of Carolina Piedmont reservoirs, (2) that the level of major chemical constituents in Lake Wylie reflect the geology and mineralogy of the drainage system, (3) that Lake Wylie is phosphorus limited, and (4) that heavy metal concentrations show large variations temporally and spatially, but that no adverse effects on aquatic life have been noted from these constituents. The data from the interim water quality study are presented in ER-OL Sections 2.4 and 6.1.1.

Data from the water quality studies of Lake Wylie since the FES-CP was issued are presented in Table 4.4. These data are from the time period 1974-1978 and represent spatial and temporal averages. A comparison of these data with those presented in the FES-CP shows a decrease in nitrogen, phosphorus, and silica nutrients, and increases in metals, iron, manganese, magnesium, and potassium; values for copper, alkalinity, hardness, and total suspended and dissolved solids remained about the same. Data from the time period 1978-1980 indicate similar differences from the FES-CP.

Data collected by the State of South Carolina (South Carolina Wildlife and Marine Resources Department, Columbia, South Carolina) for the period 1975-1976 in Lake Wylie, including the Big Allison Creek lake area (i.e., the area to receive discharges from Catawba Nuclear Station) show somewhat better water quality (for example, lower nutrient levels) than that indicated in the FES-CP. This study concluded that these data did not indicate reasons for immediate concern to the fishery resources of the lake.

In a study (State of South Carolina Water Resources Commission, March 1981) of the Catawba-Wateree River system in South Carolina, the state surveyed physical and chemical water quality in an attempt to identify existing and potential problems associated with people's use of the river system. The study cites only occasional exceedances of state water quality standards in the river basin. The state study indicated that only nutrients, especially phosphorus, consistently occurred at "higher than desirable concentrations." Although this study cites U.S. EPA identification of eutrophic conditions in Lake Wylie, adverse effects of nutrient enrichment and eutrophication have not been identified for the higher trophic communities, such as fish. It is noted, however, that the state has designated Lake Wylie as being "water quality limited" for the purpose of defining the level of waste treatment required to maintain state standards for dissolved oxygen. This designation of Lake Wylie requires waste treatment of effluents containing oxygen-demanding substances, ammonia, and phosphorus to be more advanced than secondary treatment technology or "best practicable technology," as defined by the U.S. EPA.

4.3.3 Meteorology

The discussion of the general climatology of the site and vicinity contained in the FES-CP remains unchanged. The FES-CP did not include a discussion of severe weather phenomena experienced in the region of the Catawba station. Thunderstorms, tornadoes, and hurricanes occur in the region. About 54 thunderstorms (Changery, November 1981) can be expected on about 42 days each year (National Climatic Center, 1976). Hail often accompanies severe thunderstorms. During the period 1955-1967, 14 occurrences of hail with diameters 19 mm (3/4 in.) or greater were reported in the one-degree latitude-longitude square containing the site. Tornadoes are not uncommon in the region. For a 161-km square (100-mi square) corresponding to 26,000 km^2 (10,000 mi^2) containing the site, an average of 2.6 tornadoes per year were reported for the period 1950-1976 (Kelly, August 1978). Using an average tornado path area of 7.3 km^2 (2.8 mi^2), the computed recurrence interval for a tornado at the Catawba site is about 1360 years (Thom, December 1963). The applicant has examined tornado occurrences in the region for the period 1956-1980, and calculated a slightly longer recurrence interval of 1610 years. In the period 1871 to 1978, about 23 tropical depressions, tropical storms, and hurricanes have passed within about 80 km (50 mi) of the site. Hurricane David, September 1979, was the last hurricane to affect the area.

Since the FES-CP was issued, the applicant has relocated the onsite meteorological tower and collected two additional years (12/17/75 - 12/16/77) of meteorological data. For this period of record, prevailing winds at the 10 m (33 ft) level are from the south-southwest (13.9%) and from the southwest (13.5%). A somewhat bimodal airflow pattern is evident with winds from the south, south-southwest, and southwest totalling about 35.5% and winds from the north, north-northeast, and northeast totalling about 24.9%. The wind direction frequencies observed at the new tower location for the 2-year period of record contrast markedly with observations for the 1-year period (6/30/71 - 6/30/72) used for the FES-CP. Prevailing winds also were from the southwest (19.5%) but winds from the south-southwest occurred only about 5.3% of the time. Strong secondary airflow from the northeast (16.9%) also was evident for the earlier data collection period, but is not discernable from the most current data. The applicant has attributed these differences to "synoptic based variations in direction preferences" (that is, natural variations in winds caused by the movement of large-scale weather features); however, the differences could be attributable to changes in terrain and vegetation caused by plant construction or to nonrepresentative tower locations.

Similar differences also are evident in the distribution of atmospheric stability conditions as defined by vertical temperature gradient. For example, for the most current two-year period of record, moderately stable (Pasquill type "F") and extremely stable (Pasquill type "G") conditions occurred 8.7% and 11.7% of the time, respectively. For the earlier 1-year period of record, these conditions occurred 14.1% and 12%, respectively. Extremely unstable (Pasquill type "A") conditions occurred 10.2% of the time for the period of June 30, 1971 to June 30, 1972, while these conditions were observed 18.7% of the time for the period of December 17, 1975 to December 16, 1977. Atmospheric stability conditions defined by vertical temperature gradient are more dependent on tower location and instrument exposure than synoptic variations in airflow patterns.

As discussed in Section 5.14.3, the staff has requested the applicant to initiate several studies to determine the representativeness of meteorological data collected at the Catawba site. The results of these studies will be incorporated into the FES.

4.3.4 Ecology

4.3.4.1 Terrestrial Ecology

The description of the plant-life communities on the Catawba site presented in the FES-CP remain valid. Actual animal surveys had not been performed on site by the time the FES-CP was published. Such studies were performed and the results presented to NRC in 1975 (Duke Power Company). As a result of these studies evidence was found for 80 species of birds, 15 species of mammals, 6 species of amphibians, and 11 species of reptiles on site.

4.3.4.2 Aquatic Ecology

Lake Wylie was originally impounded in 1904; however, the dam was raised 15 m (50 ft) in 1925. The impoundment's nominal pool elevation has not changed since that time. Impoundments undergo ecological succession resulting in shifts in species diversity and abundance. Initially the biotic community is highly productive followed by a decrease in production and ultimate stability. Lake Wylie has through the years achieved a degree in ecological stability, however, increasing nutrient enrichment has resulted in the lake being described as having a trophic status of mesotrophic to eutrophic (ER-OL Section 2.2.2.1.3).

<u>Phytoplankton</u>

In a year-long survey (Industrial BIO-TEST Laboratories, Inc., 1974) conducted from September 1973 to August 1974 the applicant found that the phytoplankton community of Lake Wylie was dominated by diatoms, green algae, cryptomonads, blue-green algae, and dinoflagellates. Green algae, diatoms, and blue-green algae represented the greatest number of different taxa. Diatoms, which are typically cold water algae, were prevalent in the spring and fall, and reached their greatest abundance in the lake between March and May. Green and blue-green algae were found to be most abundant from March to August and May through September, respectively. Blue-greens reached their highest densities in June.

Sampling conducted during 1977 by the South Carolina Department of Health and Environmental Control (SCDHEC) indicated a diverse algal community that is dominated primarily by diatoms followed by blue-greens. Their findings indicate that Lake Wylie is being affected by nutrient enrichment (Johnson and de Kozlowski, 1981).

Periphyton

Monitoring, contracted by the applicant from September 1973 to August 1974, reported that the dominant periphytic algae were diatoms (Industrial BIO-TEST Laboratories, Inc., 1974). The study found that populations exhibited a bimodal seasonal distribution with maximum densities present in October and April with minimum concentration occurring in January and July. The SCDHEC monitored periphyton from Lake Wylie in 1977 (Johnson and de Kozlowski, 1981). Over 97% of the periphytic taxa collected from the lake were diatoms. No periphytic blue-green algae were observed.

Zooplankton

The applicant found that the dominant zooplankton genera in Lake Wylie were primarily planktonic or limnetic species characteristic of most North American reservoirs. A total of 41 genera were collected from the lake in the vicinity of the station. The dominant taxa found were Copepoda, Cladocera, and Rotifera. Rotifers averaged 47% of the total zooplankton, copepods 43% and cladocerans 10%. Immature copepods were a numerically significant component of the zooplankton throughout the year. Nauplii were usually more abundant in the spring but densities were occasionally high in the fall and winter near the Catawba station discharge and intake. Cladocerans were the least abundant of the three major zooplankton taxonomic groups on Lake Wylie. Bosmina longirostris, the dominant species of cladoceran, was generally more abundant in October, May, and June with maximum densities in June.

Rotifers were the best represented group in Lake Wylie both in species diversity and density. Most common species were Conochilus spp., Keratella spp. and Polyarthra spp. Peak densities for all three species were in the spring.

Weiss et al. (1975) found that seasonal fluctuations occurred in zooplankton composition in the lake but the community averaged about 72% rotifers, 20% copepods, 5% protozoans and 3% cladocerans throughout the year generally agreeing in ranking with the earlier study. Weiss et al. (1975) found that maximum population densities in Lake Wylie occurred during the spring with a secondary peak in the fall.

Benthos

The applicant reported a total of 88 macroinvertebrate taxa from Lake Wylie in the vicinity of the station (ER-OL, Section 2.2.3.1). The midges (Chironomidae) were the most diverse group with 33 taxa known from the study area. The dominant invertebrates from the grab samples were the Asiatic clam, Corbicula sp. (24.9% of the total density) and immature tubificid worms (23.4%). The Asiatic clam dominated the benthic biomass. Other common taxa included species of the midges and the burrowing mayfly (Hexagenia spp.). Peaks in total macroinvertebrate density occurred in December, April, and June. Minimum densities occurred in mid and late summer and were attributed to midge emergence and fish predation. Corbicula sp. densities peaked in December and February and declined thereafter.

The applicant found that the Asiatic clam densities averaged 505/m^2 with the highest recorded of 1472/m^2 in the vicinity of the Catawba station (ER-OL Section 2.2.2.3.?). Densities were highest at shallow depths with a sandy or muddy-sandy substrate. Densities of Corbicula sp. have continued to increase in Lake Wylie since they were first collected in 1968. The clams usually reach a size of 35 mm (1.4 in.) to 45 mm (1.8 in.) (Nash, undated).

On April 10, 1981, the staff issued Inspection and Enforcement Bulletin 81-03 to holders of operating licenses and construction permits requiring them to submit the following information: the known occurrence of Corbicula sp. in the vicinity of their plants, an inspection of plant equipment for fouling by this organism, and a description of methods (in use or planned) for preventing and detecting fouling by Corbicula sp. The applicant responded on July 8, 1981 (Parker, 1981) and stated that Asiatic clams were known from Lake Wylie. Further, the applicant stated that inspection of the nuclear service water system, the fire protection system, and the conventional low-pressure service water found four small clams, one in the service water supply header and three small clams in the fire system. Some small clam shells and shell fragments have been reported from the fire protection system deluge nozzles in the past. The fire protection systems were still on temporary construction lake water supplies which are not chlorinated. The applicant stated (Parker, 1981) that provisions have been designed into the station to (1) minimize the introduction of clams into the raw water systems, (2) performance monitor components to verify adequate flow, (3) allow visual inspection of intake piping and inlet heat exchanger heads during maintenance, (4) and aid in removing these organisms if they become established in piping and components (see Section 4.2.6.2).

The 1977 study by SCDHEC found that the midge larvae Chaoborus was the most abundant organism in the lake comprising over 90% of the fauna (Johnson and de Kozlowski, 1981).

Fish

A total of 28 fish species from 9 families were collected from 4 locations near the Catawba site (ER-OL Section 2.2.2.4.1). A lakewide survey by Industrial BIO-TEST Laboratories, Inc. (1974) and unpublished cove rotenone data collected during 1978 and 1979 by South Carolina Wildlife and Marine Resources Department found that the dominant species are threadfin shad, gizzard shad, bluegill, largemouth bass, redbreast sunfish, pumpkinseed, redear sunfish, black crappie, white catfish, channel catfish, quillback, yellow perch, and longnose gar.

Threadfin shad were the most numerous fish collected near the Catawba site accounting for 27.6% of the total (ER-OL Section 2.2.2.4.2). Nash (personal communication, 1981) thought that the threadfin shad population in Lake Wylie is relatively stable, although naturally occurring low water temperatures during the winter of 1975-1976 is suspected of causing a threadfin dieoff (Nash, 1980). White catfish were the most abundant of the catfishes near the site and bluegills the most abundant of the sunfishes. The largemouth bass accounted for the greatest biomass of all species collected at locations near the Catawba site (ER-OL, Section 2.2.2.4.2).

Average standing crop estimates from cove rotenone for major sports species in Lake Wylie in 1978-1979 were 11.4 kg/ha (12.8 lb/acre) for largemouth bass, 6.9 kg/ha (7.7 lb/acre) for channel catfish, 3.4 kg/ha (3.8 lb/acre) for black crappie (Nash, 1980).

Attempts have been made at establishing a striped bass fishery in Lake Wylie. These have been largely unsuccessful and stocking of fry has been discontinued (Nash, personal communication, 1981).

A limited commercial catfish basket fishery apparently exists on Lake Wylie. Industrial BIO-TEST Laboratories, Inc. (1974) reported that approximately six individuals commercially fished the lake in 1973-1974. Nash (personal communication, 1981) stated that there are presently two to three individuals still fishing on a part-time basis. Since the harvest is unregulated in South Carolina, no estimates of harvest or effort are available.

All fish species collected from Lake Wylie can be generally classified as spring and/or summer spawners. Actual spawning time varies considerably from year to year. Some species apparently begin spawning earlier in the Allen Steam Plant discharge area than elsewhere (Industrial BIO-TEST Laboratories, Inc., 1974). In the 1973-1974 study the peak shad (Dorosoma spp.) spawning activity apparently occurred during May. Shad larvae made up 85% of the total number of larval fish taken between the end of March and the beginning of July. Most of the spawning activity of golden shiners occurred during April and May. White catfish apparently reach spawning condition earlier in the Allen discharge area than elsewhere. Peak activity for this species occurred in June. Peak sunfish spawning probably occurred in May and June while most crappie spawning apparently occurred in April. Highest larval densities reported from the sampling station nearest the Catawba intake were 38.5 larval fish/100 m^3 of water in early May with 96% of the larvae collected identified as shad (Industrial BIO-TEST Laboratories, Inc., 1974).

The most common external fish parasite or disease is the protozoan Epistylis (ER-OL, Section 2.2.2.4.3 and Nash, 1980). Other parasites and diseases are known however infestations were low and of little concern. Epistylis has been found on 12 host species and contributes to the spring mortalities of black crappie. It has also been frequently identified on largemouth bass and white bass particularly during the winter months (Nash, 1980). The factors contributing to Epistylis infestations are unknown, however, organic enrichment and release of nutrients during lake destritification have been suggested (ER-OL, Section 2.2.2.4.3).

4.3.5 Threatened and Endangered Species

On September 1, 1981 a letter (Adensam, 1981) was sent to the U. S. Fish and Wildlife Service (FWS) area office in Asheville, North Carolina, notifying them of the proposed licensing of Catawba Nuclear Station Units 1 and 2. Adensam (1981) requested that the NRC be notified of any federally listed or proposed endangered or threatened plant or animal species in the vicinity of the project. The FWS responded on September 11, 1981 (Ryan, 1981) notifying the NRC that no endangered or threatened species, listed or officially proposed for listing, are known to be in the project area. The letter states that the NRC has satisfied the requirements of Section 7(c) of the Endangered Species Act.

The State of South Carolina has its own list of endangered species (South Carolina State Regulation 50-15). In June 1980 two bird species observed on the Catawba site were added to the state list. The two species are Cooper's Hawk (Accipiter cooperii) and American Osprey (Pandion haliatus). Also in June 1980 the Carolina darter, Etheostoma collis collis, was added to the state list. This species has not been collected from Lake Wylie in the vicinity of the site and it is unlikely to be found nearby in the future. This species is known from small to medium sized streams 0.6-0.9 m (2-3 ft) deep from backwater pools or near stream banks in slow moving water (Collette, 1962) and would be unlikely to be collected from Lake Wylie.

4.3.6 Community Characteristics

The socioeconomic characteristics of the area, including demography, recreation, zoning, and land use are described in Sections 2.1 and 2.2 of the FES-CP. The area remains predominantly rural, nonfarm with residential and recreational development along Lake Wylie. Mecklenburg County, North Carolina has predominantly residential zoning within 8 km (5 mi) of the station while York County, South Carolina has no zoning outside of city limits. The area within 80 km (50 mi) of the station has been experiencing population growth at a rate fairly consistent with that previously projected in the FES-CP. Mecklenburg County experienced a 14 percent growth rate through the 1970s to arrive at a 1980 population of 404,270. This population figure is slightly lower than previously predicted. York County's 1980 population was 106,720 a little higher than predicted, resulting from a growth rate of 25% through the past decade.

Other recent data not included in the FES-CP relates to transient population estimates. Heritage U.S.A. is a campground and religious retreat complex (affiliated with the PTL Club) in Fort Mill, South Carolina. It is within 16 km (10 mi) of Catawba. The complex has about 500 employees and about the same number of vistors daily. At peak attendance there is around 38,000 for the large annual Labor Day weekend show (1980). This annual show is being moved to the Fourth of July. In the next 5 years, a hotel and World Conference Center are scheduled for completion on the property.

The Arrowwood Industrial Park, which was included in the FES-CP, has grown to about 120 different firms and a total of 11,000 employees. No other significant changes have occurred from the descriptions in the FES-CP.

4.3.7 Historic and Archeologic Sites

These topics are described in Sections 2.3 and 4.2 of the FES-CP. The sites listed on the National Register of Historic Places (U.S. Department of the Interior, 1976, and subsequent listings) and within 16 km (10 mi) of the station included: The White House, Ebenezer Academy, Tillman Hall, and the McCorkle-Fewell-Long House. All are in Rock Hill, and over 6 mi from the station. The Catawba-Ripp 230-kV line passes within a half mile of the Kings Mountain National Military Park and the Kings Mountain State Park. The National Military Park is in the National Register.

The only changes in archeologic information since the issuance of the FES-CP, was the result of the transmission corridors being archeologically surveyed. A site in the Catawba-Newport (East) 230-kV line was considered potentially eligible for nomination to the National Register of Historic Places (Brockington, 1980). The site, which was identified as a Late Archaic campsite where animals were butchered, was further tested after tower placement. The conclusion of that study was that no further investigation of the site was recommended in conjunction with the Catawba transmission line project (Canouts, 1980).

4.4 REFERENCES

Adensam E. G., NRC, letter to W. Hicklin, U.S. Fish and Wildlife Service, Ashville, NC, Subject: Catawba Nuclear Station, Units 1 and 2 - Environmental Impact Statement, September 1, 1981.

Brockington, Jr., P. E., "Test Pits in the Piedmont: An Archeological Survey of Duke Power Company's Proposed Catawba Transmission Lines," Institute of Archeology and Anthropology, University of South Carolina, Columbia, SC, August 1980 (Contained in ER-OL, Appendix 2).

Canouts, V., "The Archeological Testing Program at Site 38YK72," Institute of Archeology and Anthropology, University of South Carolina, Columbia, SC, August 1980 (Contained in ER-OL, Appendix 2).

Changery, M. J., "National Thunderstorm Frequencies for the Contiguous United States" NUREG/CR-2252, National Climatic Center, NOAA, Asheville, NC, November 1981.

Collette, B. B. "The Swamp Darters of the Subgenus Hololepis (Pisces, Percidae)," Tulane Studies in Zoology 9(4): 115-211, 1962.

Dail, L. C., Duke Power Company, letter to W. H. Regan, Jr., NRC, Subject: Environmental Report, Docket No. 50-413/414, January 5, 1977.

Duke Power Company, "Catawba Nuclear Station Terrestrial Studies," January 1975.

Federal Register Notice, 43 FR 6030, "Floodplain Management Guidelines for Implementing E.O. 11988," U.S. Water Resources Council, February 10, 1978.

Industrial BIO-TEST Laboratories, Inc., "A Baseline/Predictive Environmental Investigation of Lake Wylie-Catawba Nuclear Station and Plant Allen. Sept. 1973-Aug. 1974," Vol. II, Industrial BIO-TEST Laboratories, Inc., Northbook, IL, p. 387, 1974.

Johnson, D. L., and S. J. de Kozlowski, "Surface Water Resource Investigation of the Catawba-Wateree River System in South Carolina," South Carolina Water Resources Comm. Rept. #134, Columbia, SC, 1981.

Kelly, D. L., J. T. Schaeffer, R. P. McNulty, C. A. Doswell, III, and R. F. Abbey, "An Augmented Tornado Climatology," Monthly Weather Review, 106: 1172-1182, August 1978.

National Climatic Center, "Local Climatological Data, Charlotte, NC - Annual Summary with Comparative Data," National Climatic Center, Environmental Data Service, Asheville, NC, 1976.

Nash, V. S., "Fisheries Investigations in Lakes and Streams, District IV, Study Completion Report July 1, 1975 Through June 30, 1980, Project No. F-11," South Carolina Wildlife and Marine Resources Department, Columbia, SC, 1980.

---, "Lake Wylie Fisherman's Guide." Freshwater Fisheries Section, South Carolina Wildlife and Marine Resources Department, Columbia, SC, Undated.

Parker, W. O., Duke Power Company, letter to J. P. O'Reilly, NRC, Subject: Response to IE Bulletin 81-03 for Catawba Nuclear Station, July 8, 1981.

Ryan, C. L., U.S. Fish and Wildlife Service letter to E. Adensam, NRC, Subject: Response to E. Adensam's Letter of September 1, 1981 Dealing With Threatened and Endangered Species, September 11, 1981.

State of South Carolina Water Resources Commission, Report No. 134. "Surface Water Resource Investigation of the Catawba-Wateree River System in South Carolina," March 1981.

---, State Regulations Part 50-15 Entitled "South Carolina Nongame and Endangered Species Conservation Act 1974."

Thom, H. C. S., "Tornado Probabilities," Monthly Weather Review, pp. 730-736, October-December 1963.

U.S. Department of the Interior, National Park Service, National Register of Historic Places, Volumes 1 and 2 (and subsequent listings as they appear in the Federal Register), Washington, D.C., 1976.

Weiss, C. M., R. H. Cambell, T. P. Anderson, and S. L. Pfander, "The Lower Catawba Lakes - Characterization of Phyto- and Zooplankton Communities and Their Relationships to Environmental Factors," Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina ESE Publication Number 389, Chapel Hill, NC, 1975.

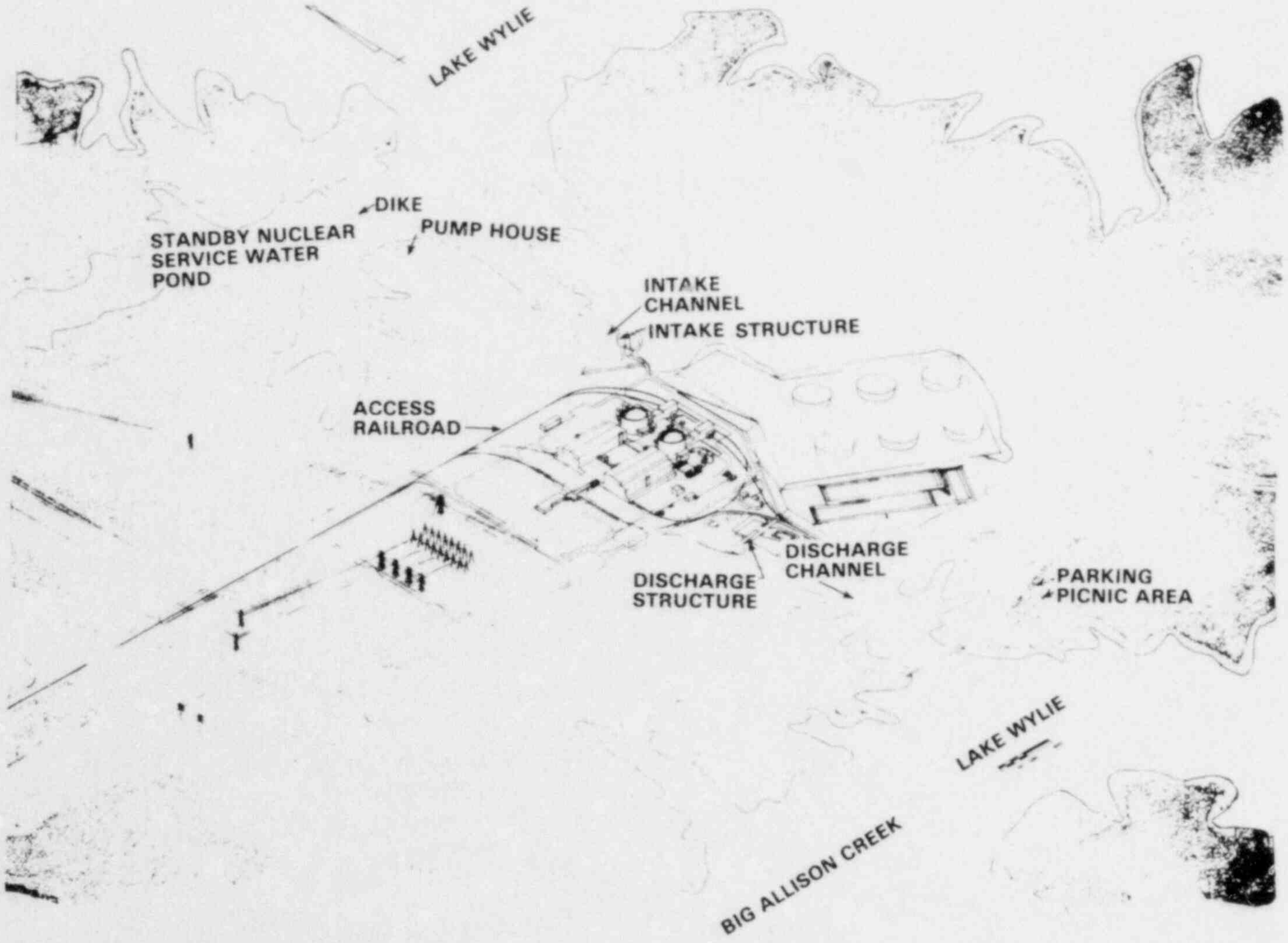

Figure 4.1 Perspective drawing, Catawba Nuclear Station
Source: ER-OL Figure 3.1.0-6, Revision 2

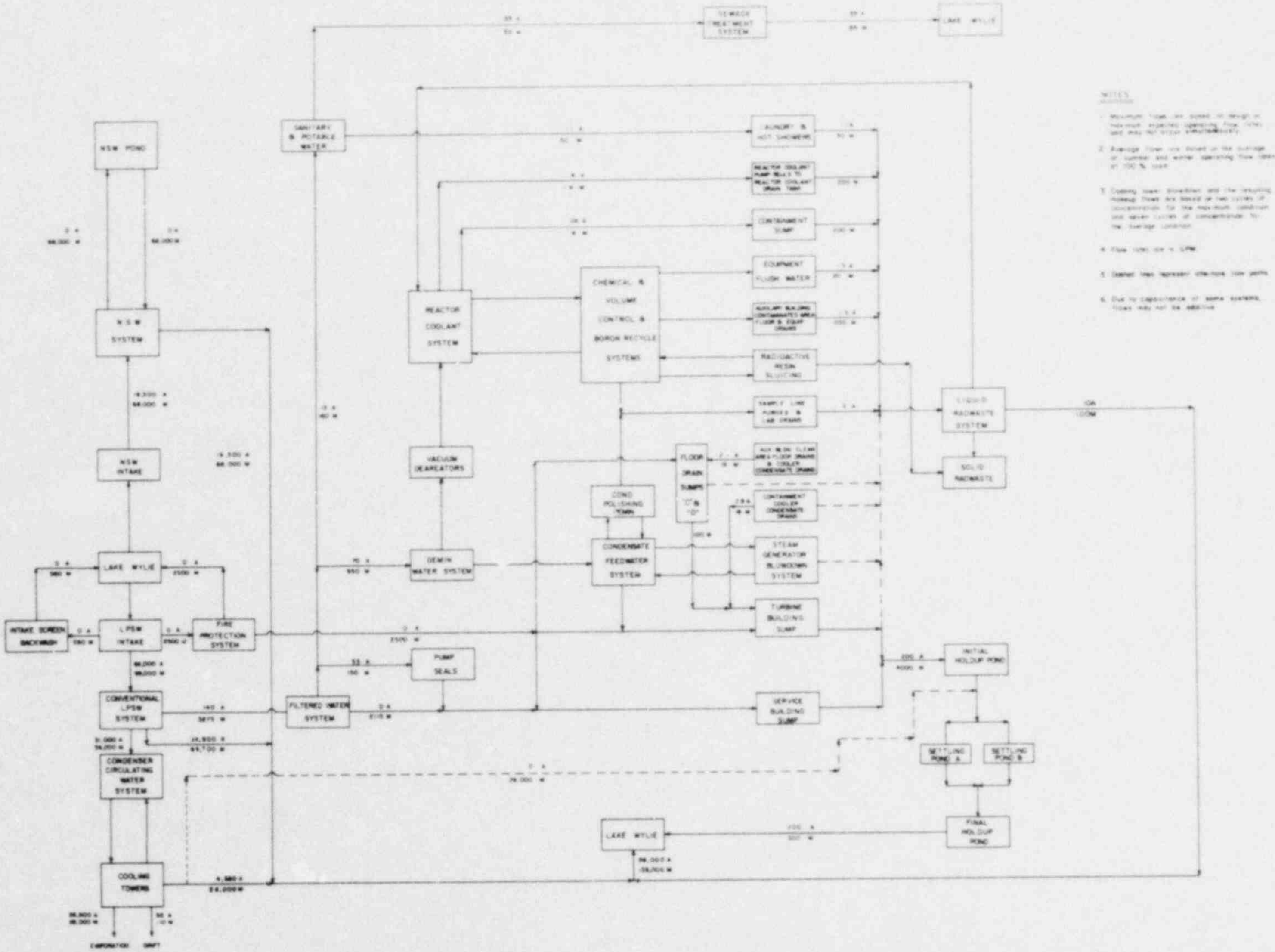

Figure 4.2 Station water use, Catawba Nuclear Station
Source: ER-OL Figure 3.3.1-1, Revision 2

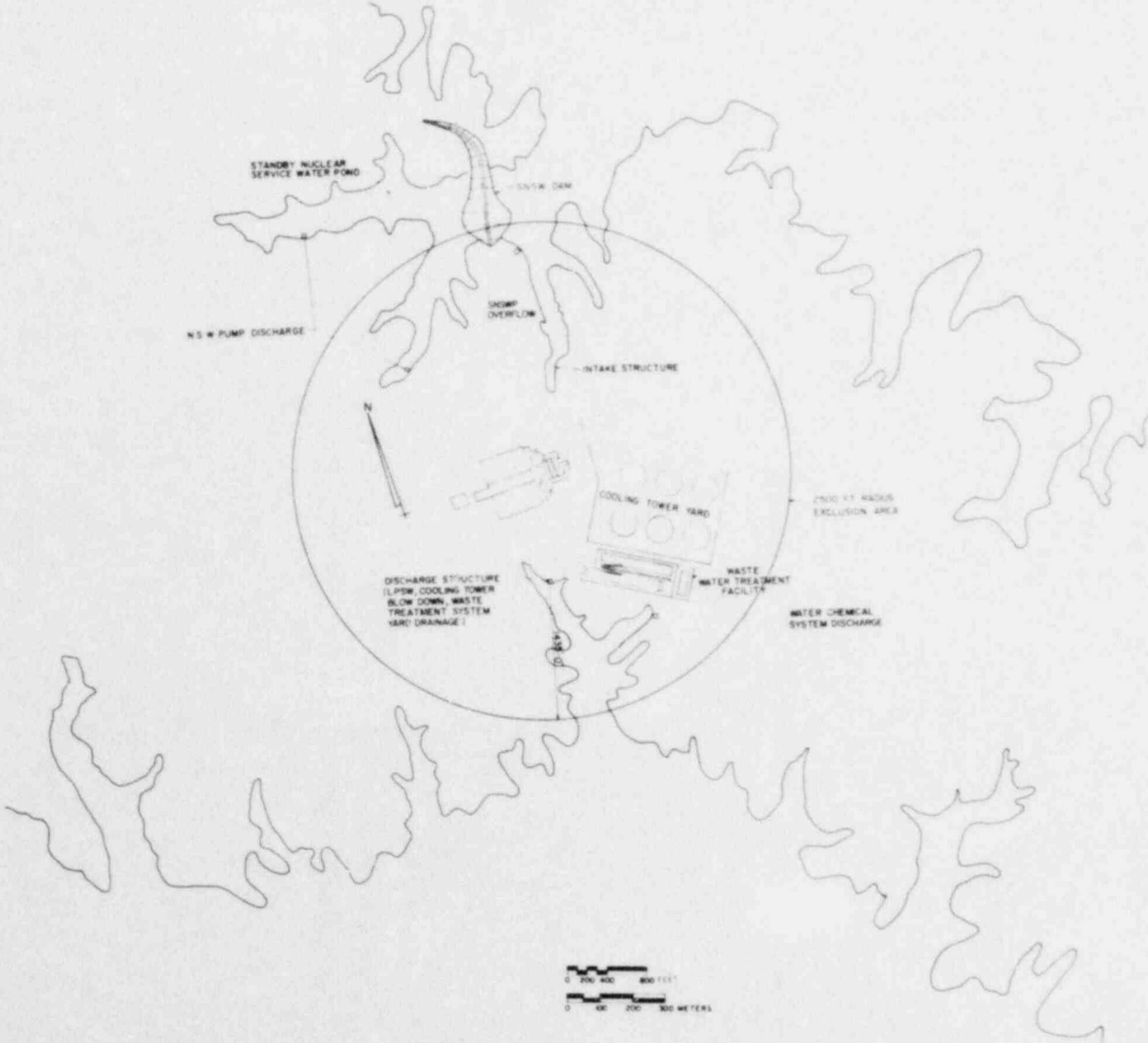

Figure 4.3 Nonradiological release points
Source: ER-OL Figure 2.1.1-5, Revision 3

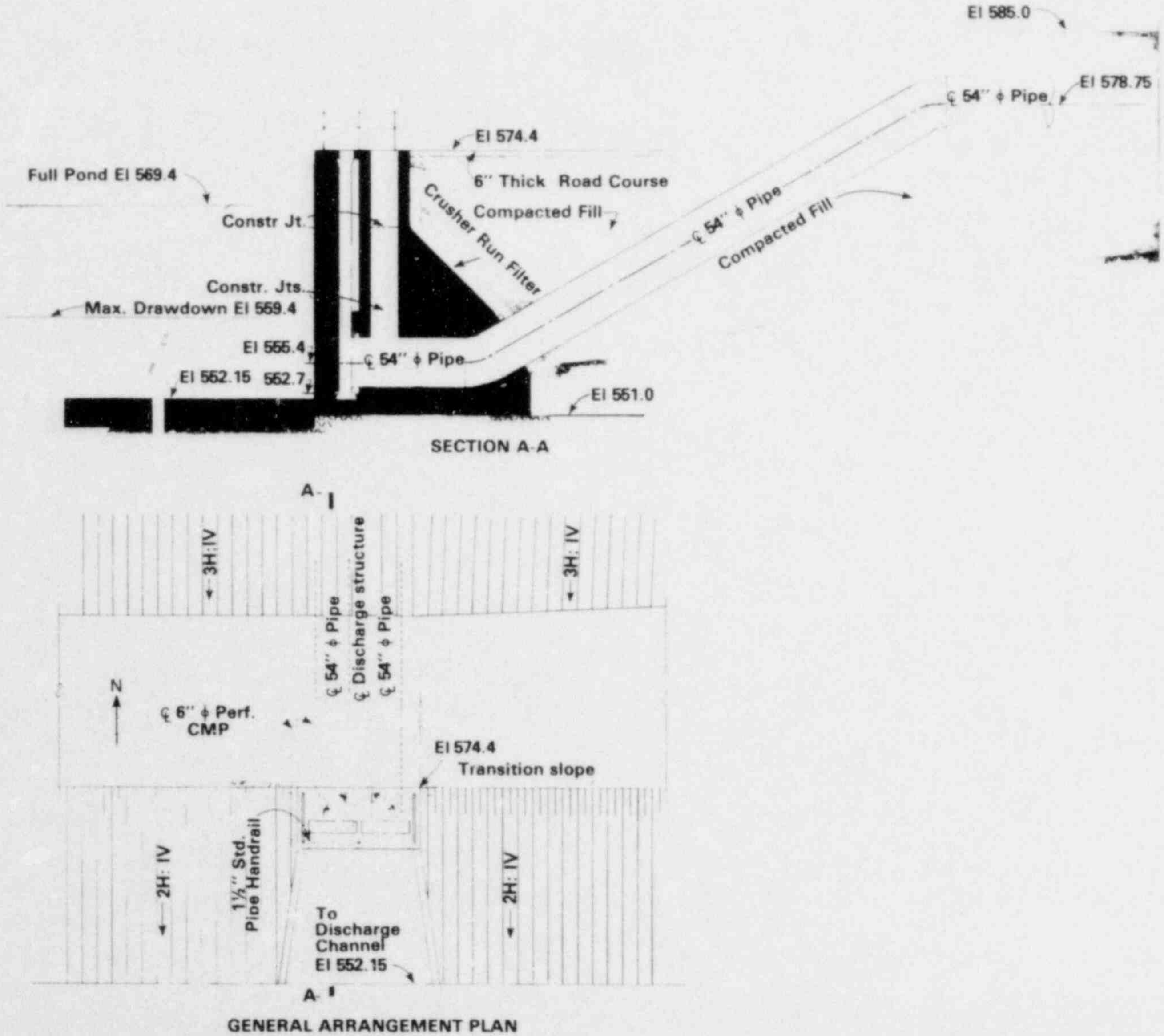

Figure 4.4 Low-pressure service water discharge structure
Source: ER-OL Figure 3.4.4-1

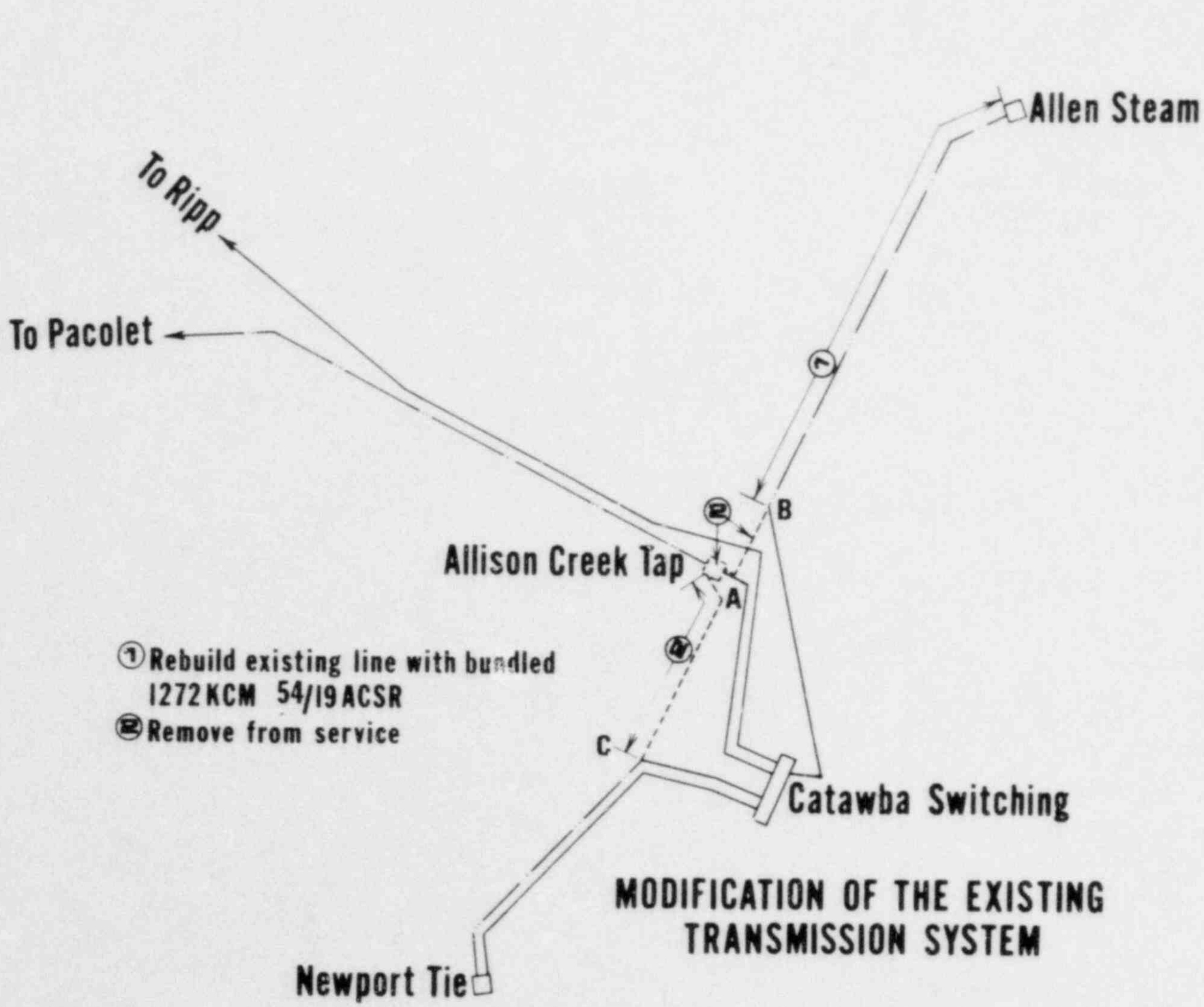

Figure 4.5 Modification of the existing transmission system
Source: ER-OL Figure 4.2.2-1

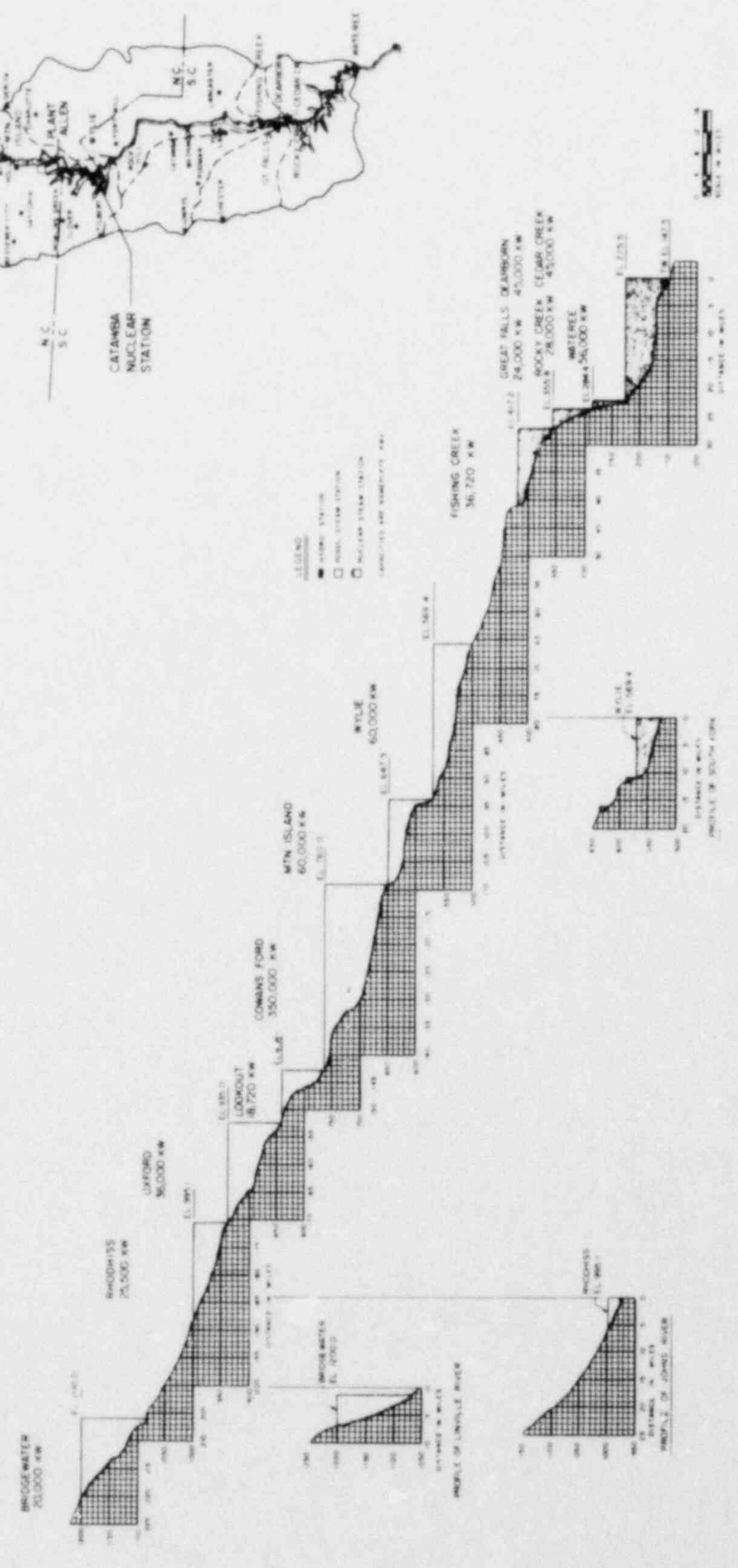

Figure 4.6 Major hydraulic features of the Catawba River drainage basin, Catawba Nuclear Station
Source: ER-OL Figure 2.4.1-1, Revision 1

Table 4.1 Catawba Nuclear Station water use

Title	Average GPM	Average Liter/min	Maximum (1) GPM	Maximum (1) Liter/min
Intakes from Lake Wylie				
I Nuclear Service Water Intake:				
Nuclear Service Water System	16,500	62,400	68,000	257,000
Nuclear Service Water Pond (Regulated)	0	0	68,000	257,000
Total	16,500	62,400	68,000	257,000
II Low Pressure Service Water Intake:				
A. Intake Screen Backwash	0	0	560	2,100
B. Fire Protection	0	0	2,500	9,500
C. Conventional LPSW System				
1. Condenser Circulating Water System				
Cooling Tower Evaporation	26,500	100,000	28,000	106,000
Cooling Tower Drift	55	210	110	420
Cooling Tower Blowdown	4,360	16,500	28,000	106,000
Subtotal	31,000	117,000	56,000	212,000
2. Filtered Water System				
a. Pump Seals	55	210	150	570
b. Demineralized Water System	70	260	950	3,600
c. Sanitary and Potable Water	13	50	160	610
Subtotal	140	530	3,275 (5)	12,400 (5)
3. LPSW Heat Removal and Service Loads	34,900	132,000	64,700	245,000
Total for Conventional Low Pressure Service Water	66,000 (C.1+C.2+C.3)	250,000	99,000 (2)	375,000 (2)
Total for Low Pressure Service Water Intake (A+B+C)	66,000	250,000	102,000	386,000
Total for Intake From Lake Wylie (Nuclear Service Water plus Low Pressure Service Water Intakes)	~82,000	310,000	~170,000	640,000

Source: ER-OL Table 3.3.1-1

Table 4.1 (Continued)

Title	Average (GPM)	Average Liter/min	Maximum (1) (GPM)	Maximum (1) Liter/min
Discharges to Lake Wylie				
I. From LPSW and NSW Intake				
From Cooling Towers	4,360	16,500	28,000	106,000
From NWS System	16,500	62,500	68,000	257,000
From Liquid Radwaste System	10	38	100	380
From Conventional LPSW System	34,900	132,000	64,700	257,000
Subtotal	~56,000	~212,000 (3)	~139,000	~526,000 (4)
II. From Sewage Treatment System	35	132	55	208
III. From Final Holdup Pond	200	760	300	1,100
Total Discharges to Lake Wylie (I+II+III)	~56,000	~212,000	~139,000	~526,000

NOTES:

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

Source: ER-OL Table 3.3.1-1

Table 4.2 Lake Wy[illegible] structure areas and water velocities for Catawba Nuclear Station

Area*	Velocity**
Full pond (el. 172.8 m (569.4 ft)	
Gross opening 28.4 m^2 (306.0 ft^2)	0.07 m/s (0.24 fps)
Through trashcracks 20.8 m^2 (224.3 ft^2)	0.10 m/s (0.33 fps)
Through screens 14.7 m^2 (158.6 ft^2)	0.14 m/s (0.47 fps)
Maximum drawdown (el 170.5 m (559.4 ft)	
Gross opening 18.1 m^2 (194.3 ft^2)	0.12 m/s (0.38 fps)
Though trashracks 13.2 m^2 (141.9 ft^2)	0.16 m/s (0.53 fps)
Though screens 9.4 m^2 (100.7 ft^2)	0.23 m/s (0.74 fps)

*Areas given are for each pump bay. There is one pump per bay. Two-unit operation will use two pumps and twice the area indicated.

**Velocities based on average water flow at 100% power operation.

Source: ER-OL Section 3.4

Table 4.3 Data on circular mechanical draft cooling towers for Catawba Nuclear Station

Number of towers	6 (3 per unit)
Number of fans/tower	13
Height	21.3 m (70 ft)
Basin diameter	77.4 m (254 ft)
Outside diameter	82.9 m (272 ft)
Drift rate (% of circulating water flow rate)	0.008%
Cooling range (summer design conditions	12.8°C (22.9°F)
Cooling tower basin temperature (summer design condition)	31.4°C (88.6°F)
Exit air temperature	38.9°C (102.1°F)

Sources: ER-OL Section 3.4; ER-OL Table 3.4.1-1; and ER-OL, Table 10.1.1-3.

Table 4.4 Catawba Nuclear Station waste water discharge

Parameter	Conc Units	Average Intake Conc	Cooling Tower Blowdown Average Conc (1)	Conventional Waste Water Treatment Avg Conc (3)	Incremental Concentrations: Dis Cove Avg Conc (4)	Incremental Concentrations: Lake Wylie Max Conc (5)	Incremental Concentrations: Lake Wylie Avg Conc (5)
Alkalinity as $CaCO_3$	mg/l	15	24(2)	10	1.5	0.28	.04
Boric Acid as B,	µg/l			12.5	44.3	.01	--
Hardness as $CaCO_3$	mg/l	16	112	12	6.7	1.3	.19
Calcium, Ca,	mg/l	3.5	25	2.5	1.5	0.29	.04
Magnesium, Mg,	mg/l	1.5	10.5	1.3	0.6	0.12	.02
Sodium, Na,	mg/l	7.3	72	70	4.6	0.9	.13
Potassium, K,	mg/l	1.8	13	1.3	0.8	0.15	.02
Aluminum, Al,	mg/l	1.6	11	2.1	0.7	0.13	.02
Iron, Fe,	mg/l	1.2	8.4	0.8	0.5	0.10	.01
Manganese, Mn,	mg/l	0.18	1.3	0.12	0.1	0.01	--
Cadmium, Cd,	µg/l	1.0	7	--	0.4	--	--
Chromium, Cr,	µg/l	6	42	--	2.5	0.5	--
Copper, Cu,	µg/l	5	35	--	2.1	0.4	--
Lead, Pb,	µg/l	3	21	--	1.3	--	--
Nickel, Ni,	µg/l	11	77	--	4.6	0.9	--
Zinc, Zn,	µg/l	19	134	--	8.0	1.6	--
Ammonia, N,	mg/l	0.19	1.3	1.1	0.1	0.01	--
Nitrate-Nitrite, N,	mg/l	0.28	2.0	2	0.1	0.02	--
Chloride, Cl,	mg/l	6.5	78	15	4.7	0.9	.13
Fluoride, F,	mg/l	0.15	1.0	0.12	0.1	0.01	--
Phosphorus, Total P.	µg/l	56	392	0.6	25.4	5	--
Silicon, Si,	mg/l	4.2	29	3.3	1.8	0.34	.05
Sulfate, SO_4,	mg/l	10	194(2)	141	12.1	3.3	.34
Suspended Solids	mg/l	10	70	16	4.2	0.82	.12
Dissolved Solids	mg/l	60	600	317	36.9	7	1.0
Total Organic Carbon	mg/l	3.1	22	9	1.3	0.26	.04
Detergents	µg/l			5.4	19.2	--	--
Ethylene Glycol	µg/l			0.5	1.9	--	--
Hydrazine	µg/l			1.0	3.5	--	--

1. Maximum is at design load, 2 cycles concentration, and average June meteorology. Average is at 76% capacity factor, 7 cycles, and annual average meteorology.
2. Alkalinity is treated with sulfuric acid.
3. Average is for 115 regenerations/year, with caustic recycle, and 8 wet layups a year including sanitary sewage 35 gpm average flow
4. Incremental concentrations in the discharge cove estimates average station wastes in a flow of 56,200 gpm (125.2 cfs).
5. Incremental concentrations in Lake Wylie are based on average station waste discharges and a flushing flow through the reservoir. The maximum incremental concentration is based on the 7-Q-10 flow of 648 cfs, and average incremental concentration is based on the average flow of 4445 cfs.

Source: ER-OL Table 3.6.1-2

Table 4.5 Catawba Nuclear Station conventional waste water treatment system effluent analysis

Design Parameter Units	Normal Range	Limit
pH	7.0-8.0	6.0-9.0[1]
Total Suspended Solids, mg/l	$\leq$30	100[1]
Biological Oxygen Demand, mg/l	$\leq$5	10[2]
Chemical Oxygen Demand, mg/l	$\leq$10	20[2]
Dissolved Oxygen, mg/l	$\geq$5	4[2]
Fe, mg/l	<1	1[1]
Cu, mg/l	<1	1[1]
Mn, mg/l	<0.5	0.5[2]

[1] 40 CFR 423 - EPA effluent guidelines and standards for steam electric power generating

[2] Design Criteria

Source: ER-OL Table 3.6.1-1

Table 4.6 Catawba Nuclear Station transmission line additions

	Catawba-Allen	Catawba-Ripp	Catawba Pacolet	Catawba-Newport (Allison Creek B&W)	Catawba-Newport (Newport B&W)	Totals
Total R/W Length-mi(km)	10.9(17.5)	24.4(39.3)	41.3(66.5)	5.2(8.3)	5.2(8.3)	86.9(139.8)
New R/W Length-mi(km)	1.3(2.1)	24.4(39.3)	1.2(1.9)	0.7(1.1)	0.7(1.1)	28.4(45.7)
Total R/W-ac(ha)	197.6(80.0)	426.2(172.5)	750.7(303.8)	93.6(37.9)	72.6(29.4)	1540.7(623.6)
Total New R/W-ac(ha)	23.8(9.6)	426.2(172.5)	22.2(9.0)	12.7(5.1)	10.2(4.1)	495.1(200.3)
Forest-ac(ha)	11.5(4.6)	323.5(130.9)	10.4(4.2)	7.7(3.1)	5.9(2.4)	359.0(145.2)
-% of total New R/W	48.2	75.0	46.8	60.5	57.8	72.5
Pasture & Agriculture -ac(ha)	0	94.2(38.1)	1.6(0.6)	0	0	95.8(38.7)
-% of Total New R/W	0	22.1	7.0	0	0	19.3
Cleared for Catawba Nuclear -ac(ha)	12.4(5.0)	8.5(3.4)	10.3(4.2)	4.2(1.7)	3.6(1.5)	39.0(15.8)
-% of Total New R/W	51.8	2.0	46.2	32.9	35.4	7.9
Water Crossings-ac(ha)	0	0	0	0.8(0.3)	0.7(0.3)	1.5(0.6)
-% of Total New R/W	0	0	0	6.6	6.8	0.3
Total New Cleared R/W -ac(ha)	11.5(4.6)	323.5(130.9)	10.4(4.2)	7.7(3.1)	5.9(2.4)	359.0(145.2)
Man-Made Structures Removed		0	2	0	0	0 2
R/R Crossings on New R/W-#		1	2	1	0	0 4
Hwy. Crossings on New R/W-#	0	5	0	0	1	6

Source: ER-OL, Table 3.9.1-1

5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

This résumé highlights changes in the staff's evaluation of the environmental effects of operating Catawba Nuclear Station in the light of information gained since the FES-CP was issued in 1973. No discussion is provided of those impacts for which there has been no new information or change since the construction review.

Land-use impacts are addressed in Section 5.2.1, and transmission line impacts as a result of the operation of Catawba station are evaluated in Section 5.2.2. Water use and hydrological impacts are updated in Sections 5.3.1 and 5.3.2, respectively. The impact of Catawba station on the Catawba River floodplain is evaluated in Section 5.3.3 pursuant to Executive Order 11988, which was promulgated after the FES-CP was issued. Effects of fogging, icing, and other emissions are updated in Sections 5.4.1 and 5.4.2. Terrestrial and aquatic ecology are reviewed and updated in Sections 5.5.1 and 5.5.2, and the effects of thermal discharge on biota are discussed in Section 5.5.2.2. The effects of the operation of Catawba station on historic and archeologic sites are reviewed in Section 5.7; socioeconomic effects are updated in Section 5.8. Information on radiological impacts of normal operation has been revised in Section 5.9 to reflect updated knowledge gained since the FES-CP was issued. Section 5.9.4 on postulated plant accidents now contains information that has been revised and updated to include Class 9 accidents and the lessons learned from the accident at Three Mile Island, Unit 2 (TMI-2). The latest information on environmental effects of the uranium fuel cycle and decommissioning is provided.

Operational monitoring programs are to be conducted in accordance with the Environmental Protection Plan (EPP) and the Environmental Technical Specifications for radiological monitoring to be issued by NRC as part of the operating license. The EPP will require the applicant, as licensee, to (1) notify NRC if changes in plant design or operation occur, or if tests or experiments affecting the environment are performed, provided that such changes, tests, or experiments involve an unreviewed environmental question; (2) maintain specific environmentally related records; (3) report violations of conditions stated in the NPDES permit or State certification pursuant to Section 401 of the Clean Water Act; (4) report unusual or important environmental events; and (5) monitor potential effects of cooling tower drift.

5.2 Land Use

5.2.1 Plant Site

Land use impacts from the operation of the station are discussed in Section 5.1 of the FES-CP. No significant changes are expected from those discussed at the CP stage of review.

5.2.2 Transmission Lines

Environmental impacts that typically could be associated with the operation of transmission lines are caused by (1) ozone production, (2) induced electrical currents, (3) electric fields, and (4) corridor maintenance. The amount of ozone produced by transmission lines has been determined to be so small that ozone poses no detrimental environmental threat.

There have been several recent studies of health effects on humans from electric fields associated with transmission lines. Although experimental work is still under way on the biological effects of electric fields along extra high voltage (EHV) transmission lines, the staff has found no major effects associated with the operation of the lower voltage (230 kV) lines as proposed by the applicant.

The applicant has designed the station-related portion of his transmission system in accordance with practices approved by the National Electric Safety Code (1977 edition) to ensure the safeguarding of persons from hazards resulting from the operation of overhead lines.

About 72% of the transmission line corridors pass through forested land. This means that about 145 ha (359 acres) will have to be maintained in a nonforested condition. This will be accomplished primarily by bush-hogging with some hand- or power-saw felling of large saplings. No herbicides are used. Because a vegetative cover is maintained, soil erosion should be minimal and wildlife habitat maintained.

5.3 Water

5.3.1 Use

5.3.1.1 Surface Water

Catawba Nuclear Station water supply will be derived from Lake Wylie. As described in Section 4.2.3, withdrawal rates for average and maximum meteorological conditions will be 312,000 l/min (82,000 gpm) and 643,000 l/min (170,000 gpm), respectively. Approximately 33% of the water withdrawn from Lake Wylie for station use will be lost to the atmosphere from operation of the cooling towers. The remaining water will be discharged back into Lake Wylie.

The present average daily surface water withdrawals from the Catawba River within 32 km (20 mi) upstream and 80 km (50 mi) downstream of the site are 333,000 l/min (88,000 gpm). The present consumptive water use of Catawba River water is estimated to be about 38,900 l/min (10,300 gpm). With the operation of the Catawba station the present average daily water withdrawals from the Catawba River in this region will almost double; however, the withdrawals will only be about 8% of the average daily flow at the Rock Hill gaging station (see Table 5.1). The present consumptive water use from the Catawba River in the region will increase from an estimated 38,900 l/min (10,300 gpm) to 140,900 l/min (37,200 gpm) with plant operation. This is less than 2% of the average daily flow at the Rock Hill gaging station.

As described in Section 4.3.1.1, the applicant has estimated the 7-day once-in-10-year low flow into Lake Wylie to be 14.6 m^3/sec (516 cfs = 8.77×10^5 l/min = 2.23×10^5 gpm). The station consumptive use will be about 11% of the 7-day once-in-10-year low flow (see Table 5.2). The total average daily consumptive water use from the Catawba River in the site region will be about 16% of the 7-day once-in-10-year low flow entering Lake Wylie.

Based on the above analysis the staff concludes that operation of the Catawba Nuclear Station will not have an adverse effect on regional water use from the Catawba River. This primarily is due to the large storage volume of Lake Wylie and the upstream control on the Catawba River provided by six dams with approximately 1.9×1^9 m^3 (1.5×10^6 acre-ft) of water storage.

5.3.1.2 Groundwater

Operation of the Catawba Nuclear Station will be sustained by water obtained from Lake Wylie. No groundwater will be used for operation of the station. A groundwater drainage system at the base of the foundation mat and basement walls of the auxiliary and reactor buildings will alter the groundwater gradient for a maximum distance of a few hundred feet around the buildings. The changes in the groundwater gradients will be within the station property boundaries and will not affect domestic groundwater wells in the vicinity of the site.

5.3.2 Water Quality

5.3.2.1 General

Water quality impacts in Lake Wylie may be caused by chemical and other wastes in the station effluent discharged during preoperational cleaning and operation. The potential for impacts to receiving water quality were assessed during the construction permit environmental review (FES-CP Sections 5.5.2.2 and 5.5.2.3). There have been changes in the volume and concentration of wastes in the station effluent as a result of changes in station design and environmental data (see Sections 4.2.6 and 4.3.2). The resulting changes in potential water quality impacts are examined below.

5.3.2.2 Surface Water

The applicant performed a thermal plume analysis on the combined service water and cooling tower blowdown releases into the Allison Creek arm of Lake Wylie. Thermal plume areas resulting from the discharge were computed for the winter with a discharge flow of 2249 l/sec (29,800 gpm) and a temperature rise of 8.6C° (15.5F°) above ambient temperature and for the summer with a discharge flow of 3242 l/sec (51,400 gpm) and a temperature rise of 4.7C° (8.5F°) above ambient temperature. Areas enclosed by the 2.8C° (5F°) isotherm above ambient lake temperatures and the 32.2°C (90°F) isotherm, with the percent of lake surface area affected, are presented on a seasonal basis in Table 5.3 for average and worst-case conditions.

Under worst-case winter (February) conditions the 2.8C° (5F°) above ambient isotherm would extend from the mouth of the discharge cove to less than 914 m (3000 ft) downstream and to 244 m (800 ft) upstream of the Allison Creek arm of Lake Wylie. This would represent less than 1.1% of the total lake area. Under average winter conditions it would affect only 0.7% of the total lake area. Under worst-case summer (August) conditions the 2.8C° (5F°) above ambient isotherm would be confined almost entirely to the discharge cove and the 32.2°C (90°F) isotherm would extend from the mouth of the discharge cove to less than 914 m (3000 ft) downstream and to 244 m (800 ft) upstream of the Allison Creek arm of Lake Wylie. This would represent an area bounded by the 32.2°C (90°F) isotherm of about 40 ha (100 acres) or 1.1% of the total lake area. Under average summer conditions the 32.2°C (90°F) isotherm would enclose 2 ha (5 acres) or 0.1% of the total lake area.

The South Carolina water quality standards require that fresh waters, other than those classified as trout habitat, not exceed 32.2°C (90°F) at any time and that temperature increases as a result of pollutant discharges be limited to 2.8C° (5.0F°) above natural temperatures, as a weekly average. Thus, the areas given above for the station under worst-case and average conditions represent the areas of Lake Wylie that would not be in compliance with water quality standards. The South Carolina Department of Health and Environmental Control has issued a National Pollutant Discharge Elimination System (NPDES) Permit for the station (Appendix I). This permit does not limit the station discharge temperature during operation or the resulting area of Lake Wylie subject to temperatures higher than those specified in the State water quality standards. However, station design, consisting of a closed cycle cooling with "cold side blowdown" (i.e., diversion of blowdown at a point in the flow path beyond passage through the cooling towers) will tend to minimize discharge of heated water from the facility.

The revised estimates of the average and maximum concentrations of wastes to be discharged to Lake Wylie by Catawba Nuclear Station during operation are given in Tables 4.4 and 4.5. With regard to average station effluent characteristics (from the cooling tower blowdown, the conventional waste water treatment system, and the sanitary waste treatment system), most of the changes are increases (see FES-CP Table 3.13 for comparison). The increases are projected for concentrations of iron, magnesium, potassium, sodium, chloride, fluoride, sulfate, hardness, and total dissolved solids. These changes are a result of changes in the estimated ambient Lake Wylie concentration of dissolved substances, changes in station water flow rates, and changes in station wastewater treatment. These same parameters are estimated to have higher incremental concentrations in Lake Wylie than projected in the FES-CP. This is due to the factors given above for the effluent levels and also due to a lower estimate of the flushing flow through the reservoir (648 cfs versus 713 cfs in the FES-CP). The staff has examined the levels of these parameters reported for the ambient conditions in Lake Wylie and the levels projected to exist in the Big Allison Creek arm of the lake and in the lake proper when station operation begins. With the possible exception of total iron, none of these constituents are currently, nor are they expected (upon station operation), to reach levels inconsistent with the designated uses assigned to Lake Wylie by the South Carolina Water Resources Commission (March 1981). Although earlier data from the applicant showed total iron concentration to average above 1.0 mg/l (that is, the value identified for protection of fresh aquatic life), the applicant's latest data show a decrease in average total iron concentration in Lake Wylie to a level below this identified value. Also, none of these parameters are currently, nor are they projected to become (upon station operation), in violation of State water quality standards.

Some constituents in the station effluents are now projected to be discharged in concentrations less than those evaluated in the FES-CP (although these concentrations represent increases over ambient levels). Included in this group are nutrients nitrate-nitrite-N, total phosphorus, and silica.

The NPDES permit (Appendix I) issued by the State for station operation has expired, but has been administratively extended, pending finalization of Effluent Guidelines and New Source Performance Standards by the U.S. Environmental Protection Agency. The staff has examined the effluent limitations and other requirements of the permit and compared them to the proposed mode of operation of the station. The staff concludes that

(1) Compliance with the limitations on cooling tower blowdown and service water discharge is likely without change or mitigation, based on the applicant's commitments to hold up blowdown to allow for residual chlorine concentration decay to a level below that in the permit and the current plans to not chlorinate the once through cooling waters (Section 4.2.6). The staff also notes that the applicant will be required, as a part of the NPDES permit, to conduct "an internal evaluation of practicable methods to reduce total residual chlorine levels from the combined discharge of cooling tower blowdown, conventional service water and nuclear service water."

(2) Compliance with the conventional waste water treatment system and metal cleaning wastes limitations is likely, based on the applicant's projected effluent analysis (Section 4.2.6) and the staff's review of applicant experience with a similar waste treatment system associated with the McGuire Nuclear Station located upstream on the Catawba River.

(3) Compliance with the sewage treatment limitations is likely, but only with careful control of the tertiary aquaculture effluent polishing lagoon operation. This system has experienced total suspended solids and biochemical oxygen demand levels in the effluent in excess of the NPDES limits (Peacock, 1981). However, corrective actions have been initiated by the applicant to maintain effluent characteristics at or below the permit limits.

The staff concludes, on the comparison of ambient lake water quality, expected discharge quality and quantity, available criteria in the literature, and the analyses presented in the FES-CP that surface water quality impacts caused by operation of Catawba Nuclear Station will be small.

5.3.3 Floodplain Aspects

The objective of the Executive Order 11988, "Floodplain Management" (May 1977), is "...to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative...."

Defining an elevation for a 100-year flood in Lake Wylie is not practical because of the high degree of regulation and storage provided by the six upstream impoundments; however, since portions of the intake and discharge structures are, by design, located below the Lake Wylie water level, these structures can be considered to be in the floodplain. All of the structures located in the floodplain were substantially complete when Executive Order 11988 was signed in

May 1977. Thus the staff concludes that consideration of alternative locations for these structures is neither required nor practicable.

The Catawba Nuclear Station, including the structures located in the floodplain, has been designed to withstand the flooding effects of a standard project flood combined with seismic failure of an upstream dam. This combination of events, which is a more severe event than the 100-year flood, reaches a static water level of 592.4 ft (180.57 m) MSL. Plant grade is at 593.5 ft (180.90 m) MSL. Based on this, the staff concludes that none of the structures located in the floodplain will be affected by flooding caused by a 100-year flood. In addition, the staff concludes that structures located in the floodplain will have a negligible effect on water levels in Lake Wylie during a flood event. This conclusion is based on the small cross sectional area of those structures in relation to the total area of Lake Wylie. The staff, therefore, concludes that the objectives of Executive Order 11988 have been met.

5.4 Air Quality

5.4.1 Fog and Ice

As stated in the FES-CP, atmospheric emissions from the mechanical draft cooling towers will consist primarily of waste heat and water vapor, resulting in conspicuous moisture plumes. When such plumes are near the ground, fogging could be observed. If air temperatures are below 0°C, icing could occur.

The applicant has used observations from the operation of two mechanical draft cooling towers at the nearby Cliffside Plant (located about 64 km (40 mi) northwest of Catawba) as the principal bases for describing atmospheric impacts resulting from cooling tower operation at the Catawba site. Several differences between the Cliffside and Catawba plants and cooling towers should be noted. Total heat load at Cliffside is about 820 MWt, while the total heat load at Catawba is about 4630 MWt. The applicant has estimated the increased moisture output and evaporation at Catawba by a ratio of the total heat loads. Other differences between plants and cooling towers, including number of cooling tower units (two at Cliffside, six at Catawba), and tower shape (rectangular at Cliffside, round at Catawba) could affect initial plume behavior. Both the Cliffside and Catawba plants are in areas with similar climatology (for example, ambient temperatures and mixing heights), although wind direction frequencies are different.

Catawba, like Cliffside, has a high frequency of low wind speed conditions, and ground contact of the plume is expected to be minimal because of the initial bouyancy of the plume. The round shape of the towers at Catawba may enhance the initial bouyancy of the plume compared with those at Cliffside. The applicant maintains that ground contact of the plume at Cliffside has been limited to within 0.3 km (0.2 mi) of the plant. Based on plume observations at Cliffside, the applicant has estimated that the extent of ground level fogging as a result of plume contact should be limited to within 0.8 (0.5 mi) km of the Catawba plant at a frequency of less than 1% per year. Icing is not expected often because of the infrequent occurrence of temperatures less than 0°C.

Steam fog (formed as cold air drifts across relatively warm water) is also of concern, although the horizontal and vertical dimensions of steam fog are not usually large away from the water body. Steam fog in the immediate vicinity of

Lake Wylie could be increased because of higher water temperatures, particularly in the vicinity of the plant discharge.

Based on observations made at Cliffside and adjusted to reflect wind direction frequencies for Catawba, the applicant has estimated the frequency and length of visible cooling tower plumes in the vicinity of Catawba (see ER Figures 5.1.4-1 and 5.1.4-2). The applicant estimates that the visible plume will be mostly confined to within 5 km (3.1 mi) of the station. The applicant has not specifically addressed the impact of the visible plume on the operation of such facilities as the municipal airport serving Rock Hill (located about 8 km (5 mi) south of the station). However, the applicant expects the impact to be minimal at this location because of the low frequency (about 5% annually) of visible plume extent.

The applicant has modeled the nonvisible humidity plume and determined that during most atmospheric conditions the increases in hourly average surface relative humidity are generally small (5-10%) within 8 km (5 mi) of the plant. Short-term increases of this order are not expected to be discernible from natural variations in relative humidity.

The determination of the atmospheric impact resulting from plant operation will depend almost entirely on comparison of the results of a preoperational (baseline) monitoring program with the results of a postoperational monitoring program. The preoperational program (described in Section 5.14.3) included fog observations and visibility monitoring at selected locations. The postoperational program (also described in Section 5.14.3) will include the same types of observations and visibility monitoring. The staff is assessing the adequacy of the monitoring programs. Any changes to the postoperational program will be included in Section 5.14.3 of the FES. The staff will evaluate the results of the preoperational and postoperational monitoring programs to determine the need for continued monitoring and/or mitigating actions to lessen the atmospheric impact of plant operation.

5.4.2 Other Emissions

As stated in the FES-CP, nonradioactive pollutants (for example, SO_2 and NO_x) produced by operation of emergency and safe shutdown diesel engines should not have a significant impact on air quality in the vicinity of the plant if fuels with relatively low sulfur content are used.

5.5 Ecology

5.5.1 Terrestrial Ecology

The terrestrial ecology impacts that were expected to be caused by operation of the plant were assessed during the construction-permit review (FES-CP Section 5.4.1). No additional impacts are expected to occur that were not considered at the construction-permit stage.

5.5.1.1 Cooling Tower Emissions

Salt drift is the principal component of cooling tower emissions. Drift deposition has the potential for adversely affecting plants, but tolerance levels of native plants, ornamentals, and crops are not known with precision. Experiments simulating drift deposition on plants indicate that some species have threshholds for visible leaf damage in the range of 10 to 20 kg/ha/month (9 to 18 lb/acre/month) of NaCl applied to the leaves during the growing season (NUREG/CR-1231). These effects can be altered by frequency of rainfall, humidity, type of salt, and sensitivity of species.

The applicant's predicted maximum NaCl deposition rate expressed on a monthly basis (2-3 kg/ha/month or 2-3 lb/acre/month) should not cause visible injury to the plants even in the areas of maximum deposition (NE and SW sectors). Further, these predicted deposition rates should not cause changes in the floral composition of the areas' vegetation. However, because of the uncertainty concerning the quantity of drift to be released (this quantity is based on a model not actual measurements) from the cooling towers and the uncertainty of threshhold levels of injury for the local flora a monitoring program will be required to detect any possible damage to the local flora caused by drift deposition. The monitoring program is specified in Section 5.14.1.

5.5.2 Aquatic

5.5.2.1 Impingement and Entrainment

The biological effects on aquatic organisms inhabiting Lake Wylie as a result of the withdrawal of water for the Catawba station heat dissipation system cannot be predicted with accuracy. Losses of aquatic life associated with the intake structure and withdrawal of water are a result of impingement and entrainment. Organisms small enough to pass through the 1-cm (3/8-in.) mesh intake screens will be entrained into the station heat dissipation system and subjected to elevated temperatures, changes in pressure, high flow velocities, and biocides. Organisms that are unable to resist the flow and are drawn into the intake structure that are too large to pass through the intake screens will be impinged. Organisms impinged on the screens and unable to escape will ultimately die and will be removed through the screen wash system for disposal.

Impingement

The flow velocities in the vicinity of the intake vary with station operation levels and Lake Wylie pond elevation. At full-pond elevation and both units at full power, the flow rate through the trashracks is 10 cm/sec (0.33 fps) and through the intake traveling screens is 14 cm/sec (0.47 fps). At the maximum lake drawdown and at full power for both units, the flow through the trashracks is 16 cm/sec (0.53 fps) and through the intake traveling screens is 23 cm/sec (0.74 fps) (ER, Section 3.4.3). The volume of water withdrawn also is a factor that influences impingement rates. The amount of water withdrawn is dependent on the station power level. If both units are operating at full capacity, the amount of water withdrawn through the low pressure service water intake structure is expected to average 4.2 m^3/sec (147 cfs) with a maximum of 6.4 m^3/sec (227 cfs) (ER-OL, Section 3.3).

Impingment of aquatic organisms will be limited almost exclusively to fish. Predicting, with accuracy, which species and the numbers of individuals that will be affected is difficult. Duke Power Company has a five-unit fossil station, Allen Steam Plant, on Lake Wylie north of the Catawba station. Intake velocities at Plant Allen (Edwards et al., 1976) vary by unit, power level, and pond level from 4.57 cm/sec (0.15 ft/sec) to 18.9 (0.62 ft/sec). Maximum flow rate is 35 m^3/sec (1236 cfs). Therefore, intake velocities are slightly less than that at the Catawba station, but the Plant Allen maximum flow rate is 5 times greater than that expected at Catawba station. Between October 1973 and September 1974, Plant Allen conducted an impingement monitoring program, the results (Edwards et al., 1976) of which may be used to aid in the evaluation of the potential impact of Catawba station. At Plant Allen a total of 55,762 fish were collected from the intake screens during the study period. Threadfin shad accounted for 98.6% of the total catch. The remaining 1.4% of the fish impinged were primarily gizzard shad, channel catfish, and bluegill. About 92% of all the threadfin shad taken were collected between November 1973 and January 1974. The high threadfin shad impingement rates during this period are attributed to natural cold-induced mortality and disequilibrium resulting from the fall cooldown of the lake. The stressed threadfin shad are unable to maintain their equilibrium or orient to the flow and are therefore impinged. The estimated number of all species of fish impinged per day calculated on a seasonal basis ranged from 195 to 5235 for the spring and the fall, respectively (Edwards et al., 1976).

Similar relative abundance by species is expected to be impinged at the Catawba station; however, the actual number of individuals is expected to be significantly lower because of the much lower volume of water withdrawn from the lake. Although siting the intake at the end of a cove is less preferable than the recessed shoreline intake at Plant Allen, the expected losses at the Catawba station are still predicted to be insignificant. Assuming a conservative 50% reduction in non-threadfin shad impingement losses at the Catawba station than was observed at Plant Allen, the annual loss of 42 channel catfish, 156 bluegills, 99 gizzard shad (one-half the Plant Allen losses in 1973-74) will not significantly affect the Lake Wylie fishery for these species. Threadfin shad losses on the order of 27,000 per year (one-half the Plant Allen losses) also are not expected to impact the lake fishery because of the high reproductive capacity of this species and the fact that many of these individuals would be lost to the fishery as a result of cold-induced mortality. The presence of Catawba station will provide a warm water refuge for this species, which will allow many to survive the winter and repopulate the lake in the spring.

It is therefore concluded that impingement as a result of the operation of Catawba station will not detrimentally affect any of the fish species inhabiting Lake Wylie.

Entrainment

Phytoplankton, zooplankton, fish eggs, and larvae are essentially free-floating organisms that are small enough to pass through the intake screens and become entrained through the station cooling systems. A 100% mortality is expected for the 25% of the organisms diverted to the cooling tower makeup stream. The remainder of the organisms will pass through various service water systems and will be subjected to physical and thermal stresses; however, some survival is expected. The percent survival is unknown for organisms entrained through these other station cooling systems; therefore, the staff conservatively estimated 100% mortality of all organisms entrained.

Phytoplankton and zooplankton mortality as a result of entrainment is not expected to be significant to lake populations since both groups of organisms exhibit high reproductive capacities and only about 7% of the flow through Lake Wylie will pass through Catawba station.

Fish eggs and larvae are seasonal and significant impacts to fish populations at other facilities as a result of entrainment have been postulated. Highest larval densities reported from the sampling station nearest the Catawba intake in the 1973-74 study (Industrial BIO-TEST Laboratories, Inc., 1974) were 38.5 larval fish/100 m^3 in early May. Approximately 96% of the larvae collected were identified as shad. The high shad levels were as a result of the high reproductive capacity of the genus and their pelagic nature. The low number of non-shad larvae reported from the 1973-74 study is principally the result of the species' use of bottom nests (Lepomis sp.) overbank and week banks (Ictalurus sp. and Pomoxis sp.) for egg laying (Breder and Rosen, 1966) and the preference of shallow shoreline habitat by the larvae.

Losses of shad larvae as a result of station operation is not anticipated to have a detrimental effect on the Lake Wylie populations. The high reproductive potential of shad and the high natural larval mortality will greatly exceed any mortality as a result of station operation.

Some localized depletion on non-shad fish larvae in the vicinity of the intake cove is expected; however, its effect on lakewide populations is expected to be insignificant.

It is therefore concluded that entrainment of aquatic organisms resulting from the operation of the Catawba station will not detrimentally affect any species inhabiting Lake Wylie.

5.5.2.2 Thermal Discharge

Some loss of phytoplankton and zooplankton entrained in the discharge plume is expected, however, the high regeneration rates exhibited by these organisms will limit areas of depletion to the discharge cove. Studies (Duke Power Company, 1976) conducted at Plant Allen on upper Lake Wylie showed no evidence that the thermal discharge from the fossil plant was causing any shift in the phytoplankton diversity toward more heat-tolerant or nuisance species. Also the discharge of Plant Allen had no overall measurable influence on zooplankton populations in Lake Wylie. Scour of benthic organisms in the vicinity of the discharge plume will occur; however, the area affected will be significantly less than 1% of the total lake bottom.

No significant impact is expected to occur to fishes inhabiting Lake Wylie as a result of the thermal discharge. Fish are highly mobile organisms and are able to avoid unfavorable temperature regimes.

Even under a worst-case condition only about 42.5 ha (105 acres) or 1% of the lake is projected to be more than 2.8°C (5°F) above ambient temperature. During the summer some species of fish will avoid this area while during the winter some species will be attracted. Studies (Duke Power Company, 1976) conducted at Plant Allen, which has a significantly larger thermal discharge plume and is located in upper Lake Wylie, concluded that the sport fishery in Lake Wylie had not been adversely affected by operation of the plant even though summer time monthly average discharge temperature reached 38.7°C (101.6°F). No shift in fish composition from sport to either forage or rough fish was observed in gill netting studies conducted in Lake Wylie outside the Plant Allen discharge cove. Similar lack of observable impact as a result of the thermal plume to fishes inhabiting the lower portions of Lake Wylie is expected.

The potential for cold-shock fish kill during the winter is minor, and the potential for this kill having a detrimental effect on the fish community is insignificant because of small areal extent of the 2.8°C (5°F) isotherm in relation to the area of Lake Wylie and the presence of two units (which lessens the probability of a complete cessation of blowdown because simultaneous outage of two units is less likely than the outage of one unit).

The potential for gas-bubble disease killing a significant number of fish in the area of discharge is minimal because closed-cycle cooling is used. This closed-cycle system is not likely to result in supersaturation of the blowdown. Furthermore, the small size and rapid mixing of the discharge plume minimizes the number of fish that can be exposed to the station discharge and the supersaturated water should it occur.

Because of the small size and rapid mixing of the expected plume in relation to Lake Wylie, the staff concluded that the fishery will not experience any of the following at significant or detectable levels: increased incidence of disease organisms, asynchrony of fish spawning, loss of eggs and larvae as a result of plume entrainment, reduction in forage, or the alteration of migratory or interspecific relationships.

It is, therefore, concluded that the thermal plume from the operation of the Catawba Nuclear Station will not detrimentally affect any species inhabiting Lake Wylie.

5.6 Endangered and Threatened Species

No federally protected endangered or threatened species are known from the Catawba site or vicinity.

For the two species of birds known from the site that are protected by the State of South Carolina, no causal link that could result in a detrimental impact between the operation of the station and either species can be identified. The Carolina darter, *Etheostoma collis collis*, although known from the drainage, has not been taken from Lake Wylie and, therefore, is not known from the site. It is concluded therefore that no impact to species protected by the State will occur.

5.7 Historic and Archeologic Site Impacts

The staff believes that operation of Catawba station will not significantly affect any sites listed or eligible for listing in the *National Register of Historic Places* (U.S. Department of the Interior, 1976, and subsequent listings). An archeologic site located in the Catawba-Newport (East) 230-kV line was originally recommended as being potentially eligible for inclusion in the *National Register of Historic Places*. However, since the site is located in cleared agricultural land, it will not be affected by normal transmission line maintenance and operation such as bush-hogging, tree trimming, etc. A letter from the State archeologist granted archeological clearance for the line (Appendix H).

The Catawba-Ripp 230-kV line near the Kings Mountain National Military Park will have no significant impact on the park. The line is not visible from the roads, trails, monuments, and visitors' center in the park.

A letter from the State historic preservation officer (Appendix H) indicates that no adverse effects on cultural resources will result from the operation of Catawba Station.

5.8 Socioeconomic Impacts

The socioeconomic impacts of plant operation are described in Section 5.6 of the FES-CP. Changes that have occurred in these topic areas since then include a revised estimate of the number of operating personnel to 846. Their annual payroll is estimated to be $14.5 million (1984 dollars). The applicant also estimates that about 200 contractual workers having an annual payroll of $2.6 million (1984 dollars) will be employed at the site during station operation (ER-OL, RQ 310.8). The staff does not expect these personnel or their families to present any significant impacts on the traffic use patterns or on the demand for private and public facilities and services in the area.

It is also estimated that the station will annually spend approximately $1.5 million (1981 dollars) on purchases of goods and services from the York and Mecklenburg counties area (ER-OL, RQ 310.7). Property taxes other than school taxes are not levied against new industry in South Carolina for a period of time dependent upon the size of the investment. For Catawba, this period is 5 years.

Therefore, for the first 5 years of operation, the taxes payable to the school district would be about $20.1 million (1981 dollars) annually. After that, the amount would be $29.2 million (1981 dollars) annually. Both of these amounts represent calculations given in 1981 tax rates. However, since the millage rates are determined so that the local jurisdictions' budgets are to be covered, both the estimated taxes and rates may vary.

The staff anticipates no other significant socioeconomic impact resulting from the station's operation.

5.9 Radiological Impacts

5.9.1 Regulatory Requirements

Nuclear power reactors in the United States must comply with certain regulatory requirements in order to operate. The permissible levels of radiation in unrestricted areas and of radioactivity in effluents to unrestricted areas are recorded in 10 CFR 20. These regulations specify limits on levels of radiation and limits on concentrations of radionuclides in the facility's effluent releases to the air and water (above natural background) under which the reactor must operate. These regulations state that no member of the general public in unrestricted areas shall receive a radiation dose, as a result of facility operation, of more than 0.5 rem in 1 calendar year, or if an individual were continuously present in an area, 2 mrems in any 1 hour or 100 mrems in any 7 consecutive days to the total body. These radiation-dose limits are established to be consistent with considerations of the health and safety of the public.

In addition to the radiation protection standards of 10 CFR 20, there are the license requirements of 10 CFR 50.36a that are to be imposed on licensees in the form of technical specifications on effluents from nuclear power reactors to keep releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, as low as is reasonably achievable (ALARA). Appendix I of 10 CFR 50 provides numerical guidance on dose-design objectives for light-water reactors (LWRs) to meet this ALARA requirement. Applicants for permits to construct and for licenses to operate an LWR shall provide reasonable assurance that the following calculated dose-design objectives will be met for all unrestricted areas: 3 mrems/yr to the total body or 10 mrems/yr to any organ from all pathways of exposure from liquid effluents; 10 mrads/yr gamma radiation or 20 mrads/yr beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems/yr to the total body or 15 mrems/yr to the skin from gaseous effluents; and 15 mrems/yr to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and the particulates.

Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with these design objectives will keep average annual releases of radioactive material in effluents at small percentages of the limits specified in 10 CFR 20 and, in fact, will result in doses generally below the dose-design objective values of Appendix I. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to ensure that the public is provided a dependable source of power, even under unusual operating conditions that may temporarily result in releases higher than such small percentages, but still well within the limits specified in 10 CFR 20.

In addition to the impact created by the station's radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR 51.20 there are generic treatments of environmental effects of all aspects of the uranium fuel cycle. These environmental data have been summarized in Table S-3 (see Table 5.4) and are discussed later in this report in Section 5.10. In the same manner the environmental impact of transportation of fuel and waste to and from an LWR is summarized in Table S-4 (see Table 5.5) and presented in Section 5.9.3 of this report.

Recently an additional operational requirement for uranium-fuel-cycle facilities, including nuclear power plants, was established by the Environmental Protection Agency in 40 CFR 190. This regulation limits annual doses (excluding radon and daughters) for members of the public to 25 mrems total body, 75 mrems thyroid, and 25 mrems other organs from <u>all</u> fuel-cycle facility contributions that may impact a specific individual in the public.

5.9.2 Operational Overview

During normal operations of Catawba, small quantities of radioactivity (fission and activation products) will be released to the environment. As required by NEPA, the staff has determined the estimated dose to members of the public outside the plant boundaries resulting from the radiation from these radioisotope releases and relative to natural-background-radiation dose levels.

These facility-generated environmental dose levels are estimated to be very small because of both the station design and the development of a program that will be implemented at Catawba to contain and control all radioactive emissions and effluents. As mentioned in Section 4.2.5, radioactive-waste management systems are incorporated into the plant design. These systems are designed to remove most of the fission-product radioactivity that is assumed to leak, in small amounts, from the fuel, as well as most of the activation-product radioactivity produced by neutrons in the reactor-core vicinity. The effectiveness of these systems will be measured indirectly by process and effluent radiological monitoring systems that record the amounts of radioactive constituents remaining in the various airborne and waterborne process and effluent streams. The amounts of radioactivity released through vents and discharge points to be further dispersed and diluted to points outside the plant boundaries are to be recorded and published semiannually in the Radioactive-Effluent-Release Reports for the station.

The small amounts of radioactive materials that are released in treated airborne effluents will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally much dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, the small amounts of radioactive materials that are released in treated waterborne effluents released will be diluted with plant waste water and then further diluted as they mix with Lake Wylie beyond the plant boundary (see Table D.5).

Radioisotopes in the station's effluents that enter unrestricted areas will produce doses through their radiations to members of the general public in a manner similar to the way doses are produced from background radiations (that is, cosmic, terrestrial, and internal radiations), which also include radiation from nuclear-weapons fallout. These radiation doses can be calculated for the many potential radiological exposure pathways specific to the environment around the facility, such as direct-radiation doses from the gaseous plume or liquid effluent stream outside the plant boundaries, or internal-radiation-dose commitments from radioactive contaminants that might have been deposited on vegetation, or in meat and fish products eaten by people, or that might be present in drinking water outside the plant or incorporated into milk from cows at nearby farms.

These doses, calculated for the "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure), form the basis of the NRC staff's evaluation of impacts. Actually, these estimates are for a fictitious person because assumptions are made that tend to overestimate the dose that would accrue to members of the public outside the plant boundaries. For example, if this "maximally exposed" individual were to receive the total body dose calculated at the plant boundary as a result of external exposure to the gaseous plume, he/she is assumed to be physically exposed to gamma radiation at that boundary for 70% of the year, an unlikely occurrence.

Site-specific values for various parameters involved in each dose pathway are used in the calculations. These include calculated or observed values for the amounts of radioisotopes released in the gaseous and liquid effluents, meteorological information (for example, wind speed and direction) specific to the site topography and effluent release points, and hydrological information pertaining to dilution of the liquid effluents as they are discharged.

An annual land census will identify changes in the use of unrestricted areas to permit modifications in the programs for evaluating doses to individuals from principal pathways of exposure. This census specification will be incorporated into the Radiological Technical Specifications and satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR 50. As use of the land surrounding the site boundary changes, revised calculations will be made to ensure that the dose estimate for gaseous effluents always represents the highest dose that might possibly occur for any individual member of the public for each applicable foodchain pathway. The estimate considers, for example, where people live, where vegetable gardens are located, and where cows are pastured.

An extensive radiological environmental monitoring program, designed specifically for the environs of Catawba, provides measurements of radiation and radioactive contamination levels that exist outside the facility boundaries both before and after operations begin. In this program, offsite radiation levels are continuously monitored with thermoluminescent detectors (TLDs). In addition, measurements are made on a number of types of samples from the surrounding area to determine the possible presence of radioactive contaminants which, for example, might be deposited on vegetation, be present in drinking water outside the plant, or be incorporated into cow's milk from nearby farms. The results for all radiological environmental samples measured during a calendar year of operation are recorded and published in the Annual Radiological Environmental Operating Report for the facility. The specifics of the final operational-monitoring program and the requirement for annual publication of the monitoring results will be incorporated into the operating license Technical Specifications for Catawba station.

5.9.3 Radiological Impacts from Routine Operations

5.9.3.1 Radiation Exposure Pathways: Dose Commitments

The potential environmental pathways through which persons may be exposed to radiation originating in a nuclear power reactor are shown schematically in Figure 5.1. When an individual is exposed through one of these pathways, the dose is determined in part by the amount of time he/she is in the vicinity of the source, or the amount of time the radioactivity inhaled or ingested is retained in his/her body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. The annual dose commitment is calculated to be the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing at about the midpoint after the station begins operation. (Calculation for the midpoint of station operation represents an average exposure over the life of the plant.) However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure because of the turnover of the nuclide by physiological processes and radioactive decay.

There are a number of possible exposure pathways to humans that are appropriate to be studied to determine the impact of routine releases from the Catawba site on members of the general public living and working outside the site boundaries, and whether the releases projected at this point in the licensing process will in fact meet regulatory requirements. A detailed listing of these exposure pathways would include external radiation exposure from the gaseous effluents, inhalation of iodines and particulate contaminants in the air, drinking milk from a cow or eating meat from an animal that feeds on open pasture near the site on which iodines or particulates may have deposited, eating vegetables from a garden near the site that may be contaminated by similar deposits, and drinking water or eating fish caught near the point of discharge of liquid effluents.

Other less important pathways include: external irradiation from radionuclides deposited on the ground surface, eating animals and food crops raised near the site using irrigation water that may contain liquid effluents, shoreline, boating and swimming activities near lakes or streams that may be contaminated by effluents, drinking potentially contaminated water, and direct radiation from within the plant itself.

Calculations of the effects for most pathways are limited to a radius of 80 km (50 mi). This limitation is based on several facts. Experience, as demonstrated by calculations, has shown that all individual dose commitments (>0.1 mrem/yr) for radioactive effluents are accounted for within a radius of 80 km from the plant. Beyond 80 km the doses to individuals are smaller than 0.1 mrem/yr, which is far below natural-background doses, and the doses are subject to substantial uncertainty because of lim tations of predictive mathematical models.

The NRC staff has made a detailed study of all of the above important pathways and has evaluated the radiation-dose commitments both to the plant workers and the general public for these pathways resulting from routine operation of the facility. A discussion of these evaluations follows.

5.9.3.1.1 Occupational Radiation Exposure for Pressurized Water Reactors (PWRs)

Most of the dose to nuclear plant workers results from external exposure to radiation coming from radioactive materials outside the body rather than from internal exposure from inhaled or ingested radioactive materials. Experience shows that the dose to nuclear plant workers varies from reactor to reactor and from year to year. For environmental-impact purposes, it can be projected by using the experience to date with modern PWRs. Recently licensed 1000-MWe PWRs are operated in accordance with the post-1975 regulatory requirements and guidance that place increased emphasis on maintaining occupational exposure at nuclear power plants ALARA. These requirements and guidance are outlined primarily in 10 CFR 20; Standard Review Plan, Chapter 12 (NUREG-0800); and Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

The applicant's proposed implementation of these requirements and guidelines is reviewed by the NRC staff during the licensing process, and the results of that review are reported in the staff's Safety Evaluation Reports. The license is granted only after the review indicates that an ALARA program can be implemented. In addition, regular reviews of operating plants are performed to determine whether the ALARA requirements are being met.

Average collective occupational dose information for 239 PWR reactor years of operation is available for those plants operating between 1974 and 1980. (The year 1974 was chosen as a starting date because the dose data for years before 1974 are primarily from reactors with average rated capacities below 500 MWe.)

These data indicate that the average reactor annual collective dose at PWRs has been about 440 person-rems, with some plants experiencing an average plant lifetime annual collective dose to date as high as 1300 person-rems (NUREG-0713, Vol. 2). These dose averages are based on widely varying yearly doses at PWRs. For example, for the period mentioned above, annual collective doses for PWRs have ranged from 18 to 5262 person-rems per reactor. However, the average annual dose per nuclear plant worker of about 0.8 rem (NUREG-0713, Vol 2) has not varied significantly during this period. The worker dose limit, established by 10 CFR 20, is 3 rems/quarter (if the average dose over the worker lifetime is being controlled to 5 rems/year) or 1.25 rems/quarter if it is not.

The wide range of annual collective doses experienced at PWRs in the United States results from a number of factors such as the amount of required maintenance and the amount of reactor operations and inplant surveillance. Because these factors can vary widely and unpredictably, it is impossible to determine in advance a specific year-to-year annual occupational radiation dose for a particular plant over its operating lifetime. There may on occasion be a need for relatively high collective occupational doses, even at plants with radiation protection programs designed to ensure that occupational radiation doses will be kept ALARA.

In recognition of the factors mentioned above, staff occupational dose estimates for environmental impact purposes for Catawba are based on the assumption that the facility will experience the annual average occupational dose for PWRs to date. Thus the staff has projected that the collective occupational doses for each unit at Catawba will be 480 person-rems, but doses could average as much as 3 to 4 times this value over the life of the plant.

In addition to the occupational radiation exposures discussed above, during the period between the initial power operation of Unit 1 and the similar startup of Unit 2, construction personnel working on Unit 2 will potentially be exposed to sources of radiation from the operation of Unit 1. The applicant has estimated that the integrated dose to construction personnel, over a period of 2 years, will be about 7.2 person-rems. This radiation exposure will result predominantly from Unit 1 radioactive components and gaseous effluents from Unit 1. Based on experience with other PWRs, the staff finds that the applicant's estimate is reasonable. A detailed breakdown of the integrated dose to the construction workers by the location of their work and its duration is given in Section 12.4 of the FSAR.

The average annual dose of about 0.8 rem per nuclear-plant worker at operating BWRs and PWRs has been well within the limits of 10 CFR 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear power plant workers and compared it in Table 5.6 to published risks for other occupations. Based on these comparisons, the staff concludes that the risk to nuclear plant workers from plant operation is comparable to the risks associated with other occupations.

In estimating the health effects resulting from both offsite (see Section 5.9.3.2) and occupational radiation exposures as a result of normal operation of this facility, the NRC staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information. Specifically, the staff's estimates are based on information compiled by the National Academy of Sciences' Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR I)(1972).

The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number). The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer-mortality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this report. The staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980 report of the National Academy of Science's Advisory Committee in the Biological Effects of Ionizing Radiation (BEIR III) (1980).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (BEIR I). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology.

The preceding values for risk estimators are consistent with the recommendations of a number of recognized radiation-protection organizations, such as the International Commission on Radiological Protection (ICRP)(1977), the National Council on Radiation Protection and Measurement (NCRP)(1975), the National Academy of Sciences (BEIR III), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)(1977).

The risk of potential fatal cancers in the exposed work-force population at the Catawba facility and the risk of potential genetic disorders in all future generations of this work-force population, is estimated as follows: multiplying the annual plant-worker-population dose (about 480 person-rems/unit) by the risk estimators, the staff estimates that about 0.06 cancer death may occur in the total exposed population and about 0.12 genetic disorder may occur in all future generations of the same exposed population. The value of 0.06 cancer death means that the probability of one cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 6 chances in 100. The value of 0.12 genetic disorder means that the probability of 1 genetic disorder in all future generations of the entire work force as a result of 1 year of facility operation is about 12 chances in 100.

5.9.3.1.2 Public Radiation Exposure

- Transportation of Radioactive Materials

The transportation of "cold" (unirradiated) nuclear fuel to the reactor, of spent irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to waste burial grounds is considered in 10 CFR 51.20. The contribution of the environmental effects of such transportation to the environmental costs of licensing the nuclear power reactor is set forth in Summary Table S-4 from 10 CFR 51.20, reproduced herein as Table 5.5. The cumulative dose to the exposed population as summarized in Table S-4 is very small when compared to the annual collective dose of about 60,000 person-rems to this same population or 26,000,000 person-rems to the U.S. population from background radiation.

The transshipment of spent fuel between Oconee, McGuire, and Catawba is discussed in Appendix G.

- Spent Fuel Storage

The environmental analysis in Section 5.9 and Appendix D takes into account impacts from exposures to routine releases resulting from spent fuel from Catawba and the spent fuel from Oconee and McGuire that may be stored at Catawba. The aspects of handling spent fuel from Oconee and McGuire within the fuel-handling facility at Catawba will be discussed in the Safety Evaluation Report for Catawba.

- Direct Radiation for PWRs

Radiation fields are produced around nuclear plants as a result of radioactivity within the reactor and its associated components, as well as a result of radioactive-effluent releases. Direct radiation from sources within the plant is primarily a result of nitrogen-16, a radionuclide produced in the reactor core. Because the primary coolant of a PWR is contained in a heavily shielded area, dose rates in the vicinity of PWRs are generally undetectable (less than 5 mrems/year).

Low-level radioactivity storage containers outside the plant are estimated to make a dose contribution at the site boundary of less than 1% of that resulting from the direct radiation from the plant.

- Radioactive-Effluent Releases: Air and Water

As pointed out in an earlier section, all effluents from this facility will be subject to extensive decontamination, but small controlled quantities of radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Estimates of site-specific radioisotope-release values have been developed on the basis of estimates regarding fuel performance and the descriptions of operational and radwaste systems in the applicant's ER and FSAR and by using the calculational models and parameters developed by the NRC staff in NUREG-0017. These have been supplemented by extensive use of the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, and should be studied to obtain an understanding of airborne and waterborne releases from the facility.

These radioactive effluents are then diluted by the air and water into which they are released before they reach areas accessible to the general public.

Radioactive effluents can be divided into several groups. Among the airborne effluents the radioisotopes of the fission product noble gases, krypton and xenon, as well as of argon, do not deposit on the ground nor are they absorbed and accumulated within living organisms; therefore, the noble gas effluents act primarily as a source of direct external radiation emanating from the effluent plume. Dose calculations are performed for the site boundary where the highest external-radiation doses to a member of the general public as a result of gaseous effluents have been estimated to occur; these include the total body and skin doses as well as the annual beta and gamma air doses from the plume at that boundary location.

Another group of airborne radioactive effluents--the fission product radioiodines, as well as carbon-14 and tritium--are also gaseous but these tend to be deposited on the ground and/or inhaled into the body during breathing. For this class of effluents, estimates of direct external-radiation doses from deposits on the ground, and of internal radiation doses to total body, thyroid, bone, and other organs from inhalation and from vegetable, milk, and meat consumption are made. Concentrations of iodine in the thyroid and of carbon-14 in bone are of particular significance here.

A third group of airborne effluents, consisting of particulates that remain after filtration of airborne effluents in the plant prior to release, includes fission products such as cesium and barium and activated corrosion products such as cobalt and chromium. The calculational model determines the direct external radiation dose and the internal radiation doses for these contaminants through the same pathways as described above for the radioiodines, carbon-14, and tritium. Doses from the particulates are combined with those of the radioiodines, carbon-14, and tritium for comparison to one of the design objectives of Appendix I to 10 CFR 50.

The waterborne-radioactive-effluent constituents could include fission products such as nuclides of strontium and iodine; activation products, such as nuclides of sodium and manganese; and tritium as tritiated water. Calculations estimate the internal doses (if any) from fish consumption, from water ingestion (as drinking water), and from eating of meat or vegetables raised near the site on irrigation water, as well as any direct external radiation from recreational use of the water near the point of discharge.

The release values for each group of effluents, along with site-specific meteorological and hydrological data, serve as input to computerized radiation-dose models that estimate the maximum radiation dose that would be received outside the facility via a number of pathways for individual members of the public, and for the general public as a whole. These models and the radiation dose calculations are discussed in the October 1977 Revision 1 of Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," and in Appendix B of this statement.

Examples of site-specific dose assessment calculations and discussions of parameters involved are given in Appendix D. Doses from all airborne effluents except the noble gases are calculated for individuals at the location (for example, the site boundary, garden, residence, milk cow, meat animal) where the highest radiation dose to a member of the public has been established from all applicable pathways (such as ground deposition, inhalation, vegetable consumption, cow milk consumption, or meat consumption). Only those pathways associated with airborne effluents that are known to exist at a single location are combined to calculate the total maximum exposure to an exposed individual. Pathway doses associated with liquid effluents are combined without regard to any single location, but they are assumed to be associated with maximum exposure of an individual through other than gaseous-effluent pathways.

5.9.3.2 Radiological Impact on Humans

Although the doses calculated in Appendix D are based primarily on radioactive-waste treatment system capability and are well below the Appendix I design objective values, the actual radiological impact associated with the operation of the facility will depend, in part, on the manner in which the radioactive-waste treatment system is operated. Based on its evaluation of the potential performance of the liquid and gaseous radwaste treatment systems, the NRC staff has concluded that the systems as now designed and built are capable of controlling effluent releases to meet the dose-design objectives of Appendix I to 10 CFR 50.

Operation of Catawba station will be governed by operating license Technical Specifications that will be based on the dose-design objectives of Appendix I to 10 CFR 50. Because these design-objective values were chosen to permit flexibility of operation while still ensuring that plant operations are ALARA, the actual radiological impact of plant operation may result in doses close to the dose-design objectives. Even if this situation exists, the individual doses for the member of the public subject to maximum exposure will still be very small when compared to natural background doses (~100 mrems/year) or the dose limits (500 mrems/year - total body) specified in 10 CFR 20 as consistent with considerations of the health and safety of the public. As a result, the staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of Catawba station.

Operating standards of 40 CFR 190, the Environmental Protection Agency's Environmental Radiation Protection Standards for Nuclear Power Operations, specify that the annual dose equivalent must not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials (radon and its daughters excepted) to the general environment from all uranium-fuel-cycle operations and radiation from these operations that can be expected to affect a given individual. The NRC staff concludes that under normal operations Catawba station is capable of operating within these standards.

The radiological doses and dose commitments resulting from a nuclear power plant are well known and documented. Accurate measurements of radiation and radioactive contaminants can be made with very high sensitivity so that much smaller amounts of radioisotopes can be recorded than can be associated with any possible observable ill effects. Furthermore, the effects of radiation on living systems have for decades been subject to intensive investigation and consideration by individual scientists as well as by select committees that have occasionally been constituted to objectively and independently assess radiation dose effects. Although, as in the case of chemical contaminants, there is debate about the exact extent of the effects of very low levels of radiation that result from nuclear power plant effluents, upper bound limits of deleterious effects are well established and amenable to standard methods of risk analysis. Thus, the risks to the maximally exposed member of the public outside of the site boundaries or to the total population outside of the boundaries can be readily calculated and recorded. These risk estimates for Catawba station are presented below.

The risk to the maximally exposed individual is estimated by multiplying the risk estimators presented in Section 5.9.3.1.1 by the annual dose-design objectives for total-body radiation in 10 CFR 50, Appendix I. This calculation results in a risk of potential premature death from cancer to that individual from exposure to radioactive effluents (gaseous or liquid) from 1 year of reactor operations of less than one chance in one million.* The risk of potential premature death from cancer to the average individual within 80 km (50 mi) of the reactors from exposure to radioactive effluents from the reactors is much less than the risk to the maximally exposed individual. These risks are very small in comparison to natural cancer incidence from causes unrelated to the operation of Catawba station.

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation of this facility (that is, 82 person-rems) by the preceding risk estimators, the staff estimates that about 0.01 cancer death may occur in the exposed population and about 0.02 genetic disorder may occur in all future generations of the exposed population. The significance of these risk estimates can be determined by comparing them to the natural incidence of cancer death and genetic abnormalities in the U.S. population and in the first five generations of the U.S. population, respectively. Multiplying the estimated U.S. population for the year 2000 (~260 million persons) by the current incidence of actual cancer fatalities (~20%) and the current incidence of actual genetic diseases (~11%), about 52 million cancer deaths and about 140 million genetic abnormalities are expected in the year 2000 population and in the first five generations of the year 2000 population, respectively (BEIR III; American Cancer Society, 1978). The risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of Catawba station are very small fractions (less than one part in a billion) of the estimated normal incidence of cancer fatalities and genetic abnormalities in the year 2000 population and in the first five generations of the year 2000 population, respectively.

On the basis of the preceding comparison, the staff concludes that the risk to the public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operation of Catawba station will be very small.

5.9.3.3 Radiological Impacts on Biota Other Than Humans

Depending on the pathway and the radiation source, terrestrial and aquatic biota will receive doses that are approximately the same or somewhat higher than humans receive. Although guidelines have not been established for acceptable limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are sufficiently protective for other species.

Although the existence of extremely radiosensitive biota is possible and increased radiosensitivity in organisms may result from environmental interactions with other stresses (for example, heat or biocides), no biota have yet

*The risk of potential premature death from cancer to the maximally exposed individual from exposure to radioiodines and particulates would be in the same range as the risk from exposure to the other types of effluents.

been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding the station. Furthermore, at all nuclear plants for which radiation exposure to biota other than humans has been analyzed (Blaylock, 1976), there have been no cases of exposure that can be considered significant in terms of harm to the species, or that approach the limits for exposure to members of the public that are permitted by 10 CFR 20. Inasmuch as the 1972 BEIR Report (BEIR I) concluded that evidence to date indicated no other living organisms are very much more radiosensitive than humans, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this facility.

5.9.3.4 Radiological Monitoring

Radiological environmental monitoring programs are established to provide data where there are measurable levels of radiation and radioactive materials in the site environs and to show that in many cases no detectable levels exist. Such monitoring programs primarily are conducted to verify the effectiveness of in-plant systems used to control the release of radioactive materials and to ensure that unanticipated buildups of radioactivity will not occur in the environment. Secondarily, the environmental monitoring programs could identify the highly unlikely existence of releases of radioactivity from unanticipated release points that are not monitored. An annual surveillance (land census) program will be established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs or of the Technical Specifications conditions that relate to the control of doses to individuals.

These programs are discussed in greater detail in NRC Regulatory Guide 4.1, Revision 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and the Radiological Assessment Branch Technical Position, Revision 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program."*

5.9.3.4.1 Preoperational

The preoperational phase of the monitoring program should provide for the measurement of background levels of radioactivity and radiation and their variations along the anticipated important pathways in the areas surrounding the facility, the training of personnel, and the evaluation of procedures, equipment, and techniques. The applicant proposed a radiological environmental monitoring program to meet these objectives in the ER-CP, and it was discussed in the FES-CP. This early program has been updated and expanded; it is presented in Section 6.1.5 of the applicant's ER-OL and is summarized here in Table 5.7.

The applicant states that the preoperational program has been implemented at least 2 years before initial criticality of Unit 1 to document background levels of direct radiation and concentrations of radionuclides that exist in the environment. The preoperational program will continue up to initial criticality of

---

*Available from the Radiological Assessment Branch, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Unit 1 at which time the operational radiological monitoring program will commence.

The staff has reviewed the preoperational environmental monitoring plan of the applicant and finds that it is acceptable as presented. However, the current NRC staff position is that a total of about 40 dosimetry stations (or continuously recording dose-rate instruments) should be placed as follows: an inner ring of stations in the general area of the site boundary and an outer ring in the 6-to-8-km (4-to-5-mi) range from the site with a station in each sector of each ring (16 sectors x 2 rings = 32 stations). The remaining eight stations should be placed in special interest areas such as population centers, nearby residences and schools, and in two or three areas to serve as control stations.

Although a proposal to require real-time monitors that can be read is being considered by the NRC staff, the capability of such a system to provide useful, timely information to implement the offsite protection actions following accidents has not been established. Such raw monitor readings must be corrected for background and nonplant initiated radiations and processed through complex computer models using concurrent meteorological conditions to provide accurate and intelligible information to the control room. This processed information is then used for protective action decisions. The staff is presently managing a consultant contract that is studying such a system. After the results of the contract effort have been received, the staff will determine whether or not such a system will serve a useful purpose in emergency situations; the staff will then determine whether or not to require such a system for every operating reactor site.

5.9.3.4.2 Operational

The operational, offsite radiological-monitoring program is conducted to provide data on measurable levels of radiation and radioactive materials in the site environs in accordance with 10 CFR 20 and 50. It assists and provides backup support to the effluent-monitoring program recommended in NRC Regulatory Guide 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants."

The applicant states that the operational program will in essence be a continuation of the preoperational program described above with some periodic adjustment of sampling frequencies in expected critical exposure pathways. The proposed operational program will be reviewed before Catawba station is in operation. Modification will be based upon anomalies and/or exposure pathway variations observed during the preoperational program.

The final operational-monitoring program proposed by the applicant will be reviewed in detail by the NRC staff, and the specifics of the required monitoring program will be incorporated into the operating license Radiological Technical Specifications.

5.9.4 Environmental Impact of Postulated Accidents

5.9.4.1 Plant Accidents*

The staff has considered the potential radiological impacts on the environment of possible accidents at the Catawba Nuclear Station, Units 1 and 2, in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980 (45 FR 40101-40104). The following discussion reflects the staff's considerations and conclusions.

Section 5.9.4.2 deals with general characteristics of nuclear power plant accidents including a brief summary of safety measures to minimize the probability of their occurrence and to mitigate their consequences if they should occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become enviromental hazards. Potential adverse health effects and impacts on society associated with actions to avoid such health effects also are identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are described. This is followed by a summary review of safety features of the Catawba Nuclear Station and of the site that act to mitigate the consequences of accidents.

---

*With respect to psychological stress impacts, the U.S. Court of Appeals for the District of Columbia Circuit has held, in People Against Nuclear Energy (PANE) v. NRC No. 81-1131, that the National Environmental Policy Act (NEPA) requires the Commission to evaluate the effects on psychological health of operation of the Three Mile Island Unit 1 facility. On July 15, 1982 the Commission issued a Statement of Policy, "Consideration of Psychological Stress Issues," providing guidance on the applicability of the decision to NEPA issues in other reactor licensing proceedings. The Commission indicated that in accordance with the opinion in PANE, cognizability of psychological stress impacts under NEPA hinges on three elements:

> First, the impacts must consist of "post traumatic anxieties," as distinguished from mere dissatisfaction with agency proposals or policies. Second, the impacts must be accompanied by physical effects. Third, the "post traumatic anxieties" must have been caused by "fears of a recurring catastrophe." This third element means that some kind of nuclear accident must already have occurred at the site in question, since the majority's holding was directed to "post-traumatic" anxieties and by fears of a "recurring" catastrophe. Moreover, the majority clearly had only serious accidents in mind, because of the use of the word "catastrophe" and its references to the "unique" Three Mile Island Unit 2 accident in the opinion. [Policy Statement at 3. (Underlining added.)]

Since there has been no nuclear accident at the Catawaba site, the elements necessary for consideration of psychological stress impacts in accordance with the Policy Statement are not present in connection with the Catawba reactors.

The results of calculations of the potential consequences of accidents that have been postualted in the design basis are then given. Also described are the results of calculations for the Catawba site using probabilistic methods to estimate the possible impacts and the risks associated with severe accident sequences of exceedingly low probability of occurrence.

5.9.4.2 General Characteristics of Accidents

The term "accident," as used in this section, refers to any unintentional event not addressed in Section 5.9.3 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Normal release limits are specified in the Commission's regulations at 10 CFR 20, and 10 CFR 50, Appendix I.

There are several features that combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation comprising the first line of defense are to a very large extent devoted to the prevention of the release of these radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defense that are designed to mitigate the consequences of failures in the first line. Descriptions of these features for Catawba Units 1 and 2 may be found in the applicant's FSAR and in the staff's Safety Evaluation Report (to be issued in 1983). The most important mitigative features are described in Section 5.9.4.4(1) below.

These safety features are designed taking into consideration the specific locations of radioactive materials within the plant; their amounts; their nuclear, physical, and chemical properties; and their relative tendency to be transported into and for creating biological hazards in the environment.

(1) <u>Fission Product Characteristics</u>

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the reactor core in the form of fission products. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent-fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials also are normally present in the water that circulates in the reactor coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment depends not only on mechanical forces that might physically transport them, but also upon their inherent properties, particularly their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids and a few are gaseous in nature. These characteristics have a significant bearing upon the assessment of the environmental radiological impact of accidents.

The gaseous materials include radioactive forms of the chemically inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are very low frequency but credible events (see Section 5.9.4.3). It is for this reason that the safety analysis of each nuclear power plant incorporates a hypothetical design-basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment structure. If these gases were further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure is designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process and in some chemical forms may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release from the fuel. If released to the environment, the principal radiological hazard associated with the radioiodines is ingestion into the human body and subsequent concentration in the thyroid gland. Because of this, the potential for release of radioiodines to the atmosphere is reduced by the use of special systems designed to retain the iodine.

The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperatures, so they have a strong tendency to condense (or "plate out") upon cooler surfaces. In addition, most of the iodine compounds are quite soluble in, or chemically reactive with, water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release from containment structures that have large internal surface areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may "escape" into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces (for example, dew), the radioiodines will show a strong tendency to be absorbed by the moisture.

Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and therefore, by comparison with the noble gases and iodine, a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes very high. By the same token, such materials, if they escape by volatilization from the fuel, tend to condense quite rapidly to solid form again when transported to a lower temperature region and/or dissolve in water when present. The former mechanism can have the result of producing some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surface features by gravitational settling or by precipitation (fallout), where they will become "contamination" hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years (see Table 5.8). Many of them decay through a sequence or chain of decay processes and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes is the reason that they are hazardous materials.

(2) Exposure Pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive materials, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways from the transport of radiation and radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Figure 5.1. There are two additional possible pathway that could be significant for accident releases that are not shown in Figure 5.1. One of these is the fallout onto open bodies of water of radioactivity initially carried in the air. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This creates the potential for the release of radioactive material into the hydrosphere through contact with groundwater. These pathways may lead to external exposure to radiation, and to internal exposures if radioactive material is inhaled or ingested from contaminated food or water.

It is characteristic of these pathways that during the transport of radioactive material by wind or by water the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The result of these natural processes is to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but they also tend to increase the number who may be exposed. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere which vary considerably with time and from place to place.

This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time.

(3) Health Effects

The cause-and-effect relationships between radiation exposure and adverse health effects are quite complex (National Research Council, 1979; Land, 1980) but they have been more exhaustively studied than any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rems for a few persons and about 25 rems for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 10 to 20 times larger than the latter dose, also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe, but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in the close proximity of such accidents if measures are not or cannot be taken to provide protection, such as by sheltering or evacuation.

Lower levels of exposures also may constitute a health risk, but the ability to define a direct cause-and-effect relationship between any given health effect and a known exposure to radiation is difficult given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necessary to assess such effects on a statistical basis. Such effects include randomly occurring cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. Occurrences of cancer in the exposed population may begin to develop only after a lapse of 2 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), occurrences of cancer may begin to develop at birth (no latent period) and end at age 10 (that is, the plateau period is 10 years). The health consequences model currently being used is based on the 1972 BEIR I Report of the National Academy of Sciences (NAS). The occurrence of cancer itself is not necessarily indicative of fatality.

Most authorities agree that a reasonable, and probably conservative, estimate of the randomly occurring number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths (although zero is not excluded by the data) per million person-rems. The range comes from the latest NAS BEIR III Report (1980), which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the current NRC health-effects models. In addition, approximately 220 genetic changes per million person-rems would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million person-rems currently used by the NRC staff.

(4) Health Effects Avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is a slow one, however, and where the material becomes relatively fixed in its location as an environmental contaminant (such as in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential environmental societal impact of severe accidents is the avoidance of the health hazard rather than the health hazard itself, by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential economic impacts that this can cause are discussed below.

5.9.4.3 Accident Experience and Observed Impacts

The evidence of accident frequency and impacts in the past is a useful indicator of future probabilities and impacts. As of mid-1981, there were 71 commercial nuclear power reactor units licensed for operation in the United States at 50 sites with power-generating capacities ranging from 50 to 1130 MWe. (The Catawaba Units 1 and 2 are designed for 1145 MWe per unit.) The combined experience with these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities (Oak Ridge National Laboratory, 1980; NUREG-0651). Some of these have resulted in releases of radioactive material to the environment, ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience base is not large enough to permit a reliable quantitative statistical inference. It does, however, suggest that significant environmental impacts caused by accidents are very unlikely to occur over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these units, during the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979. In addition to the release of a few million curies of xenon-133, it has been estimated that approximately 15 curies of radioiodine also was released to the environment at TMI-2 (U.S. Nuclear Regulatory Commission, Special Inquiry Group, 1980). This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. No other radioactive fission products were released in measurable quantity.

It has been estimated that the maximum cumulative offsite radiation dose to an individual was less than 100 mrems (U.S. Nuclear Regulatory Commission, Special Inquiry Group, 1980; President's Commission on the Accident at Three Mile Island, 1979). The total population exposure has been estimated to be in the range from about 1000 to 3000 person-rems. This exposure could produce between none and one additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 person-rems and approximately a half-million cancers are expected to develop in this group over its lifetime (U.S. Nuclear Regulatory Commission, Special Inquiry Group, 1980; President's Commission on the Accident at Three Mile Island, 1979), primarily from causes other than radiation. Trace quantities (barely above the limit of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were impacted.

Accidents at nuclear power plants also have caused occupational injuries and a few fatalities but none attributed to radiation exposure. Individual worker exposures have ranged up to about 4 rems as a direct consequence of reactor accidents (although there have been higher exposures to individual workers as a result of other unusual occurrences). However, the collective worker exposure levels (person-rem) are a small fraction of the exposures experienced during normal routine operations that average about 440 to 1300 person-rems in a PWR and 740 to 1650 person-rems in a BWR per reactor-year.

Accidents also have occurred at other nuclear reactor facilities in the United States and in other countries (Oak Ridge National Laboratory, 1980; NUREG-0651). Because of inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at the Enrico Fermi Atomic Power Plant, Unit 1. Fermi Unit 1 was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power in 4 years following the accident. It operated successfully and completed its mission in 1973. This accident did not release any radioactivity to the environment.

A reactor accident in 1957 at Windscale, England, released a significant quantity of radioiodine, approximately 20,000 curies, to the environment. This reactor, which was not operated to generate electricity, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor, the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-ft) stack. Milk produced in a 518-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. This kind of accident cannot occur in a water-cooled reactor like Catawaba, however.

5.9.4.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the Nuclear Regulatory Commission has conducted a safety evaluation of the application to operate Catawba Units 1 and 2. Although this evaluation contains more detailed information on plant design, the principal design features are presented in the following section.

(1) <u>Design Features</u>

The Catawba Nuclear Station contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design-basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESFs). The possibilities or probabilities of failure of these systems are incorporated in the assessments discussed in Section 5.9.4.5(2).

Containment consists of a free-standing steel structure within a separate reinforced concrete reactor building and is designed to minimize accidental radioactivity releases to the environment. Safety injection systems are incorporated to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage.

The ice condenser is designed to prevent unacceptable postaccident pressures in the containment and to provide a medium (by the ice bed containing sodium tetraborate) for the removal of iodine from the containment atmosphere. The containment spray system further minimizes fission product leakage by cooling and scrubbing the postaccident containment atmosphere.

All the mechanical systems mentioned above are supplied with emergency power from onsite diesel generators in the event that normal offsite station power is interrupted.

The fuel-handling building for each unit also has accident-mitigating systems. The safety-grade ventilation system contains both charcoal and high-efficiency particulate filters. This ventilation system also is designed to keep the area around the spent-fuel pool below the prevailing barometric pressure during fuel-handling operations so that outleakage will not occur through building openings. If radioactivity were to be released into the building, it would be drawn through the ventilation system and any radioactive iodine and particulate fission products would be removed from the flow stream before exhausting to the outdoor atmosphere.

There are features of the plant that are necessary for its power-generation function that can also play a role in mitigating certain accident consequences. For example, the main condenser, although not classified as an ESF, can act to mitigate the consequences of accidents involving leakage from the primary to the secondary side of the steam generators (such as steam generator-tube ruptures). If normal offsite power is maintained and the turbine bypass system is operable, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of radioactivity released to the environment. In this case, the capability of the normally operating waste gas system to remove fission products would come into play.

Much more extensive discussions of the Catawba Nuclear Station safety features and characteristics may be found in the applicant's FSAR. The staff evaluation of these features is addressed in the SER. In addition, the implementation of the lessons learned from the TMI-2 accident--in the form of improvements in design and procedures and operator training--will significantly reduce the likelihood of a degraded-core accident which could result in large releases of fission products to the containment. Specifically, the applicant will be required to meet those TMI-related requirements specified in NUREG-0737. As noted in Section 5.9.4.5(7), no credit has been taken for these actions and improvements in discussing the radiological risk of accidents.

(2) Site Features

The NRC's reactor site criteria, 10 CFR 100, require that the site for every power reactor have certain characteristics that tend to reduce the risk and potential impact of accidents. The discussion that follows briefly describes the Catawba site characteristics and how they meet these requirements.

The site has an exclusion area as required by 10 CFR 100. The exclusion area, located within the 158-ha (391-acre) site owned by the Duke Power Company, is a circular area with a 762-m (2500-ft) radius measured from the centerline between Catawba Units 1 and 2. There are no permanent residents within the exclusion area. The applicant owns all the land and mineral rights within the exclusion area except for a 1-acre cemetery owned by the Concord Cemetery Association in agreement with the Duke Power Company. With the ownership and the agreement providing control, the applicant has the authority, required by 10 CFR 100, to determine all activities in this area. Activities unrelated to plant operation that occur within the exclusion area include activity associated with the construction of Unit 2, visitation at the Concord Cemetery for the purpose of conducting memorial or burial services, water-related activities in and around two small Lake Wylie coves that extend into the exclusion area, and persons viewing the site and picnicking in the 2-acre visitors' overlook area. There are no railroads, highways, or waterways traversing the exclusion area, but in case of an emergency, arrangements have been made to limit access and control the activity and evacuation of anyone in the exclusion area.

Beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR 100. The LPZ for the Catawba site is a circular area with a 6096-m (20,000-ft) radius centered on a line midway between Units 1 and 2. Except for Lake Wylie and its tributaries, the LPZ consists mostly of wooded areas and some farmland. Within the zone the applicant must ensure that there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents and other members of the public in the event of a serious accident. The applicant has indicated that there were about 7428 persons residing in the LPZ in 1980, and projects the population to increase to approxmately 16,755 by the year 2020. In case of a radiological emergency, the applicant has made arrangements to carry out protective actions, including evacuation of personnel in the vicinity of the Catawba Nuclear Station. (See also the following section on Emergency Preparedness.)

10 CFR 100 also requires that the distance from the reactor to the nearest boundary of a densely populated area containing more than about 25,000 residents be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ. Since accidents of greater potential hazards than those commonly postulated as representing an upper limit are conceivable, although highly improbable, it was considered desirable to add the population center distance requirements in 10 CFR 100 to provide for protection against excessive exposure doses to people in large centers. The city of Rock Hill, South Carolina, located about 9 km (5.8 mi) south-southeast of the plant, with a population of 34,968 persons in 1980 is the nearest population center. The distance from the site to Rock Hill is at least one and one-third times the distance to the outer boundary of the LPZ. The nearest major city within 80 km (50 mi) is Charlotte, North Carolina, which had a population of 310,794 in 1980 and is located about 18 km (11 mi) northeast of the site. The population density within 48 km (30 mi) of the site is projected for 1982 to be 300 persons per square mile and is not expected to exceed 425 persons per square mile during the life of the plant.

The safety evaluation of the Catawba site also has included a review of potential external hazards generated by man (activities off site that might adversely affect the operation of the plant and cause an accident). This review encompassed nearby industrial, transportation, and military facilities that might create explosive, missile, toxic gas, or similar hazards. The risk to Catawba station from such hazards has been found to be negligibly small. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards are given in the staff's Safety Evaluation Report (SER). Also discussed in the staff's SER are design provisions required for severe natural phenomena such as earthquakes, floods, and tornadoes.

(3) Emergency Preparedness

Emergency preparedness plans including protective action measures for Catawba station and environs are in an advanced, but not yet fully completed stage. In accordance with the provisions of 10 CFR 50.47, effective November 3, 1980, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plans are provisions for two emergency planning zones (EPZs). A plume exposure pathway EPZ of about 16 km (10 mi) in radius and an ingestion exposure pathway EPZ of about 80 km (50 mi) in radius are required. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC and the Federal Emergency Management Agency (FEMA) have agreed that FEMA will make a finding and determination as to the adequacy of state and local government emergency response plans. NRC will determine the adequacy of the applicant's Emergency Response Plans with respect to the standards listed in Section 50.47(b) of 10 CFR 50, the requirements of Appendix E to 10 CFR 50, and the guidance contained in NUREG-0654/FEMA-REP-1, Revision 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," dated November 1980. After the above determinations by NRC and FEMA, the NRC will make a finding in the licensing process as to the overall and integrated state of preparedness. The NRC staff findings will be reported in its SER. Further, if those findings indicate that the risk to the public from severe accidents, discussed in the following sections, is significantly larger because of the details of the final plans, a supplement to the Environmental Statement will be issued. Although the presence of adequate and tested emergency plans cannot prevent an accident, it is the staff's judgment that such plans can and will substantially mitigate the consequences to the public if an accident should occur.

5.9.4.5 Accident Risk and Impact Assessment

(1) Design-Basis Accidents

As a means of ensuring that certain features of the Catawba Nuclear Station meet acceptable design and performance criteria, both the applicant and the staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment and calculations have been performed to estimate the potential radiological consequences to persons off site. For each postulated initiating event, the potential radiological consequences cover a considerable range of values, depending upon the particular course taken by the accident and the conditions, including wind direction and weather prevalent during the accident.

In the safety analysis and evaluation of the Catawba Nuclear Station, three categories of accidents have been considered. These categories are based upon their probability of occurrence and include (a) incidents of moderate frequency (events that can reasonably be expected to occur during any year of operation), (b) infrequent accidents (events that might occur once during the lifetime of the plant), and (c) limiting faults (accidents not expected to occur but that have the potential for significant releases of radioactivity). The radiological consequences of incidents in the first category, also called anticipated operational occurrences, are discussed in Section 5.9.3. Some of the initiating events postulated in the second and third categories for the Catawba Nuclear Station are shown in Table 5.9. These events are designated design-basis accidents in that specific design and operating features as described above in Section 5.9.4.4(1) are provided to limit their potential radiological consequences. Approximate radiation doses to the whole body and the thyroid that might be received by a person at the boundary of the plant exclusion area during the first 2 hours of the accidents were calculated by the applicant and are also shown in the table. The results shown in the table reflect the expectation that engineered safety and operating features designed to mitigate the consequences of the postulated accidents would function as intended. An important implication of this expectation is that the releases considered are limited to noble gases and radioiodines and that any other radioactive materials (for example, in particulate form) are not expected to be released. The results also use the meteorological dispersion conditions that are an average value determined by actual site measurements. In order to contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 5.9 are sometimes referred to as "realistic" doses.

These calculations indicate that the risk of incurring any adverse health effects as a consequence of these events is exceedingly small. By comparison with the estimates of radiological impact for normal operations shown in Section 5.9.3, the staff also concludes that radiation exposures from design-basis accidents are roughly comparable to the exposures to individuals and the population from normal station operations over the expected lifetime of the plant.

The staff is carrying out calculations to estimate the potential upper bounds for individual exposures from the same initiating accidents in Table 5.9 for the purpose of implementing the provisions of 10 CFR 100. For these calculations, much more pessimistic (conservative or worst-case) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include much larger amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESFs in a degraded mode,* and very poor meteorological dispersion conditions. A license to operate the plant will not be given unless the results of these calculations would show that for these events the exposures are not expected to exceed 25 rems to the whole body and 300 rems to the thyroid of any individual at the exclusion area boundary over a period of 2 hours. For calculation of the thyroid dose, it will be assumed that an individual is located at a point on the exclusion area boundary where the radioiodine concentration in the plume has its highest value and inhales at a breathing rate characteristic of a person jogging for a period of 2 hours. The health risk to an individual receiving 300 rems to the thyroid is the potential appearance of benign or malignant thyroid nodules in about 1 out of 10 cases, and the development of a fatal thyroid cancer in about 4 out of 1000 cases.

The staff also will evaluate the potential upper bounds for individual exposures at the outer edge of the low population zone in its SER. These exposures, in general, are not limiting. However, a license to operate will not be issued unless the calculated exposures are also less than 25 rems to the whole body or 300 rems to the thyroid.

None of the calculations of the impacts of design-basis accidents described in this section take into consideration possible reductions in individual or population exposures as a result of taking any protective actions.

(2) Probabilistic Assessment of Severe Accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design-basis accidents discussed in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe,

*The containment structure, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR 100.11(a).

both for the plant itself and for the environment. These severe accidents, heretofore frequently called Class 9 accidents, can be distinguished from design-basis accidents in two primary respects: they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment.

The assessment methodology employed is that described in the Reactor Safety Study (RSS) which was published in 1975 (NUREG-75/014).* However, the sets of accident sequences that were found in the RSS to be the dominant contributors to the risk in the prototype PWR (Westinghouse-designed Surry Unit 1) have recently been updated ("rebaselined") (NUREG-0715). The rebaselining has been done largely to incorporate peer group comments (NUREG/CR-0400) and better data and analytical techniques resulting from research and development after the publication of the RSS. Entailed in the rebaselining effort was the evaluation of the individual dominant accident sequences--as they are understood to evolve. The earlier technique of grouping a number of accident sequences into the encompassing "Release Categories" as was done in the RSS has been largely (but not completely) eliminated.

The Catawba plants are Westinghouse-designed PWRs having design and operating characteristics similar to the RSS prototype PWR. Therefore, the present assessment for Catawba has used as its starting point the rebaselined accident sequences and release categories referred to above, and more fully described in Appendix E. Characteristics of the sequences and release categories used (all of which involve partial to complete melting of the reactor core) are shown in Table 5.10. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events and those that could be initiated by deliberate acts of sabotage are not included in these event sequences. The radiological consequences of such events would not be different in kind from those which have been treated. Moreover, there are design requirements in 10 CFR 50, Appendix A, relating to effects of natural phenomena, and safeguards requirements in 10 CFR 73, ensuring that these potential accident intiators are in large measure taken into account in the design and operation of the plant. The data base for assessing the probabilities of events more severe than the design bases for natural phenomena and sabotage is small. Hence, inclusion, in an accurate manner, of accident sequences initiated by natural phenomena and sabotage events more severe than used as design bases in the staff's SER is beyond the state of the art of probabilistic risk assessment. In addition, the staff judges that the additional risk from severe accidents initiated by natural events or sabotage is within the uncertainty of risks presented for the sequences considered here.

Calculated probability per reactor-year associated with each accident sequence or release category used is shown in the second column in Table 5.10. As in the RSS there are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in the data base on failure rates of individual plant components that were used to calculate the probabilities (NUREG/CR-0400). The probability of accident sequences from the Surry plant were used to give a perspective of

*Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 5.9.4.5(7).

the societal risk at Catawba because, although the probabilities of particular accident sequences may be substantially different and even improved for Catawba, the overall effect of all sequences taken together is likely to be within the uncertainties (see Section 5.7.4.5(7) for a discussion of uncertainties in risk estimates).

The magnitudes (curies) of radioactivity release for each accident sequence or release category are obtained by multiplying the release fractions shown in Table 5.10 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 5.8 for a Catawba unit at a core thermal power level of 3565 MWt, the power level used in the FSAR. The 54 nuclides shown in the table represent those (of the hundreds actually present in an operating plant) that are the major contributors to the health and economic effects of severe accidents. They were selected on the basis of the half-life of the original nuclide, consideration of the health effects of daughter products, and the approximate relative offsite dose contribution.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS (NUREG-0340) adapted and modified as described below to apply to a specific site. The essential elements are shown in schematic form in Figure 5.2. Environmental parameters specific to the site of Catawba station have been used and include the following:

- meteorological data for the site representing a full year of consecutive hourly measurements and seasonal variations

- projected population for the year 2000 extending throughout regions of 80-km (50-mi) and 563-km (350-mi) radius from the site

- the habitable land fraction within the 563-km (350-mi) radius

- land-use statistics, on a statewide basis, including farm land values, farm product values including dairy production, and growing season information, for the State of South Carolina and each surrounding state within the 563-km (350-mi) region

For the region beyond 563 km (350 mi), the U.S. average population was assumed.

To obtain a probability distribution of consequences, the calculations are performed assuming the occurrence of each accident-release sequence at each of 91 different "start" times throughout a 1-year period. Each calculation utilizes the site-specific hourly meteorological data and seasonal information for the time period following each "start" time. The consequence model also contains provisions for incorporating the consequence reduction benefits of evacuation, relocation, and other protective actions. Early evacuation and relocation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage. The evacuation model used (see Appendix F) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the Midland site are estimates made by the staff and are partly based upon evacuation time estimates prepared by the applicant. There normally would be special facilities near a plant, such as schools or hospitals, where special equipment or personnel may be required to effect evacuation. Several such facilities have been identified near the Catawba site, such as the Carrowinds Theme

Park and York General Hospital and Ambulance Service. Further, there may be people who either do not receive notification to evacuate or who choose not to evacuate; therefore, actual evacuation effectiveness could be greater or less than that characterized but would not be expected to be very much less.

The other protective actions include: (a) either complete denial of use (interdiction), or permitting use only at a sufficiently later time after appropriate decontamination of food stuffs such as crops and milk, (b) decontamination of severely contaminated environment (land and property) when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels, and (c) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels reduce to such values by radioactive decay and weathering so that land and property can be economically decontaminated as in (b) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment.

Early evacuation within and early relocation of people from outside the plume exposure pathway EPZ (see Appendix F) and other protective actions as mentioned above are considered as essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for Catawba include the benefits of these protective actions.

There are also uncertainties in each facet of the estimates of consequences and the error bounds may be as large as they are for the probabilities (see Figure 5.2).

The results of the calculations using this consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions, and costs associated with property damage by radioactive contamination.

(3) Dose and Health Impacts of Atmospheric Releases

The results of the calculations of dose and health impacts performed for the Catawba Nuclear Station and site are presented in the form of probability distributions in Figures 5.3 through 5.6 and are included in the impact summary Tables 5.11 and 5.12. All the accident sequences and release categories shown in Table 5.10 contribute to the results, the consequences from each being weighted by its associated probability.

Figure 5.3 shows the probability distribution for the number of persons who might receive whole-body doses equal to or greater than 200 rems and 25 rems, and thyroid doses equal to or greater than 300 rems from early exposure,* all on a per-reactor-year basis. The 200-rem whole-body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated

*Early exposure to an individual includes external doses from the radioactive cloud and the contaminated ground, and the dose from internally deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposure are excluded.

for the treatment of radiation injury. The 25-rem whole-body (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and 300-rem thyroid dose figures correspond to the Commission's guideline values for reactor siting in 10 CFR 100.

Figure 5.3 shows in the left-hand portion that there are approximately 6 chances in 1 million (6×10^{-6}) per reactor-year that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves run almost parallel in horizontal lines initially shows that if one person were to receive such doses, the chances are about the same that ten to hundreds would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about 1 in 1 million (10^{-6}) that 1000 or more people might receive doses of 200 rems or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 32-km (20-mi) radius of the plant. Virtually all would occur within a 160-km (100-mi) radius.

Figure 5.4 shows the probability distribution for the total population exposure in person-rems; that is, the probability per reactor-year that the total population exposure will equal or exceed the values given. Most of the population exposure up to 1 million person-rems would occur within 80 km (50 mi) but the more severe releases (as in the first two accident sequences in Table 5.10) would result in exposure to persons beyond the 80-km (50-mi) range as shown.

For perspective, population doses shown in Figure 5.4 may be compared with the annual average dose to the population within 80 km (50 mi) of the Catawba site resulting from natural background radiation of 160,000 person-rems, and to the anticipated annual population dose to the general public (total U.S.) from normal plant operation of 40 person-rems (excluding plant workers) (Appendix D, Tables D.7 and D.9).

Figure 5.5 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 80 km (50 mi) are shown separately. Further, the fatal, latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

Figure 5.6 provides probability distributions and Table 5.12 provides probabilities and consequences for early fatalities. Two cases are shown, representing two potential protective actions. The first case shows the results considering early evacuation of the entire 10-mi plume exposure pathway EPZ, the model for which is more fully discussed in Appendix F. For this case, the model predicts near-zero early fatalities within the EPZ. The early fatalities predicted by the calculation are all within 32 km (20 mi) of the site. A second possible emergency response is early relocation of people after passage of the plume. This is considered to be a possible response to significant ground contamination in the relatively restricted "footprint" from passage of the cloud. The benefits of this protective action in the distance between 10 and 25 mi from the plant, combined with the evacuation of the EPZ, are shown also in Figure 5.6 and Table 5.12. Figure F.1 in Appendix F shows the effects of a much more pessimistic emergency response, as well as a more optimistic evacuation assumption.

(4) Economic and Societal Impacts

As noted in Section 5.9.4.2, the various measures for avoiding adverse health effects including those resulting from residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for Catawba station and environs also have been made. Unlike the radiation exposure and health effect impacts discussed above, impacts associated with avoiding adverse health effects are more readily transformed into economic impacts.

The results are shown as the probability distribution for cost of offsite mitigating actions in Figure 5.7 and are included in the impact summary Table 5.11. The factors contributing to these estimated costs include the following:

- evacuation costs
- value of crops contaminated and condemned
- value of milk contaminated and condemned
- costs of decontamination of property where practical
- indirect costs resulting from the loss of use of property and incomes derived therefrom

The last-named costs would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 5.7 shows that at the extreme end of the accident spectrum these costs could exceed several billion dollars but that the probability that this would occur is exceedingly small, less than one chance in a 10 million per reactor-year.

Additional economic impacts that can be monetized include costs of decontamination of the facility itself and the costs of replacement power. Probability distributions for these impacts have not been calculated but they are included in the discussion of risk considerations in Section 5.9.4.5(6) below.

(5) Releases to Groundwater

A groundwater pathway for public radiation exposure and environmental contamination that could be unique for severe reactor accidents was identified in Section 5.9.4.2(2). Consideration has been given to the potential environmental impacts of this pathway for the Catawba Nuclear Station. The principal contributors to the risk are the core-melt accidents associated with the evaluated accident sequences and release categories. The penetration of the basemat of the containment buildings can release molten core debris to the strata beneath the station. The soluble radionuclides in the debris can be leached and transported in the groundwater to downgradient domestic wells used for drinking water or to surface water bodies used for drinking water, aquatic food, and recreation. In pressurized water reactors such as the Catawba units, there is an additional opportunity for groundwater contamination resulting from the release of sump water to the ground through a breach in the containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS) (NUREG-0440). The LPGS compares the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for four conventional, generic land-based nuclear plants and for a floating nuclear plant, wherein the nuclear reactor would be mounted on a barge and moored in a body of water. Parameters for each generic land-based site were chosen to represent averages for a wide range of real sites and were thus "typical" although they represented no real sites. The study concluded that the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathway.

The discussion in this section is a summary of an analysis performed to determine whether or not the liquid pathway consequences of a postulated accident at the Catawba site would be unique when compared with the generic "small river" land-based site considered in the LPGS. The method of comparison consists of a direct scaling up or down of the LPGS population doses based on the relative values of key parameters characterizing the LPGS small river site and the Catawba site. The parameters that were evaluated include the amounts and rate of release of radioactive materials to the ground, groundwater travel time, sorption on geological media, surface water transport, drinking water usage, aquatic food consumption, and shoreline usage.

All of the reactors considered in the LPGS were Westinghouse pressurized water reactors (PWRs) with ice condenser containments; thus, they are directly comparable with the equipment present at Catawba station. The source term used for Catawba in this comparison is assumed to be equal to that used in the LPGS.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, alternative sources of water for drinking, irrigation, and industrial uses would be expected to be found, if necessary. Commercial and sport fishing, as well as many other water-related activities could be restricted. The consequences would, therefore, be largely economic or societal, rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

The Catawba Nuclear Station is located on a peninsula on the South Carolina side of Lake Wylie, a power generation reservoir on the Catawba River. Groundwater at the site is present within limited joints and fractures in a granitic (adamellite) bedrock. At the site the groundwater table, under ambient conditions, slopes rather steeply toward Lake Wylie, both north and south of the station. A dewatering system reverses the normal direction of groundwater flow during normal station operations.

The station's dewatering system has the potential to place contaminated groundwater directly into Lake Wylie, with virtually no holdup or dilution, if the system continued to operate in its "normal" mode following a melt-through accident. To prevent this from occurring, it is necessary to shut down the dewatering system and allow groundwater levels to return to their preconstruction levels. Duke Power Company has committed to providing instruction in the plant Emergency Procedures to secure the dewatering pumps in cases of accidents where core degradation is indicated. Therefore, the pathway to Lake Wylie with no holdup or dilution is considered to be blocked. Although Catawba station uses dewatering, the units are structurally designed to handle the hydrostatic loads accompanying a return of preplant groundwater levels.

Major site buildings are founded on the adamellite bedrock material. This material demonstrates a very low hydraulic conductivity. It is conservatively assumed that in the case of a core-melt accident releasing contaminated material to this rock, groundwater transport would occur along fractures known to be present at shallow depths. Maps of these fractures in their preconstruction condition, as prepared by the applicant, show them to be virtually absent at the basemat level. Contamination would reach the waters of Lake Wylie, some 210 m (700 ft) distant, through the shallow system of fractures. The initial flow of groundwater would be toward the site as a result of the cone of depression caused by the dewatering system. Following shutdown or failure of the dewatering system under normal operating conditions, the time required for water levels to rebound to preconstruction conditions would be about 56 days. Following reestablishment of normal gradients, flow would be toward the lake. Groundwater would travel through the sparsely fractured bedrock to reach Lake Wylie. Analysis of groundwater travel time has been conservatively estimated to be in the range of 1 to 20 years following reestablishment of a "lakeward" gradient. The wide range is due to the complicated flow path fluids must follow to reach Lake Wylie.

For groundwater travel times on the order of years, the only significant contributors to population dose are Cs-137 and Sr-90. Landstrom et al. (1978) report on field experiments measuring the retardation of several nuclides in similar fractured materials. Retardation factors presented by Landstrom et al. (1978) are about 560 for Cs-137 and 6 for Sr-90. Using these values of retardation, the travel time for Cs-137 at Catawba would range from 560 to 11,200 years and for Sr-90 the travel time would be 6 to 120 years. When these times are compared to 5.7 years for Sr-90 and 51 years for Cs-137 in the LPGS case, the larger travel times at Catawba would allow a smaller portion of the radioactivity to enter the river system. Virtually all the Cs-137 will have decayed before reaching Lake Wylie. The quantity of Sr-90 that would enter the river would be reduced by a factor of from 1 to 17 over that used in the LPGS case. For conservatism, however, the Catawba dose assessment assumes that the quantity of Sr-90 entering the river will be equal to that of the LPGS case.

The Catawba River would be the direct receptor of any radionuclides released through the groundwater. There are no drinking water wells that would be directly affected by such a release.

There would be one major municipal water user affected by contamination of the Catawba River System. The City of Charleston, South Carolina, draws about 10% of its water from Lake Moultrie; this proportion is expected to increase to about 50% by 1990. The estimated 1990 population of Charleston affected by such an accident is 325,000 people. There are other smaller users between Lake Wylie and Charleston that would also be affected.

The hypothetical LPGS river site had a water drinking population of 620,000 people distributed down the river. Hence, the uninterdicted drinking-water dose for the Catawba site was calculated to be about 70% of that for the LPGS river site by comparing the populations, groundwater travel times and dilutions for the two sites, the radioactive source terms being essentially equal.

Population dose resulting from the consumption of finfish, mollusks, and crustaceans was calculated in a similar manner to the drinking-water dose. The annual harvest that could be affected by contamination downstream of the Catawba site has been conservatively estimated to be about 3.0×10^6 kg. The LPGS small river site, by comparison, used an annual fish harvest of 1.2×10^6 kg. The uninterdicted population dose due to fish consumption from the Catawba site was calculated to be about 1.8 times that of the LPGS site when consumption of the fisheries harvest, dilution, and groundwater travel time were compared.

Lake Wylie is a popular summer residential area, and it is assumed that a large segment of the population participates in swimming, water skiing and other water contact activities. These activities would expose people to direct radiation from contaminated water and sediments. The LPGS population dose assessment, however, showed that virtually all of the shoreline, boating and swimming dose resulted from Cs-137. Because almost no Cs-137 is predicted to escape in the case of Catawba, the staff estimates that the shoreline/contact population dose will be virtually zero in comparison with the LPGS site.

In summary, the staff's analyses have shown that population doses at the Catawba site resulting from drinking water, fisheries consumption, and recreation exposure are approximately 0.7, 1.8, and 0.0 times the exposures computed for the LPGS small river site, respectively. The total dose at the Catawba site is equal to about 0.27 times the LPGS total dose. Therefore, it has been demonstrated that the Catawba liquid pathway contribution to population dose is of the same order of magnitude as that predicted for the LPGS small river site and the Catawba site is not unique in its liquid pathway contribution to risk.

Finally, there are measures which could be taken to further minimize the impact of the liquid pathway. Landstrom et al. (1978) demonstrated experimentally that additional retention of strontium and cesium could be accomplished by pressure grouting of the fracture network with a thin slurry of bentonite. Adequate time to accomplish such a grouting in the vicinity of Catawba station is indicated by the calculated travel times to Lake Wylie.

(6) Risk Considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Because the ranges of both factors are quite broad, it also is useful to combine them to obtain average measures of environmental risk. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with normal operational releases.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time. Such a quantification of risk does not at all mean that there is universal agreement that peoples' attitudes about risks, or what constitutes an acceptable risk, can or should be governed solely by such a measure. At best, it can be a contributing factor to a risk judgment, but not necessarily a decisive factor.

Table 5.13 shows average values of risk associated with population dose, early fatalities for various protective actions, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Because the probabilities are on a per-reactor-year basis, the averages shown also are on a per-reactor-year basis.

The population exposures and latent cancer fatality risks may be compared with those for normal operation shown in Appendix D. The comparison (excluding exposure to the station's personnel) shows that the accident risks are comparable with those for normal operation.

There are no early fatality or economic risks associated with protective actions and decontamination for normal releases; therefore, these risks are unique for accidents. For perspective and understanding of the meaning of the early fatality risk of 0.0011 per reactor-year for evacuation to 16 km (10 mi) and no relocation, however, the staff notes that to a good approximation the population at risk is that within about 32 km (20 mi) of the plant, about 620,000 persons in the year 2000. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 1316 from motor vehicle accidents, 48 from falls, 19 from drowning, 18 from burns, and 7 from firearms (National Research Council, 1979, p. 577). The early fatality risk from reactor accidents is thus an extremely small fraction of the total risk embodied in the above combined accident modes.

Figure 5.8 shows the calculated risk expressed as whole-body dose to an individual from early exposure as a function of the downwind distance from the plant within the plume exposure pathway EPZ. The values are on a per-reactor-year basis and all accident sequences and release categories in Table 5.10 contributed to the dose, weighted by their associated probabilities.

Evacuation and other protective actions can reduce the risk to an individual of early fatality or of latent cancer fatality. Figure 5.9 shows curves of constant risk per reactor-year to an individual, living within the plume exposure pathway EPZ of the Catawba site, of latent cancer fatality as functions of distance resulting from potential accidents in the reactor. For persons living within the plume exposure pathway EPZ, the calculations show that protective actions can reduce the risk of early fatality to near zero. Directional variation of these curves reflects the variation in the average fraction of the year the wind would be blowing into different directions from the station. For comparison the following risks of fatality per year to an individual living in the United States may be noted (National Research Council, 1979, p. 577: automobile accident 2.2×10^{-4}, falls 7.7×10^{-5}, drowning 3.1×10^{-5}, burning 2.9×10^{-5}, and firearms 1.2×10^{-5}.

The economic risk associated with evacuation and other protective actions could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels, coal or oil, for example, would emit substantial quantities of sulfur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (National Research Council, 1979, pp. 559-560). This effect has not, however, been sufficiently quantified to draw a useful comparison at this time.

There are other economic impacts and risks which are not included in the cost calculations discussed in Section 5.9.4.5(4) that can be monetized. These are accident impacts on the facility itself that result in added costs to the public (ratepayers, taxpayers, and/or shareholders). These costs would be for decontamination and repair or replacement of the facility and replacement power. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. If an accident occurs during the first full year of Catawba Unit 1 operation, the economic penalty associated with the initial year of the unit's operation is estimated at between $950 and $1,600 million calculated in 1982 dollars (Comptroller General, 1981) for decontamination and restoration, including replacement of the damaged nuclear fuel. For purposes of this analysis, the staff used the conservative (high) estimate of $1,600 million and in addition assumed the total cost occurs during the first year of the accident. In reality the costs would be spread over several years thereafter. Although insurance would cover $300 million of the $1,600 million, the insurance is not credited against the $1,600 million because the $300 million times the risk probability should theoretically balance the insurance premium. In addition, the staff estimates additional fuel costs of $130 million (1984 dollars) for replacement power during each restoration year for Catawba Unit 1. This estimate assumes that the energy that would have been forthcoming from the unit (assuming 55% capacity factor) will be replaced 85% by coal-fired generation, 10% by oil-fired generation, and 5% by other nuclear generation. Assuming the nuclear unit does not operate for 8 years, the total additional replacement power costs would be approximately $1,040 million in 1984 dollars.

If the probability of sustaining a total loss of the original facility is taken as the sum of the occurrences of a core-melt accident (the sum of the probabilities for the categories in Table 5.10), then the probability of a disabling accident happening during each year of the unit's service life is 4.8×10^{-5}. Multiplying the previously estimated costs of $2,640 million for an accident to Catawba Unit 1 during the initial year of its operation by the above 4.8×10^{-5} probability results in an economic risk of approximately $127,000 (in 1984 dollars) applicable to Catawba Unit 1 during its first year of operation. This also is approximately the economic risk (in 1984 dollars) to Catawba Unit 1 during the second and each subsequent year of its operation. Although nuclear units depreciate in value and may operate at reduced-capacity factors so that the economic consequences resulting from an accident become less as the units become older, this is considered to be offset by higher costs of decontamination and restoration of the units in the later years as a result of inflation.

The economic risk to Catawba Unit 2 (in 1984 dollars) also is approximately $127,000 during its first year and each subsequent year of operation because of the balancing effect of escalation and the present worth discount factor. The $127,000 annual risk for each unit in 1984 dollars is equivalent to an annual risk of $87,000 in 1980 dollars, assuming a 10% discount rate.

(7) Uncertainties

The foregoing probabilistic and risk assessment discussion has been based upon the methodology presented in the Reactor Safety Study (RSS) which was published in 1975 (NUREG-75/014). There are substantial uncertainties associated with the numerical estimates of the likelihood, as well as the consequences, of reactor accidents that are evaluated using this methodology.

In the consequence calculations, uncertainties arise from an oversimplified analysis of the magnitude and timing of the fission product release, from uncertainties in calculated energy release, from radionuclide transport from the core to the receptor, from lack of precise dosimetry, and from statistical variations of health effects. Recent investigations of accident source terms, for example, have shown that a number of physical phenomena affecting fission product transport through the primary cooling system and the reactor containment have been neglected. Some of these processes have the potential for substantially reducing the quantity of fission products predicted to be released from the containment for some accident sequences. Such a reduction in the source term would result in substantially lower estimates of health effects, particularly the estimate of early fatalities.

One area given considerable recent thought with respect to uncertainty is atmospheric dispersion. Although recent developments in the area of atmospheric dispersion modeling used in CRAC (the computer code developed in RSS) indicate that an improved meteorological sampling scheme would reduce the uncertainties arising from this source (including the effect of washout by precipitation), large uncertainties would still remain in the calculations of radionuclide concentrations in the air and the ground from which radiological exposures to an individual and the population are calculated. These uncertainties arise from lack of precise knowledge about the particle-size distribution of the radionuclides released in particulate forms and about their chemical behavior. Therefore, the parameters of particulate deposition which exert considerable influence on the calculated results have uncertain values. Vertical rise of the radioactive plume is dependent on the heat and momentum associated with the release categories and calculations of both factors have considerable uncertainty. The duration of the release that determines cross-wind spread of the plume is another example of considerable uncertainty. Warning time before evacuation has considerable impact on effectiveness of offsite emergency response; and this parameter is not precisely calculated because of its dependence on other parameters (for example, time of release) that are not precisely known.

The state of the art for quantitative evaluation of the uncertainties in the probabilistic risk analysis such as the type presented here is not well developed. Therefore, although the staff has made a reasonable analysis of the risks presented herein, there are large uncertainties associated with the results shown. It is the qualitative judgment of the staff that the uncertainty bounds could be well over a factor of 10, but not as large as a factor of 100.

The accident at Three Mile Island occurred in March 1979 at a time when the accumulated experience record was about 400 reactor-years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity (National Research Council, 1979, p. 553). It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents like that one, by a significant number of investigative groups both within NRC and outside of it. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident" (NUREG-0660, Vol. I) collects the various recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization, and Management. The action plan presents a sequence of actions, some already taken, that result in a gradually increasing improvement in safety as individual actions are completed. The Catawba units are receiving and will receive the benefit of these actions on the schedule indicated in NUREG-0660. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements.

5.9.4.6 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at Catawba station. These have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and groundwater pathways. Included in the considerations are postulated design-basis accidents and more severe accident sequences that lead to a severely damaged reactor core or core melt.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe but the likelihood of their occurrence is judged to be small. This conclusion is based on (1) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment, (2) the fact that, in order to obtain a license to operate Catawba station, it must comply with the applicable Commission regulations and requirements, and (3) a probabilistic assessment of the risk based upon the methodology developed in the RSS. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is roughly comparable with the risk from normal operation, although accidents have a potential for early fatalities and economic costs that cannnot arise from normal operations. The risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population.

The staff has concluded that there are no special or unique circumstances about the Catawba site and environs that would warrant special mitigation features for Catawba Units 1 and 2.

5.10 Impacts From the Uranium Fuel Cycle

The Uranium Fuel Cycle rule, 10 CFR 51.20 (44 FR 45362), reflects the latest information relative to the reprocessing of spent fuel and to radioactive waste management as discussed in NUREG-0116 and NUREG-0216, which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the Atomic Energy Commission report WASH-1248. The NRC staff also was directed to develop an explanatory narrative that would convey in understandable terms the significance of releases in Table S-3 in 10 CFR 51.20. The narrative also was to address such important fuel cycle impacts as environmental dose commitments and health effects and socioeconomic and cumulative impacts, where these are appropriate for generic treatment. This explanatory narrative was published in the Federal Register on March 4, 1981 (46 FR 15154-15175). Appendix C to this report contains a number of sections that address the impacts of the LWR-supporting fuel cycle that reasonably appear to have significance for individual reactor licensing sufficient to warrant attention for National Environmental Policy Act purposes.

Table S-3 of the final rule is reproduced in its entirety as Table 5.4 in this report. Specific categories of natural resource use included in the table relate to land use, water consumption, thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

On April 27, 1982, the U.S. Court of Appeals for the District of Columbia Circuit issued a decision addressing the validity of the waste management portion of Table S-3. Natural Resources Defense Council v. NRC, No. 74-1586 (D.C. Cir., April 27, 1982). The Commission is considering the effect of this decision and intends to issue a policy statement providing further guidance regarding it.

Appendix C to this report contains a description of the environmental impact assessment of the uranium fuel cycle as related to the operation of the Catawba facility. The environmental impacts are based on the values given in Table S-3 (Table 5.4) and on an analysis of the radiological impact from radon-222 and technetium-99 releases. The staff has determined that the environmental impact of this facility on the U.S. population from radioactive gaseous and liquid releases (including radon and technetium) resulting from the uranium fuel cycle is very small when compared with the impact of natural background radiation. In addition, the nonradiological impacts of the uranium fuel cycle have been found to be acceptable.

5.11 Decommissioning

The purpose of decommissioning is to safely remove nuclear facilities from service and to remove or isolate the associated radioactivity from the environment so that part of the facility site that is not permanently committed can be released for other uses. Alternative methods of accomplishing this purpose and the environmental impacts of each method are discussed in NUREG-0586.

Since 1960, 68 nuclear reactors, including 5 licensed reactors that had been used for the generation of electricity, have been or are in the process of being decommissioned. Although no large commercial reactor has undergone decommissioning to date, the broad base of experience gained from smaller facilities is generally relevant to the decommissioning of any type of nuclear facility.

Radiation doses to the public (as a result of decommissioning activities) at the end of a commercial power reactor's useful life should be small and will come primarily from the transportation of waste to appropriate repositories. Radiation doses to decommissioning workers should be well within the occupational exposure limits imposed by regulatory requirements.

The NRC is currently conducting a generic rulemaking that will develop a more explicit overall policy for decommissioning commercial nuclear facilities.

Specific licensing requirements are being considered that include the development of decommissioning plans and financial arrangements for decommissioning nuclear facilities.

Estimates of the economic cost of decommissioning are provided in Section 6 of this statement.

5.12 Noise Impacts at Catawba

Sound pressure levels expected to result from operation of the Catawba Nuclear Station have been calculated for 17 receptor locations (see Figure 5.10). These receptor locations are the same ones chosen by the applicant (ER-OL Section 2.7) and represent points within noise sensitive land use areas in the vicinity of the site. Ambient measurements representative of the residual noise level (L_{90} or noise level exceeded 90% of the time) were made by the applicant at each of these receptors over a time period of at least a day to determine diurnal variation. Those measurements include the effect of construction activity of Catawba; the ambient measurements generally varied over space and time from 30-to-50 dBA [noise is measured as A-weighted sound level in decibels (db)].

A computer model based largely on the Edison Electric Institute environmental noise guide (Report 3637, 1978) was used to predict the effect of plant noise on the above 17 receptors. The sources of largest expected noise from Catawba Nuclear Station were used: six circular mechanical draft cooling towers, four transformers, and the three low pressure service water (LPSW) pumps at the intake structure. All sources were assumed to be in operation continuously and throughout the day and night. Standard day conditions (18°C ambient temperature and 70% relative humidity) were also assumed. Results of the model predictions appear in Table 5.14. These noise levels are the result of station operation only. Ambient levels of 30-to-50 dBA have not been accounted for in that table. The total noise level would be the logarithm sum of the ambient and plant contributions.

North and South Carolina have no noise regulations that apply to the operation of the Catawba station. However, the U.S. Environmental Protection Agency (EPA) has noise guidelines with which predictions may be compared. EPA recommends a limit of 70 dBA for the 24-hour equivalent level for farmland and general unpopulated land (EPA, March 1974). This is primarily for protection from hearing loss. For farm residents and residential areas with outside space (Catawba case), the recommendations for the day-night equivalent sound level (L_{dn}) are 55 dBA outdoors and 45 dBA indoors for protection of public health and safety with an adequate margin of safety. These identified levels of environmental noise would be expected to result in little, if any, activity interference or annoyance. The 55 dBA recommendation is violated at location 2 (prediction is 66 dBA) for any ambient level 30-to-50 dBA. Locations 1 and 3 are close to the recommended 55 dBA and may be within the EPA criterion. The accuracy of the model is not sufficient to clearly indicate compliance with the EPA recommendation at points 1 and 3. Point 2 is clearly above the 55 dBA criterion for any ambient chosen; this result is to be expected since point 2 is very close to the mechanical draft cooling tower. The high level of plant noise predicted for location 2 is not expected to be a problem since that location contains only a bridge over the discharge channel and does not represent a noise sensitive land use. Land use at locations 1 and 3 is residential, with recreational homes and permanent and recreational homes at these locations, respectively (M. Childers, Duke Power Company, personal communication, 1982).

Thus, the staff concludes that the noise provided by operation of the station will be very close to the EPA recommendation (above or below) for points 1 and 3. At other noise sensitive locations identified in the ER, predictions are very slightly above local ambient level. Adverse effects at these locations as a result of noise from routine operation at Catawba Nuclear Station would not be expected.

5.13 Emergency Planning Impacts

In connection with the promulgation of the Commission's upgraded emergency planning requirements, the staff issued NUREG-0654. The staff believes that the only noteworthy potential source of impacts to the public from emergency planning would be associated with the testing of the early notification system. The test requirements and noise levels will be consistent with those used for existing alert systems; therefore, the staff concludes that the noise impacts from the system will be infrequent and insignificant.

5.14 Environmental Monitoring

5.14.1 Terrestrial Monitoring

Because of the uncertainty concerning the quality of drift to be released from the cooling towers a monitoring program will be required to detect any possible changes to the terrestrial environment resulting from cooling tower drift. The staff recommends that this monitoring program use aerial photography using infrared film of the site area during the growing season before operation. Aerial photographs using infrared film can then be taken at intervals after Catawba station becomes operational to detect possible changes. The program will be presented in the Environmental Protection Plan, which will be included as Appendix B of the operating license.

5.14.2 Aquatic Monitoring

The certifications and permits required under the Clean Water Act provide the mechanisms for protecting water quality and aquatic biota. Operational monitoring of effluents will be required by the NPDES permit issued by the South Carolina Department of Health and Environmental Control (SCDHEC). The NRC will rely on the decisions made by the State of South Carolina, under the authority of the Clean Water Act, for any requirements for monitoring intake losses of aquatic biota and for any requirements for intake-design changes, should they be necessary. The applicant received from the SCDHEC an NPDES permit effective from June 29, 1981 through June 30, 1981 (Appendix I). The permit has been extended by the State pending finalization of effluent guidelines for the steam electric generating point source category by the U.S. Environmental Protection Agency.

An environmental protection plan will be included as Appendix B of the Catawba Nuclear Station operating license. This plan will include requirements for prompt reporting by the applicant of important events that potentially could result in significant environmental impact causally related to plant operation, for example, fish kills, mortality of any species protected by the Endangered Species Act of 1973 as amended, increase in nuisance organisms or conditions, and unanticipated or emergency discharge of waste water on chemical substances.

5.14.3 Atmospheric Monitoring

The FES-CP did not contain a description of the onsite meteorological measurements program. The current meteorological towers are not in the same location as the tower used for data collection at the construction-permit stage. The current towers are located 380 m southwest of the reactor complex. The base elevation of the towers is about 11 m above plant grade. Windspeed and direction are measured at the top a 10-m tower. Windspeed and direction also are measured at the top of a 40-m tower, and temperature difference is measured between the 10-m and 40-m levels of this tower.

The 40-m tower is an unusual structure on which to mount meteorological sensors because it is constructed from large girders. The staff is concerned about the effect of this massive structure on the representativeness of windspeed and direction measurements. Therefore, the staff has requested that the applicant provide justification that windspeed and direction measurements made at the current elevation on this tower are not affected unduly by turbulence generated by airflow over the tower structure. The applicant is considering measuring windspeed and direction on a temporary mast at a height of one tower width above the top structural component. Concurrent measurements from this elevation will be compared with measurements taken near the top structural component to determine the effect of the tower structure on windspeed and direction measurements. The results of this study will be incorporated into the FES.

The staff also is concerned about the location of the meteorological towers. The plant site is in an area of irregular terrain, with Lake Wylie at the lowest elevation, 18 m below the elevation of the meteorological tower. Because of the irregular terrain, predominance of low-windspeed conditions, and frequent intense inversions, low-level airflow may tend to follow the terrain toward lower elevations (such as, "drainage" or gravity flow). The current location of the 10-m tower may not adequately represent low-level airflow during periods of gravity flow. The staff has requested the applicant to install at least one temporary 10-m pole or tower in an area of flat terrain at plant grade to document the existence or nonexistence of low-level gravity airflow. Measurements from the top of the temporary tower(s) will be compared with measurements made at the current 10-m tower location for a period of several months covering a representative sample of conditions most conducive to low-level gravity airflow, such as, strong temperature inversions near the surface accompanied by low windspeeds. The details of this study to compare measurements will be incorporated into the FES.

The applicant has proposed to use the current meteorological measurements program as the operational program. The results of the comparative studies described above will be used to determine if changes to the current meteorological program for 10-m and 40-m windspeed and direction measurements are required for the operational program. The staff will evaluate the results of the preoperational and operational visibility measurements program after 1 year of plant operation to determine the need for continued monitoring and/or for mitigating actions to lessen the impact of cooling tower operation on visibility in the vicinity of the plant.

The applicant has concluded a preoperational program to monitor the frequency and intensity of naturally occurring ground fog around Lake Wylie. This program was conducted for a 2-year period (August 10, 1977-August 9, 1979). The preoperational program included visiometer and surface water temperature measurements at two locations (location 1, which is about 800 m north of the cooling towers, and location 2, which is about 250 m south of the cooling towers) and daily morning fog observations by security personnel near visiometer location 2 and by personnel at the Wylie Hydro Station (located about 6 km east-southeast of the station). When atmospheric conditions appeared to be conducive to the occurrence of steam fog, meteorologists conducted observations of the horizontal and vertical extent of the fog as well as transport of the fog off the lake. About six occurences were observed during the 2 years of the preoperational program.

The postoperational fog monitoring program proposed by the applicant consists of the same components as the preoperational program, that is, visiometer and surface water temperature measurements, daily observations of monitoring for occurrences near visiometer location 2 and at the Wylie Hydro Station, and selected observations of occurrences of steam fog. The applicant has proposed to continue this for at least a 1-year period after plant startup and continued operation. The staff currently is assessing the adequacy of the monitoring program, and any changes to the postoperational program will be described in the FES.

Comparisons of measurements and observations from the preoperational and postoperational fog monitoring programs will be evaluated by the staff to determine the frequency and intensity of ground fog induced by plant operation, particularly at a nearby residential community located about 1.6 km east of the plant on the east shore of Lake Wylie, and at a municipal airport located about 8 km south of the plant and about 3 km south of Lake Wylie. On the basis of this evaluation, the staff will determine the need for continued monitoring and/or mitigating actions to lessen the atmospheric impact of plant operation. The staff has recommended that the submittal of the results of the preoperational and postoperational monitoring program for fog be made a condition of the operating license.

5.14.4 Environmental Noise Monitoring

The staff recommends that the applicant conduct a short-term confirmatory noise monitoring program at the site during the first year of operation of each unit. The purpose of this program will be to quantify operational-phase noise levels and mitigative measures necessary, if any, in the vicinity of the applicant's noise assessment locations 1 and 3. The staff also recommends that this program include, to the extent practicable, the measurements of ambient noise levels at the same locations as proposed for the operational phases at a time when such levels would not be significantly affected by construction or operational activities at the site. The details of this program will be included in the Environmental Protection Plan (EPP) for the station.

5.15 References

American Cancer Society, "Cancer Facts and Figures 1979," 1978.

Atomic Energy Act of 1954.

Blaylock, B. G., and J. P. Witherspoon, "Radiation Doses and Effects Estimated for Aquatic Biota Exposed to Radioactive Releases from LWR Fuel-Cycle Facilities," Nuclear Safety, 17:351, 1976.

Breder, C. M. J., and D. E. Rosen, "Modes of Reproduction in Fishes," Natural History Press, Garden City, NY, 1966.

Carter, J., Executive Order 11988, "Floodplain Management," May 1977.

Comptroller General of the United States, "Report to the Congress," EMD-81-106, Washington, D.C., August 26, 1981.

Duke Power Company, "Environmental Report, Operating License Stage," Catawba Plant Units 1 and 2, Docket Nos. 50-413 and 50-414, Docket date June 11, 1981, as amended.

Department of Energy, Division of Environmental Control Technology, "Potential Environmental Effects of 765 kV Transmission Lines," views presented before the New York State Public Service Commission, Cases 265-29 and 265-59, 1978, November 1979.

Duke Power Company, "Plant Allen Units 1, 2, 3, 4, and 5 316(a) Demonstration," Charlotte, NC, 1976.

---, "Final Safety Analysis Report, Catawba Nuclear Station, Units 1 and 2," Docket Nos. 50-413 and 50-416, Docket date June 11, 1981, as amended.

Edison Electric Institute, Report 3637, "Electric Power Plant Environment Noise Guide" (prepared by Bolt Beranak and Newman Inc.), 1978.

Edwards, T. J., W. H. Hunt, L. E. Miller, and J. J. Servic, "An Evaluation of the Impingement of Fishes at Four Duke Power Company Steam Generating Facilities," in Thermal Ecology II, G. W. Esch and R. W. McFairlane, Eds., pp. 373-380, Technical Information Center, U.S. Energy Research and Development Administration, Washington, DC., 1976.

Federal Register Notice, 44 FR 45362, "Licensing and Regulatory Policy and Procedures for Environmental Protection; Uranium Fuel Cycle Impacts From Spent Fuel Reprocessing and Radioactive Waste Management," Final Rule, U.S. Regulatory Commission, August 2, 1979.

---, 45 FR 40101-40104, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1979," U.S. Nuclear Regulatory Commission, June 13, 1980.

---, 46 FR 15154-15175, "Appendix A, Narrative Explanation of Table S-3, Uranium Fuel Cycle Environmental Data," Proposed Rule, U.S. Nuclear Regulatory Commisssion, March 4, 1981.

Industrial BIO-TEST Laboratories, Inc., "A Baseline Predictive Environmental Investigation of Lake Wylie - Catawba Nuclear Station and Plant Allen, September 1973 - August 1974," Vol. II, Northbrook, IL, 1974.

International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, January 1977.

ITT Research Institute, "Evaluation of Health and Environmental Effects of Extra High Voltage (EHV) Transmission" (prepared for U.S. Environmental Protection Agency), Chicago, IL, February 1979.

Land, C. E., Science 209: 1197, September 12, 1980.

Landstrom, O., et al., "In Situ Experiments on Nuclide Migration in Fractured Crystalline Rocks," KBS Teknisk Rapport 110, Studsvik Energiteknik and the Geol. Survey of Sweden, 1978.

National Academy of Sciences/National Research Council, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Committee on the Biological Effects of Ionizing Radiations (BEIR I), November 1972.

---, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Committee on the Biological Effects of Ionizing Radiations (BEIR III), July 1980.

National Council on Radiation Protection and Measurements, "Review of the Current State of Radiation Protection Philosophy," NCRP Report No. 43, January 1975.

National Research Council, "Energy in Transition 1985 - 2010," Final Report of the Committee on Nuclear and Alternative Energy Systems (CONAES), Chapter 9, 1979.*

Oak Ridge National Laboratory, Nuclear Safety Information Center, "Descriptions of Selected Accidents That Have Occurred at Nuclear Reactor Facilities," ORNL/NSIC-176, Oak Ridge, TN, April 1980.

Peacock, B. (SCDHEC), letter to J. Lehr (NRC), Subject: Duke Power - Catawba Nuclear Station, York County, October 2, 1981.

Phillips, A. D., and W. T. Kaune, Battelle Pacific Northwest Laboratories, "Effects of Electric Fields on Small Laboratory Animals," paper presented at Environmental Control Symposium, Washington, DC, November 27-30, 1978.

President's Commission on the Accident at Three Mile Island, "Report of the President's Commission on the Accident at Three Mile Island," Commission Findings B, Health Effects, October 1979.

---

*This report was also published in 1980 by W. H. Freeman and Company. Pages cited will differ.

South Carolina Water Resources Commission, "Surface Water Resources Investigation of the Catawba-Wateree River System in South Carolina," March 1981.

United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," 1977.

U.S. Atomic Energy Commission, WASH-1248, "Environmental Survey of the Uranium Fuel Cycle," Washington, DC, April 1974.

U.S. Department of the Interior, National Park Service, Nation Register of Historic Places, Volumes 1 and 2 (and subsequent listings as they appear in the Federal Register), Washington, DC, 1976.

U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare and an Adequate Margin of Safety," 550/9-74-004, March 1974.

U.S. Nuclear Regulatory Commission, NUREG-75/014 (WASH-1400) "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plant," October 1975.

---, NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976.

---, NUREG-0116 (Supplement 1 to WASH-1248), "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," October 1976.

---, NUREG-0216 (Supplement 2 to WASH-1248), "Public Comments and Task Force Response Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," March 1977.

---, NUREG-0340, "Overview of the Reactor Safety Study Consequences Model," October 1977.

---, NUREG-0440, "Liquid Pathway Generic Study," February 1978.

---, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," January 1981.

---, NUREG-0651, "Evaluation of Steam Generator Tube Rupture Accidents," March 1980.

---, NUREG-0654 (FEMA-REP-1), "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," Revision 1, November 1980.

---, NUREG-0658, "Environmental Assessment for Effective Changes to 10 CFR 50 and Appendix E to 10 CFR 50; Emergency Planning Requirements for Nuclear Power Plants," August 1980.

---, NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," Vol. I, May 1980.

---, NUREG-0713, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1980," Volume 2, December 1981.

---, NUREG-0715, "Task Force Report on Interim Operations of Indian Point," August 1980.

---, NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.

---, NUREG-0800 (formerly NUREG-75/087), "Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants," Chapter 12, July 1981.

---, NUREG/CR-0400, "Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission," September 1978.

---, NUREG/CR-1231, "Remote Sensing for Detection and Monitoring of Salt Stress on Vegetation: Evaluation and Guidelines," 1980.

---, NUREG/CR-1250, Special Inquiry Group, "Three Mile Island - A Report to the Commissioners and the Public," Vol. I, Summary Section 9, Mitchell Rogovin, Director, January 1980.

<u>Industry Code</u>

National Electric Safety Code, 1977 edition.

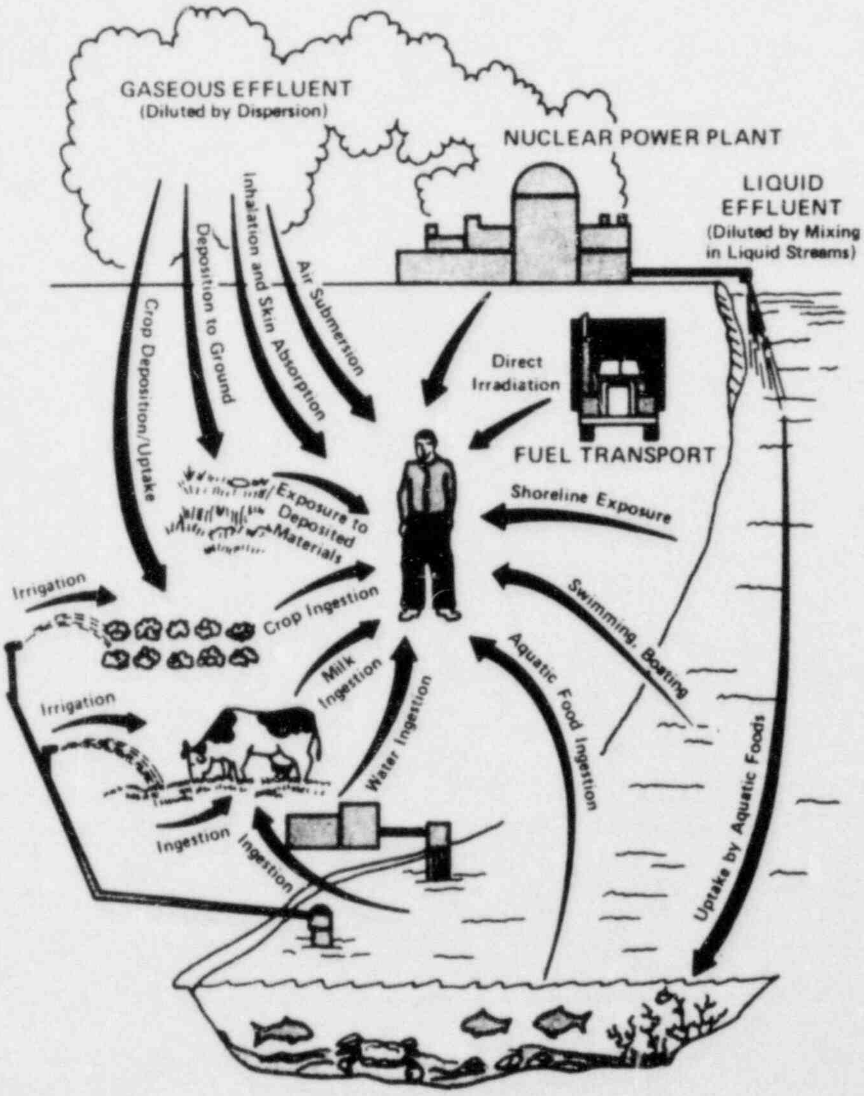

Figure 5.1 Potentially meaningful exposure pathways to individuals

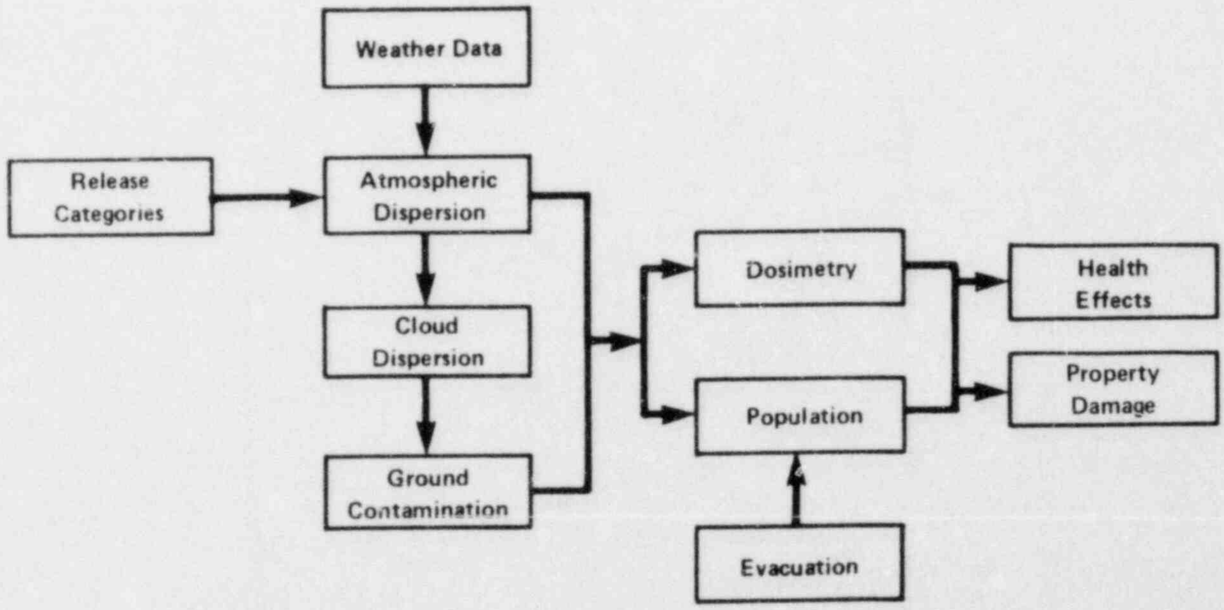

Figure 5.2 Schematic outline of atmospheric pathway consequence model

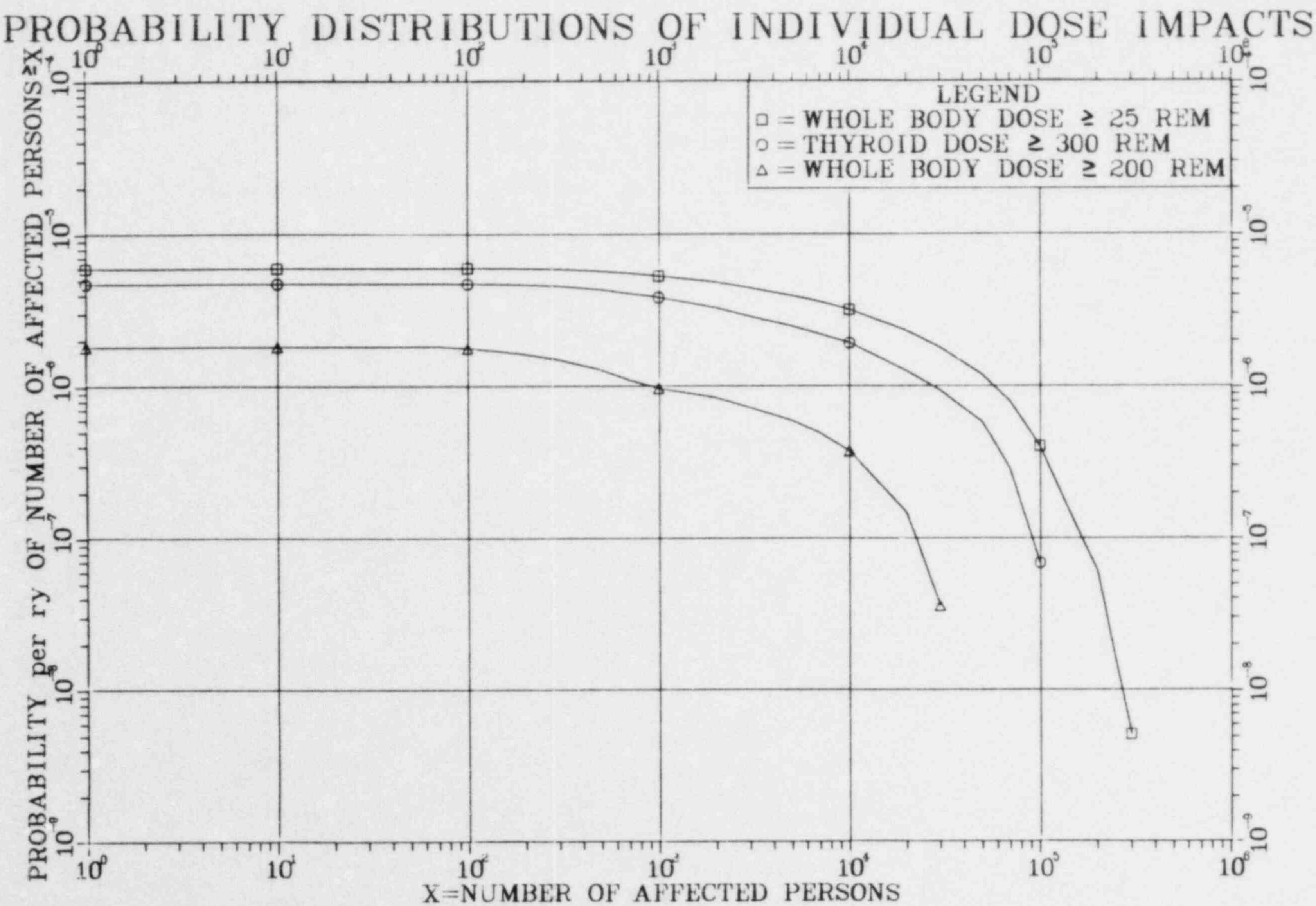

Figure 5.3 Probability distributions of individual dose impacts (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

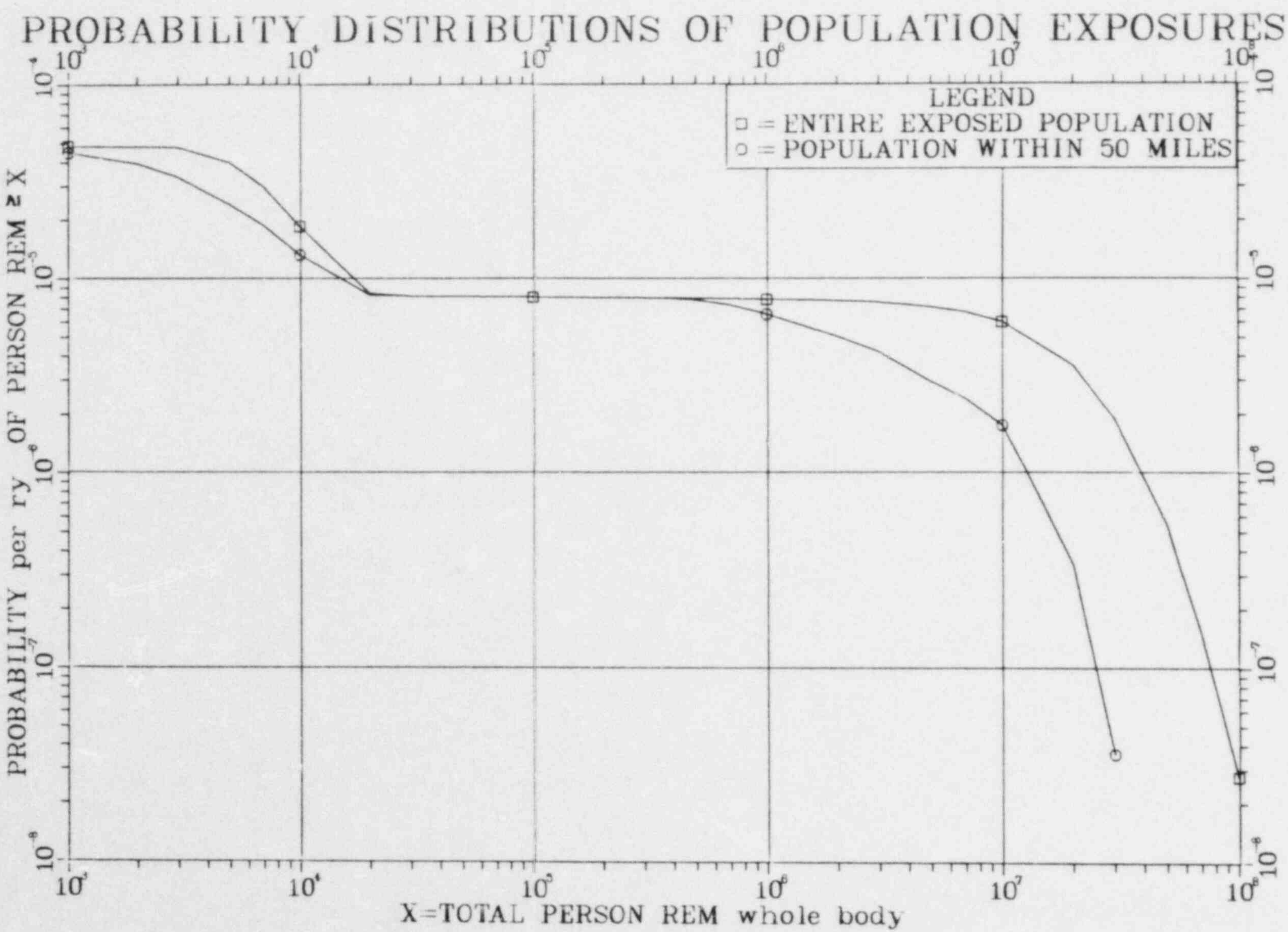

Figure 5.4 Probability distributions of population exposures (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

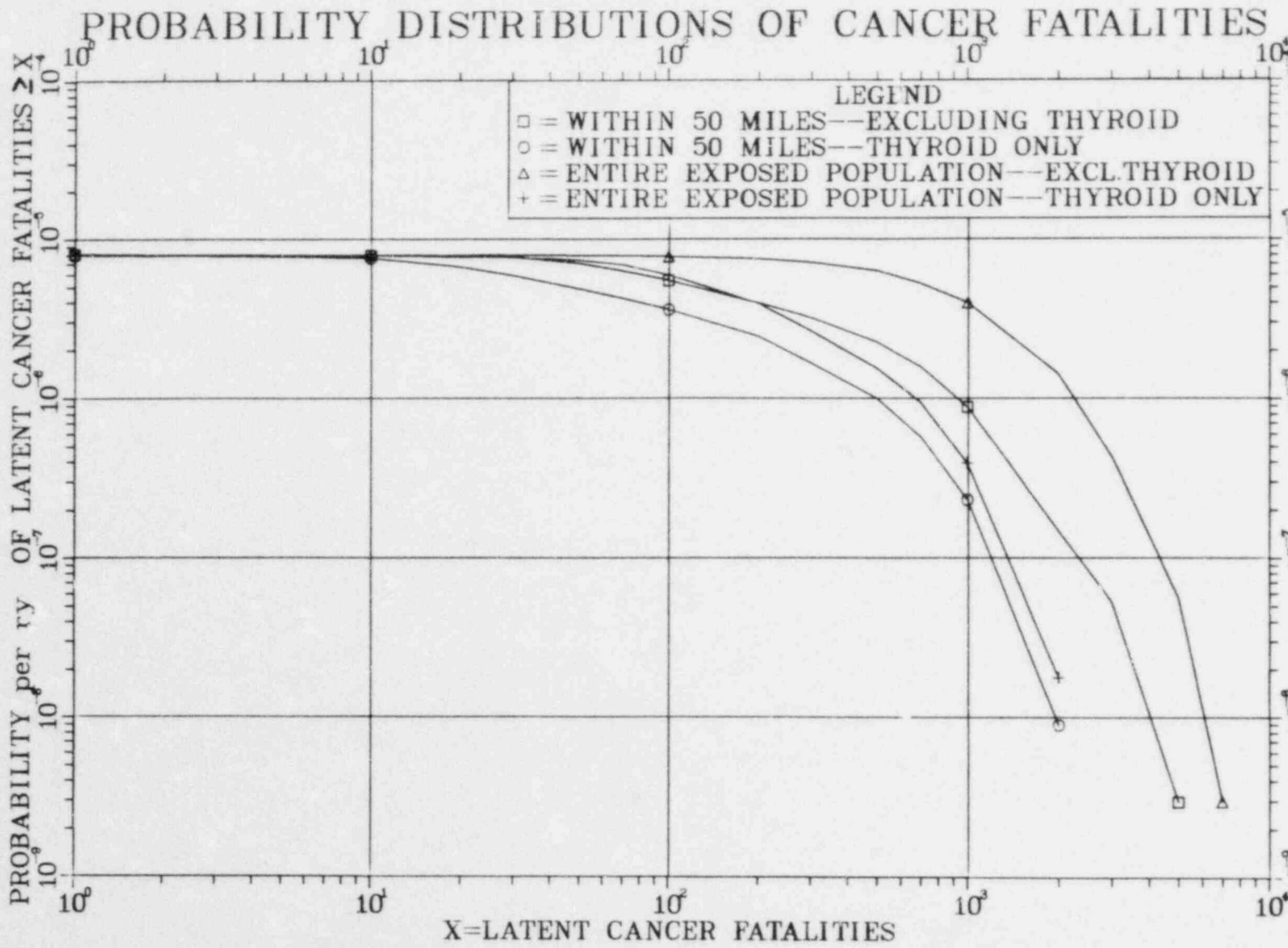

Figure 5.5 Probability distributions of cancer fatalities (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

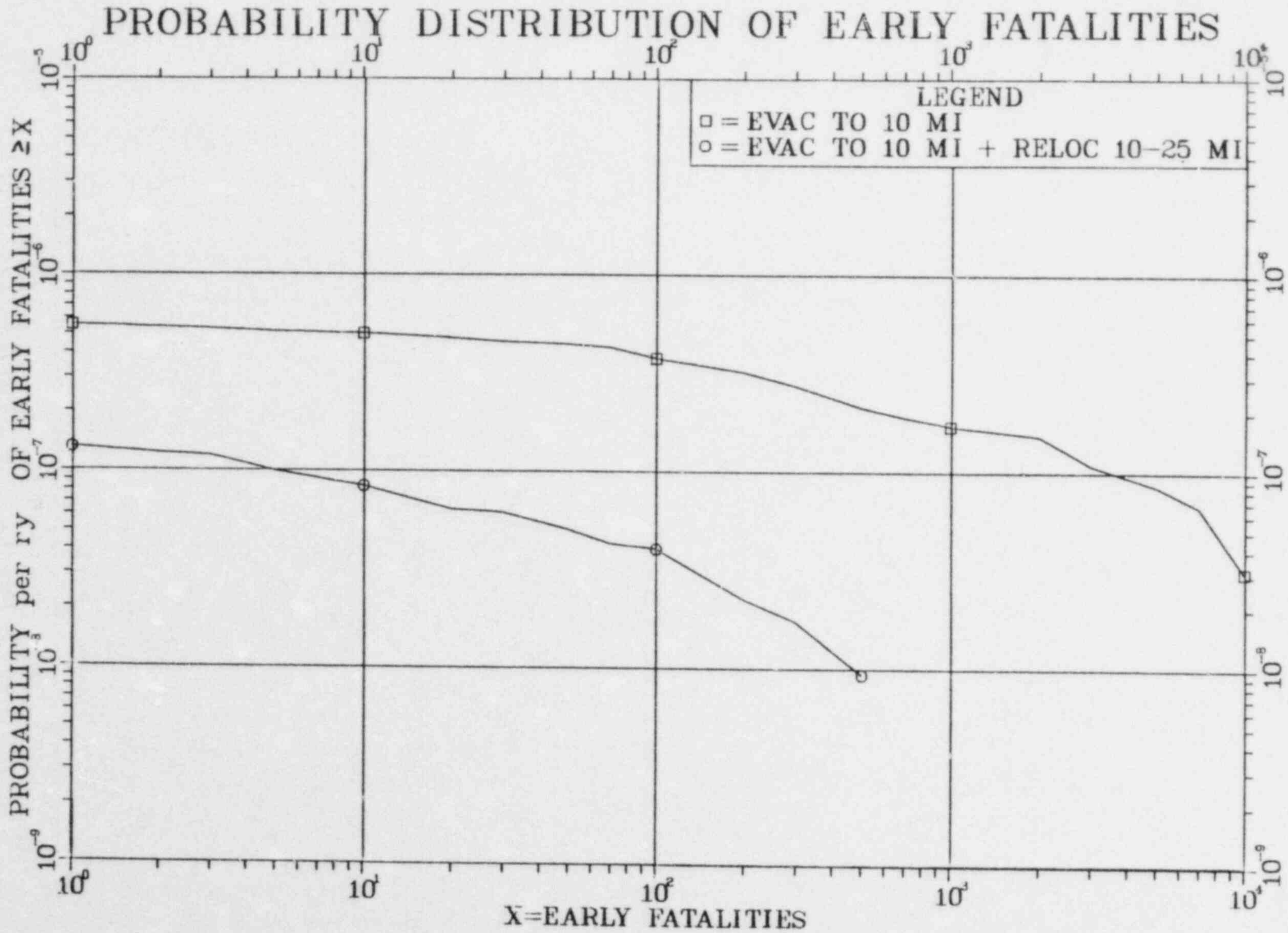

Figure 5.6 Probability distributions of early fatalities (see Section 5.9.4.5.(7) for a discussion of uncertainties in risk estimates)

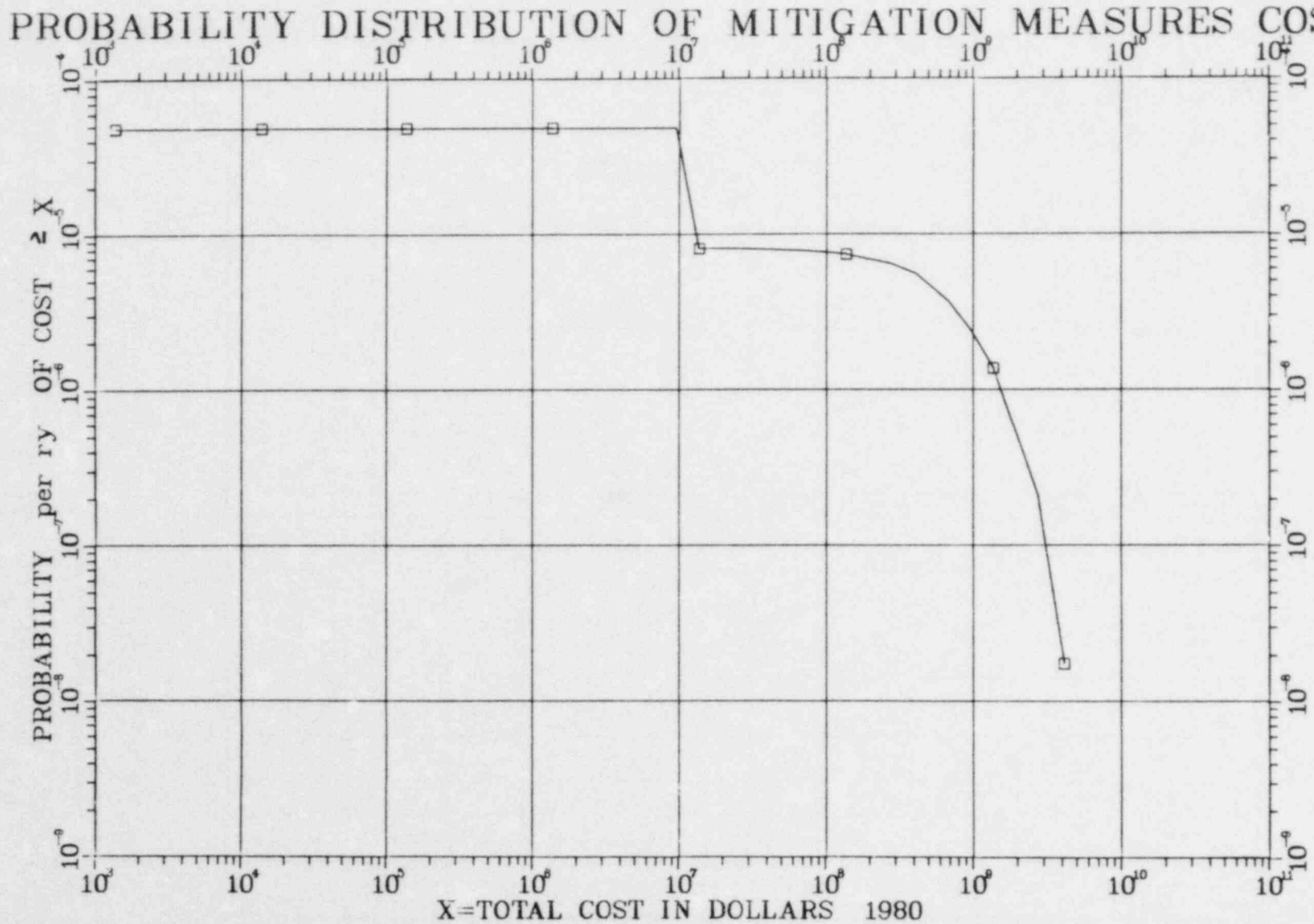

Figure 5.7 Probability distribution of mitigation measures cost (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

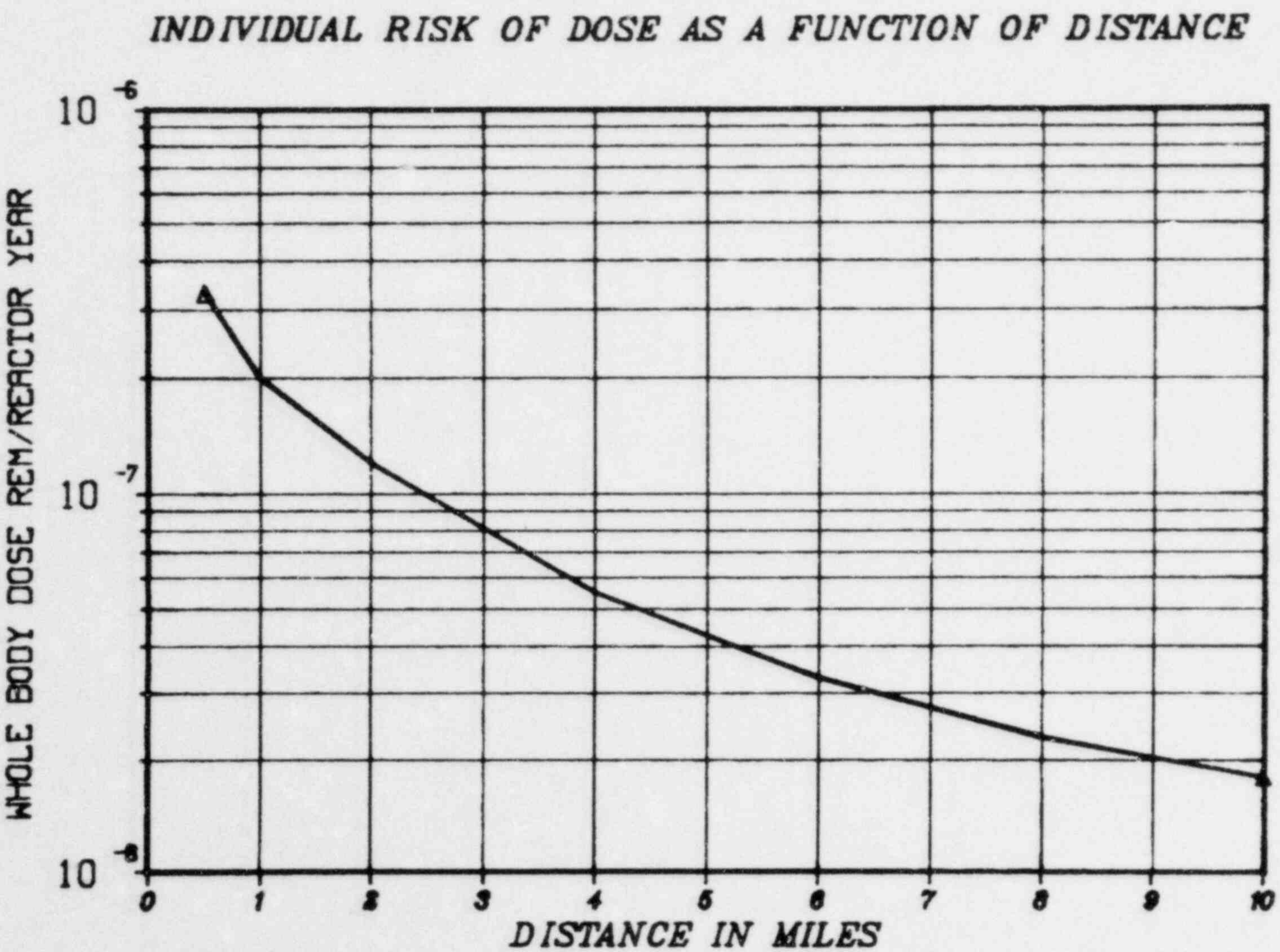

Figure 5.8 Individual risk of dose as a function of distance (curve smoothed to reflect average conditions)

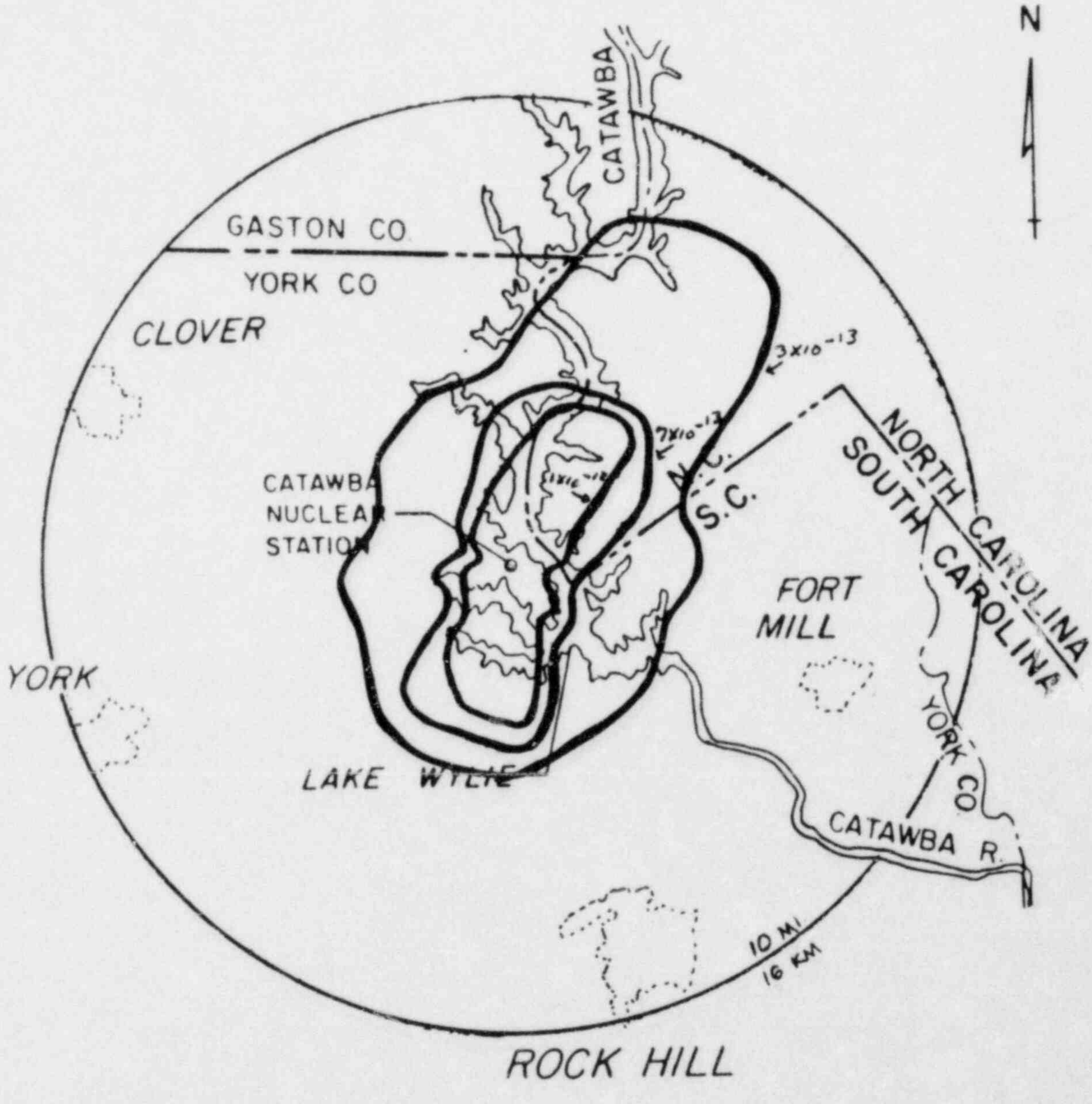

Figure 5.9 Isopleths of risk of latent cancer fatality per reactor-year to an individual

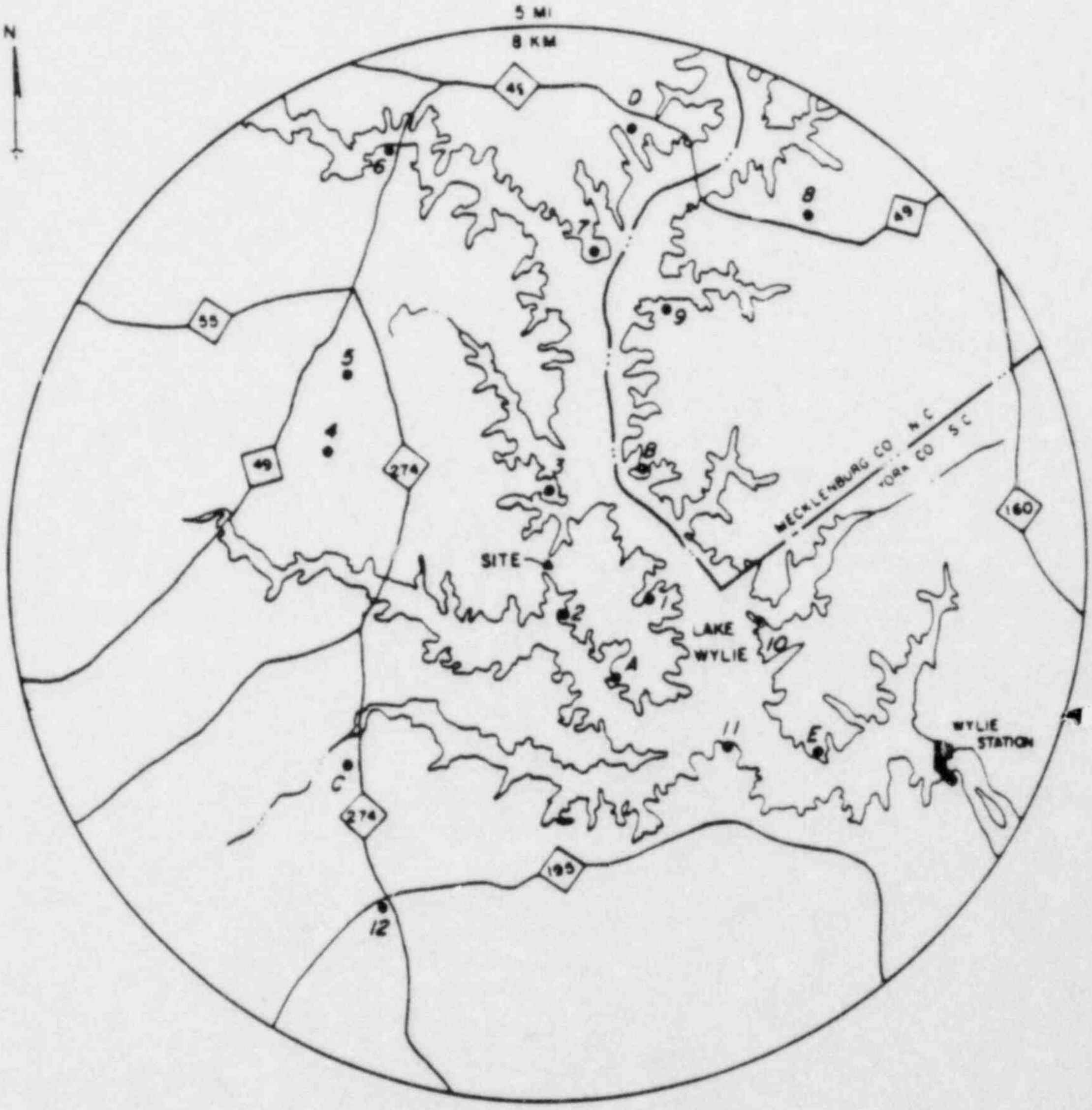

Figure 5.10 Catawba Nuclear Station site area with noise assessment locations (A-E) and (1-11)

Table 5.1 Surface water use as a percentage of average river flows, Catawba River-Lake Wylie

Use and flow	Total withdrawals		Consumptive use	
	l/min	gpm	l/min	gpm
(1) Current use	333,000	88,000	38,900	10,300
(2) Catawba Nuclear Station use	312,000	82,000	102,000	26,900
(3) Total use (1 + 2)	645,000	170,000	140,900	37,200
(4) Average daily flow in Catawba River	7,724,000	2,041,000	7,724,000	2,041,000
(5) Percent - total use to average daily flow (3 ÷ 4)	8.4		1.8	

Table 5.2 Consumptive water use as a percentage of 7-day 10-year low flow, Catawba River-Lake Wylie

Use and flow	Catawba Nuclear Station use only		Total use	
	l/min	gpm	l/min	gpm
(1) Current use	-	-	38,900	10,300
(2) Catawba Nuclear Station use	102,000	26,000	102,000	26,900
(3) Total use (1 + 2)	102,000	26,000	140,900	37,200
(4) 7-day 10-year low flow entering Lake Wylie	876,000	231,500	876,500	231,500
(5) Percent - station use or total use to 7-day 10-year low flow (3 ÷ 4)	11.6		16.1	

Table 5.3 Maximum thermal plume extent under average and worst-case conditions for the four seasons*

Season	Average conditions				Worst-case conditions			
	Area to 2.8°C (5°F) above ambient isotherm, ha (acre)	% total** lake area	Area to 32.2°C (90°F) isotherm, ha (acre)	% total** lake area	Area to 2.8°F (5°F) above ambient isotherm, ha (acre)	% total*** lake area	Area to 32.2°C (90°F) isotherm, ha (acre)	% total*** lake area
Spring	36 (90)	0.7	≈ 0	≈ 0	42 (105)	1.1	≈ 0	≈ 0
Summer	2 (5)	0.1	2 (5)	0.1	14 (35)	0.4	40 (100)	1.1
Fall	24 (60)	.5	≈ 0	≈ 0	30 (75)	0.8	≈ 0	≈ 0
Winter	36 (90)	.7	≈ 0	≈ 0	42 (105)	1.1	≈ 0	≈ 0

*From ER Table 5.1.2-1.
**Based on full pond surface area of 5041 ha (12,445 acres).
***Based on maximum drawdown 3 m (10 ft), area of 3724 ha (9,203 acres).

Table 5.4 (Summary Table S-3) Uranium-fuel-cycle environmental data[1]

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
NATURAL RESOURCES USE		
Land (acres):		
Temporarily committed[2]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons):		
Discharged to air	160	≈2 percent of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4 percent of model 1,000 MWe LWR with once-through cooling.
Fossil fuel:		
Electrical energy (thousands of MW-hour)	323	<5 percent of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf)	135	<0.4 percent of model 1,000 MWe energy output.
EFFLUENTS—CHEMICAL (MT)		
Gases (including entrainment):[3]		
SO_x	4,400	
NO_x[4]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F	.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HC1	.014	
Liquids:		
SO_4^-	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3—600 cfs. NO_3—20 cfs. Fluoride—70 cfs.
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
$C1^-$	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to environment.
Solids	91,000	Principally from mills—no significant effluents to environment.

Table 5.4 (Continued)

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
EFFLUENTS—RADIOLOGICAL (CURIES)		
Gases (including entrainment):		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	02	
Th-230	02	
Uranium	034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	83	
Tc-99		Presently under consideration by the Commission.
Fission products and transuranics	203	
Liquids:		
Uranium and daughters	2.1	Principally from milling—included tailings liquor and returned to ground—no effluents; therefore, no effect on environment.
Ra-226	0034	From UF_6 production.
Th-230	0015	
Th-234	01	From fuel fabrication plants—concentration 10 percent of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. Approximately 60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository.
Effluents—thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

[1] In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the Table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Radon-222 from the uranium fuel cycle or estimates of Technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248); and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of § 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

[3] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

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

[5] 1.2 percent from natural gas use and process.

Table 5.5 (Summary Table S-4) Environmental impact of transportation of fuel and waste to and from one light-water-cooled nulcear power reactor[1]

NORMAL CONDITIONS OF TRANSPORT

	Environmental impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lbs. per truck; 100 tons per cask per rail car
Traffic density:	
Truck	Less than 1 per day
Rail	Less than 3 per month

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals[2] (per reactor year)	Cumulative dose to exposed population (per reactor year)[3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	

ACCIDENTS IN TRANSPORT

	Environmental risk
Radiological effects	Small[4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year

[1] Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. I, NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 1717 H St. NW., Washington, D.C., and may be obtained from National Technical Information Service, Springfield, Va. 22161. WASH-1238 is available from NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microfiche, $2.25).

[2] The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3] Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

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

Table 5.6 Incidence of job-related mortalities

Occupational group	Mortality rates (premature deaths per 10^5 person-years)
Underground metal miners*	~1030
Uranium miners*	420
Smelter workers*	190
Mining**	61
Agriculture, forestry, and fisheries**	35
Contract construction**	33
Transportation and public utilities**	24
Nuclear plant worker***	23
Manufacturing**	7
Wholesale and retail trade**	6
Finance, insurance, and real estate**	3
Services**	3
Total private sector**	10

*E. L. Richardson, Secretary, "Report on Occupational Safety and Health by the U.S. Department of Health, Education, and Welfare," The President's Report on Occupational Safety and Health, May 1972.

**U.S. Bureau of Labor Statistics, "Occupational Injuries and Illness in the United States by Industry, 1975," Bulletin 1981, 1978.

***The nuclear plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The estimated occupational risk associated with the industry-wide average radiation dose of 0.8 rem is about 11 potential premature deaths per 10^5 person-years due to cancer, based on the risk estimators described in the following text. The average nonradiation-related risk for seven U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths per 10^5 person-years as shown in Figure 5 of the paper by R. Wilson and E. S. Koehl, "Occupational Risks of Ontario Hydro's Atomic Radiation Workers in Perspective," presented at Nuclear Radiation Risks, A Utility-Medical Dialog, sponsored by the International Institute of Safety and Health in Washington, D.C., September 22-23, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths describes a potential risk rather than an observed statistic.)

Table 5.7 Preoperational radiological environmental monitoring program summary

Exposure Pathway and/or Sample	Number of Samples and Sample Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE			
a. Radioiodine and Particulates	Samples from 3 offsite locations (in different sectors) at points of highest calculated annual average ground-level D/Q (Locations 200, 201, 205)	Continuous or intermittent sampler operation with sample collection monthly.	Radioiodine Cannister: Gamma Isotopic analysis for I-131 on each sample.
	1 sample from the vicinity of the community having the highest calculated annual average D/Q. (Location 212)		Particulate Filter: Gamma Isotopic analysis on each sample.
	1 sample from a control location. (Location 217)		
2. DIRECT RADIATION	40 Locations (200-207, 212, 217, 222-251)	Continuous integration with quarterly collection.	Gamma Dose on each dosimeter
3. WATERBORNE			
a. Surface	1 sample upstream of the liquid effluent discharge point. (Location 216)	Grab sample monthly.	Gamma Isotopic analysis monthly. Composite for Tritium analysis quarterly.
	1 sample in the vicinity of the liquid effluent discharge point. (Location 208)		

Source: ER-OL Table 6.1.5-1

Table 5.7 (Continued)

Exposure Pathway and/or Sample	Number of Samples and Sample Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
	1 sample downstream, beyond the mixing zone: (Location 211)		
b. Drinking	1 sample each of the 2 nearest water supplies downstream of the plant discharge. (Locations 213, 214)	Grab sample monthly.	Gross Beta and Gamma Isotopic analysis monthly. Composite for Tritium analysis quarterly.
	1 sample from a control location (Location 218)		
c. Sediment from Shoreline	1 sample each from two downstream public recreational areas. (Locations 208, 210)	Grab Sample semiannually.	Gamma Isotopic analysis on each sample.
	1 sample from a control location. (Location 215)		
4. <u>INGESTION</u>			
a. Milk	Samples from milking animals in 3 locations within 3 miles distant having the highest dose potential, if available. (Locations 209, 219, 220)	Grab Sample monthly when available.	Gamma Isotopic and I-131 analysis on each sample.
	1 sample from milking animals at a control location. (Location 221)		

Source: ER-OL Table 6.1.5-1

Table 5.7 (Continued)

Exposure Pathway and/or Sample	Number of Samples and Sample Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
b. Fish	1 sample each of bass and catfish in the vicinity of the discharge point. (Location 208)	Grab Sample semiannually	Gamma Isotopic analysis semiannually on each sample.
	1 sample each of the same types in a control location (Location 216)		
c. Broad-Leaf Vegetation	Sample from 1 offsite location at point of highest calculated annual average D/Q. (Location 201)	Grab Sample quarterly	Gamma Isotopic analysis on each sample.
	1 sample from a control location. (Location 217)		

Source: ER-OL Table 6.1.5.1

Table 5.8 Activity of radionuclides in a Catawba reactor core at 3565 MWt

Group/radionuclide	Radioactive inventory (millions of Ci)	Half-life (days)
A. <u>NOBLE GASES</u>		
Krypton-85	0.62	3,950
Krypton-85m	27	0.183
Krypton-87	52	0.0528
Krypton-88	76	0.117
Xenon-133	190	5.28
Xenon-135	38	0.384
B. <u>IODINES</u>		
Iodine-131	95	8.05
Iodine-132	130	0.0958
Iodine-133	190	0.875
Iodine-134	210	0.0366
Iodine-135	170	0.280
C. <u>ALKALI METALS</u>		
Rubidium-86	0.029	18.7
Cesium-134	8.4	750
Cesium-136	3.3	13.0
Cesium-137	5.2	11,000
D. <u>TELLURIUM-ANTIMONY</u>		
Tellurium-127	6.6	0.391
Tellurium-127m	1.2	109
Tellurium-129	35	0.048
Tellurium-129m	5.9	34.0
Tellurium-131m	14	1.25
Tellurium-132	130	3.25
Antimony-127	6.8	3.88
Antimony-129	37	0.179
E. <u>AKALINE EARTHS</u>		
Strontium-89	100	52.1
Strontium-90	4.1	11,030
Strontium-91	120	0.403
Barium-140	180	12.8
F. <u>COBALT AND NOBLE METALS</u>		
Cobalt-58	0.87	71.0
Cobalt-60	0.32	1,920
Molybdenum-99	180	2.8
Technetium-99m	160	0.25
Ruthenium-103	120	39.5
Ruthenium-105	80	0.185
Ruthenium-106	28	366
Rhodium-105	55	1.50

Table 5.8 (Continued)

Group/radionuclide	Radioactive inventory (millions of Ci)	Half-life (days)
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	4.3	2.67
Yttrium-91	130	59.0
Zirconium-95	170	65.2
Zirconium-97	170	0.71
Niobium-95	170	35.0
Lanthanum-140	180	1.67
Cerium-141	170	32.3
Cerium-143	140	1.38
Cerium-144	95	284
Praseodymium-143	140	13.7
Neodymium-147	67	11.1
Neptunium-239	1,800	2.35
Plutonium-238	0.063	32,500
Plutonium-239	0.023	8.9×10^6
Plutonium-240	0.023	2.4×10^6
Plutonium-241	3.8	5,350
Americium-241	0.0019	1.5×10^5
Curium-242	0.56	163
Curium-244	0.026	6,630

Note: The above grouping of radionuclides corresponds to that in Table 5.10.

Table 5.9 Realistic estimates of 2-hour radiation doses from design-basis accidents at exclusion area boundary

	Dose (rem) at 762 m*	
Events	Whole body	Thyroid
Infrequent accidents		
Waste gas tank failure	0.06	<0.001
Small-break LOCA**	<0.001	<0.001
Steam generator tube rupture***	0.001	0.05
Fuel-handling accident	0.007	0.004
Limiting faults		
Main steamline break	<0.001	<0.001
Control rod ejection	<0.001	0.007
Large-break LOCA	0.001	0.07

*Plant exclusion area boundary distance.

**LOCA = loss-of-coolant accident; the TMI-2 accident was one kind of a small-break LOCA.

***See NUREG-0651 for descriptions of three steam generator tube rupture accidents that have occurred in the United States.

Table 5.10 Summary of atmosphere releases in hypothetical accident sequences in a PWR (rebaselined)

Accident sequence or sequence group**	Probability per reactor-yr	Fraction of core inventory released*						
		Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru***	La†
Event V	2.0×10^{-6}	1.0	0.64	0.82	0.41	0.1	0.04	0.006
TMLB'	3.0×10^{-6}	1.0	0.31	0.39	0.15	0.044	0.018	0.002
PWR3	3.0×10^{-6}	0.80	0.2	0.2	0.3	0.02	0.03	0.003
PWR7	4.0×10^{-5}	6×10^{-3}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}

*Background on the isotope groups and release mechanisms is presented in Appendix VII, WASH-1400.

**See Appendix E for description of the accident sequences and release categories.

***Includes Ru, Rh, Co, Mo, Tc.

†Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

Note: See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.

Table 5.11 Summary of environmental impacts and probabilities

Probability of impact per reactor-year	Persons exposed, over 200 rem	Persons exposed, over 25 rem	Population exposure, millions of person-rem 50 mi/total	Latent* cancers, 50 mi/total	Cost of offsite mitigating actions, millions of dollars
10^{-4}	0	0	0/0	0/0	0
10^{-5}	0	0	0.015/0.017	0/0	13
5×10^{-6}	0	1,400	2.0/13	170/870	470
10^{-6}	900	57,000	13/39	1,400/2,900	1,500
10^{-7}	22,000	170,000	25/76	3,500/5,700	3,100
10^{-8}	44,000	270,000	42/160	8,300/6,100	6,700
Related figure	5.3	5.3	5.4	5.5	5.7

*Includes cancers of all organs. Genetic effects would be approximately twice the number of latent cancers.

Note: See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.

Table 5.12 Summary of early fatalities and probabilities

Probability of impact per reactor-year	Early fatalities for evacuation of EPZ	Early fatalities for evacuation of EPZ and relocation at 10-25 mi
10^{-4}	0	0
10^{-5}	0	0
5×10^{-6}	0	0
10^{-6}	0	0
10^{-7}	3,600	5
10^{-8}	19,000	470

Note: EPZ = emergency planning zone.

Table 5.13 Average values of environmental risks resulting from accidents per reactor-year

Environmental risk	Average value
Population exposure	
Person-rem within 50 mi	47
Total person-rem	170
Early fatalities	
Evacuation to 10 mi	0.0011
Evacuation to 10 mi plus relocation between 10 and 25 mi	0.00002
Latent cancer, fatalities	
All organs, excluding thyroid	0.0099
Thyroid only	0.0025
Cost of protective actions and decontamination	$7,100*

*1980 dollars.

Note: See Section 5.9.4.5(7) for discussions of uncertainties in risk estimates.

Table 5.14 Noise level predictions at receptor locations shown in Figure 5.10 resulting from the operation of Catawba Nuclear Station only

Receptor location	L_{eq} (dBA)	L_{dn} (dBA)	Overall (dBO)
A	45	51	60
B	43	49	58
C	27	33	47
D	16	23	39
E	26	32	46
1	50	56	64
2	60	66	72
3	49	55	63
4	28	34	48
5	26	32	46
6	15	22	39
7	24	31	45
8	17	24	40
9	27	34	47
10	35	41	53
11	32	38	50
12	20	27	42

Notes:
L_{eq} = equivalent sound level.
dBA = A-weighted sound level.
L_{dn} = day-night equivalent sound level.
dBO = overall unweighted sound level.

6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Environmental Effects

The staff has reassessed the physical, social, and economic impacts that can be attributed to operation of the Catawba station. Such impacts, beneficial or adverse, are summarized in Table 6.1 of this draft environmental statement.

At the present time the staff foresees no impacts of a magnitude requiring mitigating actions. However, the applicant is required to adhere to the following conditions for protection of the environment:

(1) Before engaging in additional construction or operational activities that may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

(2) The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement as modified and approved by the staff and implemented in Appendix B, Environmental Protection Plan (nonradiological), and Appendix A, Technical Specifications (radiological), that will be incorporated in the operating licenses for Catawba Units 1 and 2.

(3) If adverse environmental effects or evidence of irreversible environmental damage are detected during the operating life of the plant, the applicant shall provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

6.2 Irreversible and Irretrievable Commitments of Resources

There has been no change in the staff's assessment of this impact since the earlier review except that the continuing escalation of costs has increased the dollar values of the materials used for constructing and fueling the plant.

6.3 Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

There have been no significant changes in the staff's preconstruction evaluation of the relationship between environmental effects of short-term uses (construction and operation of the plant) and long-term productivity (FES-CP, Sec. 8). The conclusion that the dedication of resources for a nuclear generating plant at the Catawba site is consistent with the balancing of short- and long-term objectives for use of the environment is still valid.

6.4 Benefit-Cost Summary

The benefits and costs of operating the plant are summarized in Table 6.1, which provides the staff's assessments of degrees of benefit or cost, as well as magnitudes of impact where they are quantifiable. References that contain further information are indicated.

6.4.1 Benefits

A major benefit to be derived from the operation of the Catawba Station is the more than 12 billion kWh of baseload electrical energy which will be produced annually (this projection assumes that both units will operate at an annual average capacity of 60%). The addition of the plant also will improve the applicant's ability to reliably supply the load requirements of customers in its service area by contributing 2290 MWe of generating capacity to the bulk power system.

Another benefit to be derived is the savings in overall system production costs which will accrue from the operation of the plant. A production costs analysis was submitted by the applicant (Duke Power Company, August 7, 1981) which projected annual system production costs for the years 1984 through 199[illegible], with and without the Catawba units in service. The analysis assumed two different rates of system load growth--one with the applicant's projected annual growth rate of 4.0% and the other with energy load held constant at the 1980 level corresponding to a growth rate of zero. The average savings projected for the first full year of operation of both units are projected to be \$310 and \$47 million per year (1986 dollars), respectively, for the two load growth scenarios. The staff anticipates these savings will increase as the cost of replacement energy increases and improvement in each unit's capacity factor is realized.

The staff considers these estimates to be reasonable in light of the fact that replacement energy to service load, if the plant is not allowed to operate, will come primarily from coal-fueled generating facilities. The Department of Energy has estimated (Department of Energy, 1981) that the 1981 cost of providing energy for load from coal-fueled generating facilities rather than from nuclear generation, on the average, imposes about a \$66 million penalty per unit per year, on the supplying system* (\$132 million per year for a two-unit station). This amount appears to support the conclusion drawn in the applicant's analysis since the magnitude of this penalty already exceeds the minimum amount projected by the applicant for 1986.

6.4.2 Costs

6.4.2.1 Economic

The economic costs associated with station operation include fuel costs and operation and maintenance costs which are expected to average 8.6 mills per kWh (Duke Power Company, 1982, Table 1.3.1-3) and 3.8 mills per kWh (Duke Power

---

*Assuming nuclear unit of comparable size and operating at 60% capacity factor.

Company, 1982, Table 8.2.1-2),* respectively, in 1986, the first full year of station operation.

The applicant's estimate of decommissioning costs for each Catawba unit totals $45 million in 1977 dollars (ER-OL).

6.4.2.2 Environmental and Socioeconomic

Changes in station design, operating procedures, and environmental data that were taken into consideration in this operating-license review have not led to significant increases in the environmental or socioeconomic costs over the corresponding costs that were estimated during the construction-permit review. The costs considered include those attributable to the uranium fuel cycle and to plant accidents. Such costs are either negligible or range from small to moderate.

6.4.3 Conclusions

As a result of the analysis and review of potential environmental, technical, economic, and social impacts, the staff has prepared an updated forecast of the effects of operation of Catawba station. No new information has been obtained that alters the overall balancing of the benefits versus the environmental costs of station operation. Consequently, the staff has determined that the station will most likely operate with only minimal environmental impact. The staff finds that the primary benefits of minimizing system production costs and increasing baseload generating capacity by 2290 MWe greatly outweigh the environmental, social, and economic costs.

6.5 References

Department of Energy, "Estimates of the Costs of Delaying Operating Licenses for Nuclear Plants," May 15, 1981.

---, "A Review of the Economics of Coal and Nuclear Power," draft, September 30, 1981.

Duke Power Company, "Catawba Station ER-OL," Rev. 2, August 7, 1981.

U.S. Nuclear Regulatory Commission, NUREG-0480, "Coal and Nuclear: A Comparison of Generating Base Load Electricity by Region," December 1978.

---, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," January 1, 1981.

*Sum of 1981 fixed and variable operation and maintenance costs escalated at 10% per year. Escalation rate from U.S. DOE, "A Review of the Economics of Coal and Nuclear Power," p. IV-19.

Table 6.1 Benefit-cost summary for the Catawba plant

Benefit or cost (reference)	Magnitude or reference*	Staff assessment of benefit or cost**
BENEFITS		
Direct		
Electrical energy (Sec. 6.4.1)	12 billion kWh/yr	Large
Additional generating capacity (Sec. 6.4.1)	2290 MWe (design rating)	Moderate
Reduced generating costs (Sec. 6.4.1)	\$47-\$310 million/yr (1986)	Large
Indirect		
Local property taxes (Sec. 5.8)	\$29.2 million/yr (1981)	Large
Employment (Sec. 5.8)	846 employees	Small
Payroll (Sec. 5.8)	\$14.5 million/yr (1984)	Small
Local service and merchandise purchases by utility (Sec. 5.8)	\$1.5 million/yr (1981)	Small
COSTS		
Economic		
Fuel	8.6 mill/kWh (1986)	Small
Operation and maintenance	3.8 mill/kWh (1986)	Small
Decommissioning	\$45 million (1977)	Small
Environmental and socioeconomic		
Resources committed		
Land (Sec. 4.2.2 and 4.2.7) (station and transmission lines)	1250 ha	Small
Water (Sec. 4.2.3)	10.7 m^3/sec	Small
Uranium - U_3O_8 (NUREG-0480)	About 8000 t	Small
Damages suffered by other water users		
Surface-water consumption	(Sec. 5.3)	Small
Surface-water contamination (chemical)	(Sec. 5.3)	Small
Surface-water contamination (thermal)	(Sec. 5.3)	Small

See footnotes at end of table.

Table 6.1 (Continued)

Benefit or cost (reference)	Magnitude or reference*	Staff assessment of benefit or cost**
Damage to Lake Wylie aquatic biota		
Impingement and entrainment	(Sec. 5.5)	Small
Thermal effects	(Sec. 5.5)	Small
Chemical discharges	(Sec. 5.3)	Small
Damage to terrestrial resources		
Fog and ice	(Sec. 5.4)	Small
Transmission line maintenance	(Sec. 5.2)	Small
Adverse socioeconomic effects		
Loss of historic or archeological resources	(Sec. 5.7)	Small
Traffic	(Sec. 5.8)	Small
Demands on public facilities and services	(Sec. 5.8)	Small
Demands on private facilities and services	(Sec. 5.8)	Small
Adverse radiological health effects		
Reactor operation on		
General population	(Sec. 5.9.3)	Small
Workers on site	(Sec. 5.9.3)	Small
Balance of fuel cycle	(Sec. 5.10)	Small
Accident risks	(Sec. 5.9.4)	Small

* Where a particular unit of measure for a benefit/cost category has not been specified in the environmental impact statement (EIS), or where an estimate of the magnitude of the benefit/cost under consideration has not been made, the reader is directed to the appropriate EIS section or other source for further information.

** Subjective measure of costs and benefits is assigned by reviewers, where quantification is not possible: "Small" - impacts that in the reviewers' judgments, are of such minor nature, based on currently available information, that they do not warrant detailed investigations or considerations of mitigative actions; "Moderate" - impacts that in the reviewers' judgments are likely to be clearly evident (mitigation alternatives are usually considered for moderate impacts); "Large" - impacts that in the reviewers' judgments, represent either a severe penalty or a major benefit. Acceptance requires that large negative impacts should be more than offset by other overriding project considerations.

7 LIST OF CONTRIBUTORS

The following personnel of the U.S. Nuclear Regulatory Commission, Washington, DC, participated in the preparation of the Draft Environmental Statement:

Kahtan Jabbour	Project Manager
Dino Scaletti	Project Manager
Dee Gable	Editor
Mary Mejac	Editor
Marilee Duncan	Licensing Assistant
John Lehr	Sr. Environmental Engineer
Michael Masnik	Sr. Fishery Biologist
Germain LaRoche	Sr. Land Use Analyst
Nick Fields	Electrical Engineer
Brian Richter	Cost-Benefit Economist
Raymond Gonzales	Hydraulic Engineer
Sarbeswar Acharya	Environmental/Radiation Physicist
Jocelyn Mitchell	Nuclear Engineer
James Fairobent	Meteorologist
Edward Branagan	Health Physicist
Richard Codell	Sr. Hydraulic Engineer
Kenneth Dempsey	Nuclear Engineer
Jacques Boegli	Sr. Nuclear Engineer
Alvin Brauner	Siting Analyst
R. Wayne Houston	Assistant Director, Radiation Protection
David West	Nuclear Engineer
Steven Baker	Nuclear Engineer
Gerald Simonds	Emergency Preparedness Analyst
Argil Toalston	Chief, Antitrust and Economic Analysis Branch
Justin Long	Sr. Chemical Engineer

8 LIST OF AGENCIES, ORGANIZATIONS AND PERSONS TO WHOM COPIES OF THIS ENVIRONMENTAL STATEMENT ARE BEING SENT

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
Federal Emergency Management Administration
Governor of South Carolina
South Carolina Department of Health and Environmental Control
Catawba Regional Planning Council
County Manager of York County, South Carolina

9 RESERVED FOR STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

APPENDIX A

RESERVED FOR COMMENTS ON THE
DRAFT ENVIRONMENTAL STATEMENT

APPENDIX B

NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 miles) of the Catawba facility, employing the same dose calculation models used for individual doses (see Regulatory Guide 1.109, Revision 1), for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR, Part 50, Appendix I. In addition, dose commitments to the population residing beyond the 80-km region, associated with the export of food crops produced within the 80-km region and with the atmospheric and hydrospheric transport of the more mobile effluent species, such as noble gases, tritium, and carbon-14, are taken into consideration for the purpose of meeting the requirements of the National Environmental Policy Act, 1969 (NEPA). This appendix describes the methods used to make these NEPA population dose estimates.

1. Iodines and Particulates Released to the Atmosphere

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind; thus the concentration of these nuclides remaining in the plume is continuously being reduced. Within 80 km of the facility, the deposition model in Regulatory Guide 1.111, Revision 1, is used in conjunction with the dose models in Regulatory Guide 1.109, Revision 1. Site-specific data concerning production and consumption of foods within 80 km of the reactor are used. For estimates of population doses beyond 80 km it is assumed that excess food not consumed within the 80-km area would be consumed by the population beyond 80 km. It is further assumed that none, or very few, of the particulates released from the facility will be transported beyond the 80-km distance; thus, they will make no significant contribution to the population dose outside the 80-km region, except by export of food crops.

2. Noble Gases, Carbon-14, and Tritium Released to the Atmosphere

For locations within 80 km of the reactor facility, exposures to these effluents are calculated with a constant mean wind-direction model according to the guidance provided in Regulatory Guide 1.111, Revision 1, and the dose models described in Regulatory Guide 1.109, Revision 1. For estimating the dose commitment from these radionuclides to the U.S. population residing beyond the 80-km region, two dispersion regimes are considered. These are referred to as the first-pass-dispersion regime and the world-wide-dispersion regime. The model for the first-pass-dispersion regime estimates the dose commitment to the population from the radioactive plume as it leaves the facility and drifts across the continental United States toward the northeastern corner of the United States. The model for the world-wide-dispersion regime estimates the dose commitment to the U.S. population after the released radionuclides mix uniformly in the world's atmosphere or oceans.

(a) First-Pass Dispersion

For estimating the dose commitment to the U.S. population residing beyond the 80-km region as a result of the first pass of radioactive pollutants, it is assumed that the pollutants disperse in the lateral and vertical directions along the plume path. The direction of movement of the plume is assumed to be from the facility toward the northeast corner of the United States. The extent of vertical dispersion is assumed to be limited by the ground plane and the stable atmospheric layer aloft, the height of which determines the mixing depth. The shape of such a plume geometry can be visualized as a right cylindrical wedge whose height is equal to the mixing depth. Under the assumption of constant population density, the population dose associated with such a plume geometry is independent of the extent of lateral dispersion, and is only dependent upon the mixing depth and other nongeometrical related factors (NUREG-0597). The mixing depth is estimated to be 1000 m, and a uniform population density of 62 persons/km^2 is assumed along the plume path, with an average plume-transport velocity of 2 m/sec.

The total-body population-dose commitment from the first pass of radioactive effluents is due principally to external exposure from gamma-emitting noble gases, and to internal exposure from inhalation of air containing tritium and from ingestion of food containing carbon-14 and tritium.

(b) World-Wide Dispersion

For estimating the dose commitment to the U.S. population after the first-pass, world-wide dispersion is assumed. Nondepositing radionuclides with half-lives greater than 1 year are considered. Noble gases and carbon-14 are assumed to mix uniformly in the world's atmosphere (3.8×10^{18} m^3), and radioactive decay is taken into consideration. The world-wide-dispersion model estimates the activity of each nuclide at the end of a 15-year release period (midpoint of reactor life) and estimates the annual population-dose commitment at that time, taking into consideration radioactive decay and physical removal mechanisms (for example, C-14 is gradually removed to the world's oceans). The total-body population-dose commitment from the noble gases is due mainly to external exposure from gamma-emitting nuclides, whereas from carbon-14 it is due mainly to internal exposure from ingestion of food containing carbon-14.

The population-dose commitment as a result of tritium releases is estimated in a manner similar to that for carbon-14, except that after the first pass, all the tritium is assumed to be immediately distributed in the world's circulating water volume (2.7×10^{16} m^3) including the top 75 m of the seas and oceans, as well as the rivers and atmospheric moisture. The concentration of tritium in the world's circulating water is estimated at the time after 15 years of releases have occurred, taking into consideration radioactive decay; the population-dose commitment estimates are based on the incremental concentration at that time. The total-body population-dose commitment from tritium is due mainly to internal exposure from the consumption of food.

3. Liquid Effluents

Population-dose commitments due to effluents in the receiving water within 80 km of the facility are calculated as described in Regulatory Guide 1.109, Revision 1. It is assumed that no depletion by sedimentation of the nuclides present in the receiving water occurs within 80 km. It also is assumed that aquatic biota concentrate radioactivity in the same manner as was assumed for the ALARA evaluation for the maximally exposed individual. However, food-consumption values appropriate for the average, rather than the maximum, individual are used. It is further assumed that all the sport and commercial fish and shellfish caught within the 80-km area are eaten by the U.S. population.

Beyond 80 km, it is assumed that all the liquid-effluent nuclides except tritium have deposited on the sediments so that they make no further contribution to population exposures. The tritium is assumed to mix uniformly in the world's circulating water volume and to result in an exposure to the U.S. population in the same manner as discussed for tritium in gaseous effluents.

4. References

U. S. Nuclear Regulatory Commission, NUREG-0597, "User's Guide to GASPAR Code," June 1980.

---, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

---, Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Revision 1, July 1977.

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the light-water-reactor (LWR)-supporting fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 (see Section 5.10 of the main body of this report) and the NRC staff's analysis of the radiological impact from radon and technetium releases. For the sake of consistency, the analysis of fuel-cycle impacts has been cast in terms of a model 1000-MWe light-water-cooled reactor operating at an annual capacity factor of 80%. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff's analysis and conclusions would not be altered if the analysis were to be based on the net electrical power output of the Catawba Nuclear Station.

1. Land Use

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 460,000 m^2 (113 acres). Approximately 53,000 m^2 (13 acres) per year are permanently committed land, and 405,000 m^2 (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel-cycle plant, such as a mill, enrichment plant, or succeeding plants. On abandonment or decommissioning, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 405,000 m^2 per year of temporarily committed land, 320,000 m^2 are undisturbed and 90,000 m^2 are disturbed. Considering common classes of land use in the United States,* fuel-cycle land-use requirements to support the model 1000-MWe LWR do not represent a significant impact.

2. Water Use

The principal water-use requirement for the fuel cycle supporting a model 1000-MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43×10^6 m^3 (11.4×10^9 gal), about 42×10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (for example, evaporation losses in process cooling) of about 0.6×10^6 m^3 (16×10^7 gal) per year and water discharged to the ground (for example, mine drainage) of about 0.5×10^6 m^3 per year.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4% of those from the model 1000-MWe LWR using once-through cooling. The consumptive water use of 0.6×10^6 m^3 per year is about 2% of that from the

---

*A coal-fired plant of 1000-MWe capacity using strip-mined coal requires the disturbance of about 810,000 m^2 (200 acres) per year for fuel alone.

model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of the model 1000-MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the proposed project.

3. Fossil Fuel Consumption

Electrical energy and process heat are required during various phases of the fuel cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5% of the annual electrical power production of the model 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from the model plant. The staff finds that the direct and indirect consumptions of electrical energy for fuel-cycle operations are small and acceptable relative to the net power production of the proposed project.

4. Chemical Effluents

The quantities of chemical, gaseous, and particulate effluents associated with fuel-cycle processes are given in Table S-3. The principal species are sulfur oxides, nitrogen oxides, and particulates. On the basis of data in a Council on Environmental Quality (CEQ) report (1976), the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with the same emissions from the stationary fuel-combustion and transportation sectors in the United States; that is, about 0.02% of the annual national releases for each of these species. The staff believes that such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel cycle processes are related to fuel-enrichment, -fabrication, and -reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. The flow of dilution water required for specific constituents is specified in Table S-3. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel-cycle operations will be subject to requirements and limitations set forth in the national pollution discharge elimination system (NPDES) permit.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in large enough quantities to have a significant impact on the environment.

5. Radioactive Effluents

Radioactive effluents estimated to be released to the environment from reprocessing and waste-management activities and certain other phases of the fuel-cycle process are set forth in Table S-3. Using these data, the staff has calculated for 1 year of operation of the model 1000-MWe LWR, the 100-year involuntary environmental dose commitment* to the U.S. population from the LWR-supporting fuel cycle.

It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 400 person-rems for each year of operation of the model 1000-MWe LWR (reference reactor year, or, RRY). Based on Table S-3 values, the additional involuntary total-body dose commitments to the U.S. population from radioactive liquid effluents (excluding technetium-99) as a result of all fuel-cycle operations other than reactor operation would be about 100 person-rems per year of operation. Thus, the estimated involuntary 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is about 500 person-rems (whole-body) per RRY.

At this time the radiological impacts associated with radon-222 and technetium-99 releases are not addressed in Table S-3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings; whereas principal technetium-99 releases occur from gaseous diffusion enrichment facilities. The staff has determined that radon-222 releases per RRY from these operations are as given in Table C.1. The staff has calculated population-dose commitments for these sources of radon-222 using the RABGAD computer code described in Volume 3 of NUREG-0002, Appendix A, Chapter IV, Section J. The results of these calculations for mining and milling activities prior to tailings stabilization are listed in Table C.2.

When added to the 500-person-rem total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is approximately 640 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.**

The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining and milling, and active tailings, and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. The staff has assumed that after completion of active mining, underground mines will be sealed, returning releases of radon-222 to background levels. For purposes of providing an upper bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open-pit mines, releases from them would be 110 Ci per RRY. However, because the distribution of uranium-core reserves available by conventional mining methods is 66% underground and 34% open pit (Department of Energy, 1978), the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these

---

*The 100-year environmental dose commitment is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years.

**Based on an annual average natural-background individual dose commitment of 100 mrems and a stabilized U.S. population of 300 million.

proportions. This means that long-term releases from unreclaimed open-pit mines will be 0.34 x 110 or 37 Ci per year per RRY.

Based on the above, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods would be about 3700 Ci and 37,000 Ci per RRY, respectively. The total dose commitments for a 100- to 1000-year period would be as shown in Table C.3.

These commitments represent a worst-case situation in that no mitigating circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for open-pit uranium mines. If so, long-term releases from such mines should approach background levels.

For long-term radon releases from stabilized tailings piles, the staff has assumed that these tailings would emit, per RRY, 1 Ci per year for 100 years, 10 Ci per year for the next 400 years, and 100 Ci per year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized-tailings piles per RRY would be 100 Ci in 100 years, 4090 Ci in 500 years, and 53,800 Ci in 1000 years (Gotchy, 1978). The total-body, bone, and bronchial epithelium dose commitments for these periods are as shown in Table C.4.

Using risk estimators of 135, 6.9, and 22 cancer deaths per million person-rems for total-body, bone, and lung exposures, respectively, the estimated risk of cancer mortality resulting from mining, milling, and active-tailings emissions of radon-222 is about 0.11 cancer fatality per RRY. When the risk from radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities per RRY is estimated over a 1000-year release period. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon-induced cancer fatalities per RRY change as follows:

0.11 to 0.19 fatality for a 100-year period
0.19 to 0.57 fatality for a 500-year period
1.2 to 2.0 fatalities for a 1000-year period

To illustrate: A single model 1000-MWe LWR operating at an 80% capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1000 years as a result of releases of radon-222.

These doses and predicted health effects have been compared with those that can be expected from natural-background emissions of radon-222. Using data from the National Council on Radiation Protection and Measurements (NCRP) (1975), the staff calculates the average radon-222 concentration in air in the contiguous United States to be about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 mrems. For a stabilized future U.S. population of 300 million, this represents a total lung-dose commitment of 135 million person-rems per year. Using the same risk estimator of 22 lung-cancer fatalities per million person-lung-rems used to predict cancer fatalities for the model 1000-MWe LWR, the staff estimates that lung-cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year, or 300,000 to 3,000,000 lung-cancer deaths over periods of 100 to 1000 years, respectively.

The staff is currently in the process of formulating a specific model for analyzing the potential impact and health effects from the release of technetium-99 during the fuel cycle. However, for the interim period until the model is completed, the staff has calculated that the potential 100-year environmental dose commitment to the U.S. population from the release of technetium-99 should not exceed 100 person-rems per RRY. These calculations are based on the gaseous and the hydrological pathway model systems described in Volume 3 of NUREG-0002, Chapter IV, Section J, Appendix A. When these figures are added to the 640 person-rem total-body dose commitment for the balance of the fuel cycle, including radon-222, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is about 740 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about three billion person-rems to the U.S. population.*

The staff also considered the potential health effects associated with this release of technetium-99. Using the modeling systems described in NUREG-0002, the major risks from technetium-99 are from exposure of the gastrointestinal (GI) tract and kidney, although there is a small risk from total-body exposure. Using organ-specific risk estimators, these individual organ risks can be converted to total-body risk equivalent doses. Then, by using the total-body risk estimator of 135 cancer deaths per million person-rems, the estimated risk of cancer mortality due to technetium-99 releases from the nuclear fuel cycle is about 0.01 cancer fatality per RRY over the subsequent 100 to 1000 years.

In addition to the radon- and technetium-related potential health effects from the fuel cycle, other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures. It is estimated that an additional 0.08 to 0.12 cancer death may occur per RRY (assuming that no cure for or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

The latter exposures can also be compared with those from naturally occurring terrestrial and cosmic-ray sources. These average about 100 mrems. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million person-rems per year, or 3 billion person-rems and 30 billion person-rems for periods of 100 and 1000 years, respectively. These natural-background dose commitments could produce about 400,000 and 4,000,000 cancer deaths during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

6. <u>Radioactive Wastes</u>

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) associated with the uranium fuel cycle are specified

---

*Based on an annual average natural-background individual dose commitment of 100 mrems and a stabalized U.S. population of 300 million.

in Table S-3. For low-level waste disposal at land-burial facilities, the Commission notes in Table S-3 that there will be no significant radioactive releases to the environment. The Commission notes that high-level and transuranic wastes are to be buried at a Federal repository and that no release to the environment is associated with such disposal. NUREG-0116, which provides background and context for the high-level and transuranic Table S-3 values established by the Commission, indicates that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is anticipated from such disposal.

7. Occupational Dose

The annual occupational dose attributable to all phases of the fuel cycle for the model 1000-MWe LWR is about 200 person-rems. The staff concludes that this occupational dose will have a small environmental impact.

8. Transportation

The transportation dose to workers and the public is specified in Table S-3. This dose is small in comparison with the natural-background dose.

9. Fuel Cycle

The staff's analysis of the uranium fuel cycle did not depend on the selected fuel cycle (no recycle or uranium-only recycle), because the data provided in Table S-3 include maximum recycle-option impact for each element of the fuel cycle. Thus the staff's conclusions as to acceptability of the environmental impacts of the fuel cycle are not affected by the specific fuel cycle selected.

10. References

Council on Environmental Quality, "The Seventh Annual Report of the Council on Environmental Quality," Figs. 11-27 and 11-28, pp. 238-239, September 1976.

Department of Energy, "Statistical Data of the Uranium Industry," GJO-100(8-78), January 1978.

Gotchy, R., testimony from "In the Matter of Duke Power Company (Perkins Nuclear Station)," U.S. Nuclear Regulatory Commission, Docket No. 50-488, filed April 17, 1978.

National Council on Radiation Protection and Measurements, NCRP, "Natural Background Radiation in the United States," NCRP Report No. 45, November 1975.

U. S. Nuclear Regulatory Commission, NUREG-0002, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light-Water-Cooled Reactors," August 1976.

---, NUREG-0116 (Supplement 1 to WASH-1248), "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," October 1976.

Table C.1 Radon releases from mining and milling operations and mill tailings for each year of operation of the model 1000-MWe LWR*

Radon source	Quantity released
Mining**	4060 Ci
Milling and tailings*** (during active mining)	780 Ci
Inactive tailings*** (before stabilization)	350 Ci
Stabilized tailings*** (several hundred years)	1 to 10 Ci/year
Stabilized tailings*** (after several hundred years	110 Ci/year

*After three days of hearings before the Atomic Safety and Licensing Appeal Board (ASLAB) using the Perkins record in a "lead case" approach, ASLAB issued a decision on May 13, 1981 (ALAB-640) on the radon-222 release source term for the uranium fuel cycle. The decision, among other matters, produced new source term numbers based on the record developed at the hearings. These new numbers did not differ significantly from those in the Perkins record which are the values set forth in this table. Any health effects relative to radon-222 are still under consideration before the ASLAB. Because the source term numbers in ALAB-640 do not differ significantly from those in the Perkins record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared with dose commitments and potential health effects to the U.S. population resulting from all natural background sources. Subsequent to ALAB-640, a second ASLAB decision (ALAB-654, issued September 11, 1981) permitted intervenors a 60-day period to challenge the Perkins record on the potential health effects of radon-222 emissions. Such challenge was made, and a decision thereon is pending before the Appeal Board.

**R. Wilde, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)," Docket No. 50-488, April 17, 1978.

***P. Magno, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)" Docket No. 50-488, April 17, 1978.

Table C.2 Estimated 100-year environmental dose commitment per year of operation of the model 1000-MWe LWR

		Dosage (person-rems)		
Radon source	Radon-222 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)
Mining	4100	110	2800	2300
Milling and active tailings	1100	29	750	620
Total	5200	140	3600	2900

Table C.3 Population-dose commitments from unreclaimed open-pit mines for each year of operation of the model 1000-MWe LWR

		Population dose commitments (person-rems)		
Time span (years)	Radon-222 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)
100	3,700	96	2,500	2,000
500	19,000	480	13,000	11,000
1,000	37,000	960	25,000	20,000

Table C.4 Population-dose commitments from stabilized-tailings piles for each year of operation of the model 1000-MWe LWR

		Population dose commitments (person-rems)		
Time span (years)	Radon-222 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)
100	100	2.6	68	56
500	4,090	110	2,800	2,300
1,000	53,800	1,400	37,000	30,000

APPENDIX D

EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

1. Calculational Approach

As mentioned in the main body of this report the quantities of radioactive material that may be released annually from the Catawba facility are estimated on the basis of the description of the radwaste systems in the applicant's ER and FSAR and by using the calculational models and parameters developed by the NRC staff in NUREG-0017. These estimated effluent release values for normal operation, including anticipated operational occurrences, along with the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, are used in the calculation of radiation doses and dose commitments.

The models and considerations for environmental pathways that lead to estimates of radiation doses and dose commitments to individual members of the public near the plant and of cumulative doses and dose commitments to the entire population within an 80-km (50-mi) radius of the plant as a result of plant operations are discussed in detail in Regulatory Guide 1.109, Revision 1. Use of these models with additional assumptions for environmental pathways that lead to exposure to the general population outside the 80-km radius are described in Appendix B of this statement.

The calculations performed by the staff for the releases to the atmosphere and hydrosphere provide total integrated dose commitments to the entire population within 80 km of this facility based on the projected population distribution in the year 2000. The dose commitments represent the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing at the approximate midpoint of station operation. For younger persons, changes in organ mass metabolic parameters with age after the initial intake of radioactivity are accounted for.

Annual average relative concentration (χ/Q) and relative depositon (D/Q) values were calculated using the straight-line Gaussian atmospheric dispersion model described in Regulatory Guide 1.111, modified to reflect spatial and temporal variations in airflow using the correction factors contained in NUREG-0324. Releases through the two unit vents have been considered as ground level with mixing in the turbulent wake of plant structures in accordance with the criteria contained in Regulatory Guide 1.111, that is, releases through vents with elevations below the tops of adjacent structures are assumed not to escape from the building wake. Intermittent releases through the unit vents have been evaluated using the methodology contained in NUREG-0324. All other releases also have been considered as ground level.

A 2-year period of record (12/17/75-12/16/77) of onsite meteorological data was used for this evaluation. Windspeed and direction data were based on measurements made at the 10-m (33-ft) level, and atmospheric stability was defined by the vertical temperature gradient measured between the 10-m (33-ft) and 40-m (132-ft) levels. The results of the additional information asked for concerning tower interference on the measurement of windspeed and direction at the 40-m level and on the representativeness of the location of the 10-m tower are not expected to change the conclusions based on currently available meteorological data.

Tritium released through a vent stack will most likely be deposited through precipitation scavenging (washout), although tritium may also deposit through contact with soil, vegetation, and surface water. Once deposited, however, tritium can reevaporate from soil, vegetation, and water surfaces and be subsequently transported and deposited downwind, continuing the cycle of deposition, reevaporation, and transport. Tritium can reach surface waters through several different pathways: directly through precipitation scavenging; through molecular exchange between the atmosphere and water surface; and, indirectly through runoff or influx of groundwater. Washout of tritium by precipitation probably occurs at a rate similar to that for radioiodines. Although washout is a much more efficient mechanism for removal of material from the atmosphere than dry deposition, precipitation only occurs a small fraction of the time over an annual cycle resulting in deposited amounts comparable to those estimated for dry deposition. Assuming a representative D/Q of 1×10^{-9} m^{-2} for all atmospheric deposition processes for the vicinity of the Charlotte Water Intake (approximately 11 km (7 mi) north-northeast of the plant) and estimating an affected surface water area of 9×10^6 m^2, the amount of tritium deposited is expected to be less than 1% of the gaseous tritium releases. Similarly, assuming a representative D/Q of 1×10^{-9} m^{-2} for the vicinity of the Lake Wylie Dam (approximately 6.4 km (4 mi) east-southeast of the plant) and estimating an affected surface water area of 6.75×10^6 m^2, the amount of tritium deposited is expected to be less than 1% of the gaseous tritium releases. The amount of tritium that reaches surface water through runoff or influx of groundwater is expected to be even less than that deposited directly from the atmosphere because of retention by soil and vegetation and subsequent reevaporation and atmospheric transport.

The NRC staff estimates of the expected liquid releases (listed in Table D.4), along with the site hydrological considerations (summarized in Table D.5) were used to estimate radiation doses and dose commitments from liquid releases. The staff used the "no-recirculation" mixing model rather than the completely mixed model for calculating the doses to a maximally exposed individual from ingesting fish. The maximally exposed individual was assumed to eat fish caught in the vicinity of the plant discharge. The hydrologic models used to calculate dilution, for the purposes of fish consumption, considered the discharge of the plant, the freshwater flow rate in Big Allison Creek, the exchange of water between the discharge embayment and Lake Wylie, and the interaction of radioactive cesium with sediment.

The staff used the LADTAP model (NUREG/CR-1276) in the completely mixed mode for estimating doses to the maximally exposed individual ingesting water. Virtually the entire dose to the maximally exposed individual from ingesting water is caused by exposure to radionuclides whose half-lives are much greater than the flushing time of Lake Wylie, which is estimated to be about 46 days. As illustrated in Section 5, Appendix A, of Regulatory Guide 1.113, the calculated concentrations of radionuclides in water are very insensitive to the choice of impoundment mixing models if the ratio of half-life to flushing time is large. Therefore, the completely mixed model is adequate for estimating doses from drinking water.

(a) Radiation Dose Commitments to Individual Members of the Public

As explained in the text, calculations are made for a hypothetical individual member of the public (that is, the maximally exposed individual) who would be expected to receive the highest radiation dose from all pathways that contribute. This method tends to overestimate the doses because assumptions are made that would be difficult for a real individual to fulfill.

The estimated dose commitments to the individual who is subject to maximum exposure at selected offsite locations from airborne releases of radioiodine and particulates, and waterborne releases are listed in Tables D.6, D.7, and D.8. The maximum annual total body and skin dose to a hypothetical individual and the maximum beta and gamma air dose at the site boundary are presented in Tables D.6, D.7, and D.8.

The maximally exposed individual is assumed to consume well above average quantities of the potentially affected foods and to spend more time at potentially affected locations than the average person as indicated in Tables E-4 and E-5 of Revision 1 of Regulatory Guide 1.109. The 20-year period was chosen for these calculations as representing the midpoint of plant operation and factors into the dose models by allowing for buildup of long-lived radionuclides in the soil. It affects the estimated doses primarily for radionuclides ingested by humans that have half-lives greater than a few years.

(b) Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne and waterborne radioactive releases from the Catawba facility are estimated for two populations in the year 2000: (1) all members of the general public within 80 km (50 mi) of the station (Table D.7) and (2) the entire U.S. population (Table D.9). Dose commitments beyond 80 km are based on the assumptions discussed in Appendix B. For perspective, annual background radiation doses are given in the tables for both populations.

3. References

U.S. Nuclear Regulatory Commission, NUREG-0016, "Calculation of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors," Revision 1, January 1979.

---, NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976.

---, NUREG-0324, "XOQDOQ Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," Draft, September 1977.

---, NUREG/CR-1276, "User's Manual for LADTAP II - A Computer Program for Calculating Radiation Exposure to Man From Routine Release of Nuclear Reactor Liquid Effluents," Oak Ridge National Laboratory, May 1980.

---, Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

---, Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Reactors," Revision 1, 1977.

---, Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents From Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," Revision 1, April 1977.

Table D.1 Calculated releases of radioactive materials in gaseous effluents from Catawba (Ci/yr/reactor)

Nuclides	Reactor building stack (continuous)	Auxiliary building stack (continuous)	Waste gas processing system (continuous)	Turbine building vent (continuous)	Air ejector exhaust (continuous)	Total*
Ar-41	25	a	a	a	a	25
Kr-83m	a	a	a	a	a	a
Kr-85m	1	3	a	a	2	6
Kr-85	5	a	263	a	a	268
Kr-87	a	2	a	a	a	2
Kr-88	2	5	a	a	3	10
Kr-89	a	a	a	a	a	a
Xe-131m	6	a	9	a	a	15
Xe-133m	12	2	a	a	2	16
Xe-133	1100	120	14	a	73	1300**
Xe-135m	a	a	a	a	a	a
Xe-135	8	8	a	a	5	21
Xe-137	a	a	a	a	a	a
Xe-138	a	1	a	a	a	1
Total noble gases						1600**
Mn-54	0.00017	0.00018	0.0045	b	b	0.0049
Fe-59	0.000057	0.00006	0.0015	b	b	0.0016
Co-58	0.00057	0.0006	0.015	b	b	0.016
Co-60	0.00026	0.00027	0.007	b	b	0.0075
Sr-89	0.000013	0.000013	0.00033	b	b	0.00036
Sr-90	0.0000023	0.0000024	0.00006	b	b	0.000065
Cs-134	0.00017	0.00018	0.0045	b	b	0.0049
Cs-137	0.00029	0.0003	0.0075	b	b	0.0081
Total particulates						0.043
I-131	0.0057	0.0045	a	0.00065	0.0028	0.014
I-133	0.0016	0.0068	a	0.00098	0.0039	0.014
H-3	a	710	-	a	-	710
C-14	1	a	7	a	a	8

*Based on the staff's review of the information submitted by Duke Power Company on April 2, 1982, the staff has included releases resulting from spent fuel from Catawba and the spent fuel from Oconee and McGuire that may be stored at Catawba.

**Sum is truncated.

Notes:

a = less than 1.0 Ci/yr for noble gases and C-14, less than 10^{-4} Ci/yr for iodine.
b = less than 1% of total for this nuclide.

Table D.2 Summary of atmospheric dispersion factors (χ/Q) and relative deposition values for maximum site boundary and receptor locations near the Catawba Nuclear Station*

Location**	Source	X/Q (sec/m^3)	Relative deposition (m^{-2})
Nearest effluent-control boundary (0.7 km, NNE)	A***	3.5×10^{-5}	1.3×10^{-7}
Nearest residence and garden (0.8 km, S)	A***	2.5×10^{-5}	7.2×10^{-8}
Nearest milk cow (4.5 km, SW)	A***	4.3×10^{-7}	1.1×10^{-9}
Nearest meat animal (2.2 km, NW)	A***	1.5×10^{-6}	3.0×10^{-9}

*The values presented in this table are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111.

**"Nearest" refers to that type of location where the highest radiation dose is expected to occur from all appropriate pathways.

*** A - Reactor, auxiliary and turbine buildings, waste gas processing system, and air ejector exhaust are all continuous release sources.

Table D.3 Nearest pathway locations used for maximally exposed individual dose commitments for the Catawba Nuclear Station

Location	Sector	Distance (km)
Nearest effluent-control boundary*	NNE	0.7
Residence and garden**	S	0.8
Milk cow	SW	4.5
Meat animal	NW	2.2

*Beta and gamma air doses, total body doses, and skin doses from noble gases are determined at the effluent-control boundaries in the sector where the maximum potential value is likely to occur.

**Dose pathways including inhalation of atmospheric radioactivity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences. This particular location includes doses from vegetable consumption as well.

Table D.4 Calculated release of radioactive materials in liquid effluents from Catawba Nuclear Station, Units 1 and 2

Nuclide	Ci/yr/reactor*	Nuclide	Ci/yr/reactor*
Corrosion and Activation Products		Fission products (cont'd)	
Cr-51	0.00026	Te-129m	0.0002
Mn-54	0.00007	Te-129	0.00013
Fe-55	0.00029	I-130	0.00006
Fe-59	0.00015	Te-131m	0.00003
Co-58	0.0027	I-131	0.027
Co-60	0.00045	Te-132	0.00091
Zr-95	0.00001	I-132	0.0015
Nb-95	0.00002	I-133	0.013
Np-239	0.00004	I-134	0.00001
		Cs-134	0.027
		I-135	0.0037
Fission Products		Cs-136	0.007
		Cs-137	0.02
Br-83	0.00003	Ba-137m	0.024
Rb-86	0.00005	Ba-140	0.00002
Sr-89	0.00006	La-140	0.00002
Sr-91	0.00001	Ce-144	0.00006
Y-91	0.00001		
Mo-99	0.022	All others	0.00008
Tc-99m	0.016		
Ru-106	0.00003	Total (except H-3)	0.17
Te-127m	0.00005	H-3	710
Te-127	0.00006		

*Nuclides whose release rates are less than 10^{-5} Ci/yr/reactor are not listed individually but are included in "All others."

Table D.5 Summary of hydrologic transport and dispersion for liquid releases from the Catawba Nuclear Station*

Location	Transit time (hours)	Dilution factor of plant discharge	
		1 unit	2 unit
Nearest drinking-water intake (Rock Hill**)	0	51†	26†
Nearest sport-fishing location (discharge area)***	0	2.2	1.7
Nearest shoreline (bank near discharge area)***	0	2.2	1.7

*See Regulatory Guide 1.113.

**Based on completely mixed hydrological model for Lake Wylie.

***The staff used the "no-recirculation" model (i.e., a plug flow model) rather than the completely mixed model to estimate doses to the maximally exposed individual from ingestion of fish and from shoreline recreation. Doses from the two preceding pathways account for the majority of the estimated doses to the maximally exposed individual to radioactive liquid effluents (see Table D.6).

†Equivalent dilution factor for the "no-recirculation" model.

Table D.6 Annual dose commitments to a maximally exposed individual near the Catawba Nuclear Station

Location	Pathway	Dose (mrem/yr/unit, except as noted)			
		Noble Gases in Gaseous Effluents			
				Air Dose (mrad/yr/unit)	
		Total Body	Skin	Gamma	Beta
Nearest site boundary (0.70 km NNE)*	Direct radiation from plume	0.62	1.8	1.0	2.3
		Iodine and Particulates in Gaseous Effluents**			
		Total Body	Organ		
Nearest site boundary (0.70 km NNE)*	Ground deposition	1.3	1.3		
	Inhalation	1.0 (adult)	1.2 (adult) (thyroid)		
Nearest residence and garden (0.8 km S)***	Ground deposition	0.7	0.7		
	Inhalation	0.6 (child)	<0.1 (child) (bone)		
	Vegetable consumption	3.5 (child)	6.6 (child) (bone)		
Nearest milk cow (4.5 km SW)	Ground deposition	<0.1	<0.1		
	Inhalation	<0.1	<0.1		
	Cow milk consumption	<0.1 (infant)	0.3 (infant) (thyroid)		
Nearest meat animal (2.2 km, NW)	Meat consumption	<0.1	<0.1		
		Liquid Effluents**			
		Total Body	Organ		
Nearest drinking water at Bay City	Water ingestion	<0.1	0.1		
Nearest fish at plant-discharge area	Fish consumption	1.7 (adult)	2.3 (adult) (liver)		
Nearest shore access to plant-discharge area	Shoreline recreation	<0.1	<0.1		

*That site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for the age group and organ that results in the highest cumulative dose for the location.

***The location where the highest radiation dose to an individual from all applicable pathways has been estimated.

Table D.7 Calculated Appendix I (10 CFR 50) dose commitments to a maximally exposed individual and to the population from operation of Catawba nuclear facility

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives*	Calculated Doses**
Liquid effluents		
Dose to total body from all pathways (mrem)	3	1.8
Dose to any organ from all pathways (mrem)	10	2.4 (liver)
Noble-gas effluents (at site boundary)		
Gamma dose in air (mrad)	10	1.0
Beta dose in air (mrad)	20	2.3
Dose to total body of an individual (mrem)	5	0.6
Dose to skin of an individual (mrem)	15	1.8
Radioiodines and particulates***		
Dose to any organ from all pathways (mrem)	15	7.3 (bone)
	Population Within 80 km	
	Total Body	Thyroid
Natural-background radiation (person-rem)†	160,000	
Liquid effluents (person-rem)	3.0	3.0
Noble-gas effluents (person-rem)	0.4	0.4
Radioiodine and particulates (person-rem)	5.1	6.5

*Design objectives from Sections II.A, II.B, II.C, and II.D of Appendix I, 10 CFR 50 consider doses to maximally exposed individual and to population per reactor unit.

**Numerical values in this column were obtained by summing appropriate values in Table D.6. Locations resulting in maximum doses are represented here.

***Carbon-14 and tritium have been added to this category.

†"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average background dose for South Carolina of 97 mrems/yr, and year 2000 projected population of 1,700,000.

Table D.8 Calculated RM-50-2 dose commitments to a maximally exposed individual from operation of the Catawba nuclear facility*

Effluent and dose commitment	Annual dose per site	
	RM-50-2 design objective**	Calculated dose
Liquid effluents		
Dose to total body or any organ from all pathways (mrem)	5	3.0
Activity-release estimate, excluding tritium (Ci)	10	0.3
Noble-gas effluents (at site boundary)		
Gamma dose in air (mrad)	10	2.0
Beta dose in air (mrad)	20	4.6
Dose to total body of an individual (mrem)	5	1.2
Dose to skin of an individual (mrem)	15	3.6
Radioiodines and particulates***		
Dose to any organ from all pathways (mrem)	15	14.6 (bone)
I-131 activity release (Ci)	2	0.03

*An optional method of demonstrating compliance with the cost-benefit Section (II.D) of Appendix I to 10 CFR 50.

**Annex to Appendix I to 10 CFR 50.

***Carbon-14 and tritium have been added to this category.

Table D.9 Annual total-body population dose commitments, year 2000 (both units)

Category	U.S. population dose commitment (person-rem/yr)
Natural background radiation*	26,000,000*
Catawba Nuclear Station Units 1 and 2 (combined) operation	
Plant workers	960
General public:	
Liquid effluents**	6.0
Gaseous effluents	70
Transportation of fuel and waste	6

*Using the average U.S. background dose (100 mrems/yr) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 704, July 1977.

**80-km (50-mi) population dose.

APPENDIX E

REBASELINING OF THE RSS RESULTS FOR PWRs

The results of the Reactor Safety Study (RSS) have been updated. The update was done largely to incorporate results of research and development conducted after the October 1975 publication of the RSS and to provide a baseline against which the risk associated with various LWRs could be consistently compared.

Primarily, the rebaselined RSS results (NUREG/CR-1659) reflect use of advanced modeling of the processes involved in meltdown accidents, i.e., the MARCH computer code modeling for transient and LOCA initiated sequences and the CORRAL code used for calculating magnitudes of release accompanying various accident sequences. These codes* have led to a capability to predict the transient and small LOCA initiated sequences that is considerably advanced beyond what existed at the time the Reactor Safety Study was completed. The advanced accident process models (MARCH and CORRAL) produced some changes in the staff's estimates of the release magnitudes from various accident sequences in WASH-1400. These changes primarily involved release magnitudes for the iodine, cesium, and tellurium families of isotopes. In general, a decrease in the iodines was predicted for many of the dominant accident sequences; some increases in the release magnitudes for the cesium and tellurium isotopes were predicted.

The Reactor Safety Study Methodology Applications Program (RSSMAP) has resulted in a review of dominant accident sequences for several plants. The Sequoyah RSSMAP risk assessment indicates the importance of hydrogen control measures for reducing the likelihood of failing the ice condenser containment following severe accidents; Catawba has an ice condenser containment like Sequoyah. The applicant for Catawba has plans to satisfy the Commission's requirement on hydrogen control. Therefore, the use of the Surry rebaselined sequences is appropriate since a Catawba plant-specific assessment of accident sequence is not available.

Entailed in this rebaselining effort for the sequences as used here was the evaluation of individual dominant accident sequences as the staff understands them to evolve rather than the technique of grouping large numbers of accident sequences into encompassing, but synthetic, release categories as was done in WASH-1400. The rebaselining of the RSS also eliminated the "smoothing technique" that was criticized in the report by the Risk Assessment Review Group (sometimes known as the Lewis Report), NUREG/CR-0400. In both of the RSS designs (PWR and BWR), the likelihood of an accident sequence leading to the occurrence of a steam explosion (α) in the reactor vessel was decreased. This

*It should be noted that the MARCH code was used on a number of scenarios in connection with the TMI-2 recovery efforts and for post-TMI-2 investigations to explore possible alternative scenarios that TMI-2 could have experienced.

was done to reflect both experimental and calculational indications that such explosions are unlikely to occur in those sequences involving small-size LOCAs and transients because of the high pressures and temperatures expected to exist within the reactor coolant system during these scenarios. Furthermore, if such an explosion were to occur, there are indications that it would be unlikely to produce as much energy and the massive missile-caused breach of containment as was postulated in WASH-1400.

For rebaselining of the RSS PWR design, the release magnitudes for the risk dominating sequences, e.g., Event V, TMLB' δ, γ, and $S_2C\delta$ (described later) were explicitly calculated and used in the consequence modeling rather than being lumped into release categories as was done in WASH-1400. The rebaselining led to a small decrease in the predicted risk to an individual of early fatality or latent cancer fatality relative to the original RSS-PWR predictions. This result is believed to be largely attributable to the decreased likelihood of occurrence for sequences involving severe steam explosions (α) that breached containment. (In WASH-1400, the sequences involving severe steam explosions (α) were artificially elevated in their risk significance (i.e., made more likely) by use of the "smoothing technique.")

In summary, the rebaselining of the RSS results led to small overall differences from the predictions in WASH-1400. It should be recognized that these small differences due to the rebaselining efforts are likely to be far outweighed by the uncertainties associated with such analyses.

The accident sequences which are expected to dominate risk from the RSS-PWR design are described below. Accident sequences are designated by strings of identification characters in the same manner as in the RSS (see the table of these symbols, Table E.1). Each of the characters represents a failure in one or more of the important plant systems or features that ultimately would result in melting of the reactor core and a significant release of radioactive materials from containment.*

Probabilities and release fractions of accidents involving the spent fuel pool were roughly estimated in the RSS. It can be concluded by comparison of data in Appendix I and the main report of WASH-1400 that the probabilities and release fractions are orders of magnitude less than the accidents involving the reactor itself. Further, since the melting of the fuel and release of activity is determined basically by the freshly discharged fuel (less than 1-year cooling time), the total contents of the pool in terms of assemblies with long cooling times does not change that conclusion. Hence, impacts of these types of accidents are well below the impacts of the reactor accidents presented here.

Event V (Interfacing System LOCA)

During the Reactor Safety Study a potentially large-risk contributor was identified because of the configuration of the multiple check valve barriers used to separate the high-pressure reactor coolant system from the low design pressure portions of the ECCS (i.e., the low pressure injection subsystem - LPIS). If these valve barriers were to fail in various modes, such as a leak in one valve and rupture of the other or rupture of both valves, and suddenly exposed the

*For additional information detail see Appendix V of WASH-1400.

LPIS to high overpressures and dynamic loadings, the RSS judged that a high probability of LPIS rupture would exist. Since the LPIS is largely located outside of containment, the Event V scenario would be a LOCA that bypassed containment and those mitigating features (e.g., sprays) within containment. The RSS assumed that if the rupture of LPIS did not entirely fail the LPIS makeup function (which would ultimately be needed to prevent core damage), the LOCA environment (flooding, steam) would. Predictions of the release magnitude and consequences associated with Event V have indicated that this scenario represents one of the largest risk contributors from the RSS-PWR design. The NRC has recognized this RSS finding, and has taken steps to reduce the probability of occurrence of Event V scenarios in both existing and future LWR designs by requiring periodic surveillance testing of the interfacing valves to assure that these valves are properly functioning as pressure boundary isolation barriers during plant operations. Accordingly, Event V predictions for the RSS-PWR are likely to be conservative relative to the design and operation of the Catawba PWR plants.

TMLB'-δ, γ

This sequence essentially considers the loss and nonrestoration of all ac power sources available to the plant along with an independent failure of the steam turbine driven auxiliary feedwater train which would be required to operate to remove shutdown heat from the reactor core. The transient event is initiated by loss of offsite ac power sources which would result in plant trip (scram) and the loss of the normal way that the plant removes heat from the reactor core (i.e., via the power conversion system consisting of the turbine, condenser, the condenser cooling system, and the main feedwater and condensate delivery system that supplies water to the steam generators). This initiating event would then demand operation of the standby onsite emergency ac power supplies (two diesel generators) and the standby auxiliary feedwater system, two trains of which are electrically driven by either onsite or offsite ac power. With failure and nonrestoration of ac and the failure of the steam turbine driven auxiliary feedwater train to remove shutdown heat, the core would ultimately uncover and melt. If restoration of ac were not successful during (or following) melt, the containment heat removal and fission product mitigating systems would not be operational to prevent the ultimate overpressure (δ, γ) failure of containment and a rather large, energetic release of activity from the containment. Next to the Event V sequence, TMLB'δ, γ is predicted to dominate the overall accident risks in the RSS-PWR design.

S_2C-δ (PWR 3)

In the RSS, the S_2C-δ sequence was placed into PWR release Category 3 and it actually dominated all other sequences in Category 3 in terms of probability and release magnitudes. The rebaselining entailed explicit calculations of the consequences from S_2C-δ and the results indicated that it was next in overall risk importance following Event V and TMLB'δ, γ.

The S_2C-δ sequence included a rather complex series of dependencies and interactions that are believed to be somewhat unique to the containment systems (subatmospheric) employed in the RSS PWR design.

In essence, the S_2C-δ sequence included a small loss-of-coolant accident occurring in a specific region of the plant (reactor vessel cavity); failure of the recirculating containment heat removal systems (CSRS-F) because of a dependence on water draining to the recirculation sump from the LOCA and a resulting dependence imposed on the quench spray injection system (CSIS-C) to provide water to the sump. The failure of the CSIS(C) resulted in eventual overpressure failure of containment (δ) due to the loss of CSRS(F). Given the overpressure failure of containment, the RSS assumed that the ECCS functions would be lost, either because of the cavitation of ECCS pumps or from the rather severe mechanical loads that could result from the overpressure failure of containment. The core was then assumed to melt in a breached containment leading to a significant release of radioactive materials.

Approximately 20% of the iodines and 20% of the alkali metals present in the core at the time of release would be released to the atmosphere. Most of the release would occur over a period of about 1.5 hours. The release of radioactive material from containment would be caused by the sweeping action of gases generated by the reaction of the molten fuel with concrete. Since these gases would be initially heated by contact with the melt, the rate of sensible energy release to the atmosphere would be moderately high.

PWR 7

This is the same as the PWR release category #7 of the original RSS which was made up of several sequences such as S_2D-ε (the dominant contributor to the risk in this category), S_1D-ε, S_2H-ε, S_1H-ε, AD-ε, AH-ε, TML-ε, and TKQ-ε. All of these sequences involved a containment basemat melt-through as the containment failure mode. With the exception of TML-ε and TKQ-ε, all involve the potential failure of the emergency core cooling system following occurrence of a LOCA with the containment ESFs continuing to operate as designed until the basemat was penetrated. Containment sprays would operate to reduce the containment temperature and pressure as well as the amount of airborne radioactivity. The containment barrier would retain its integrity until the molten core proceeded to melt through the concrete containment basemat. The radioactive materials would be released into the ground, with some leakage to the atmosphere occurring upward through the ground. Most of the release would occur continuously over a period of about 10 hours. The release would include approximately 0.002% of the iodines and 0.001% of alkali metals present in the core at the time of release. Because leakage from containment to the atmosphere would be low and gases escaping through the ground would be cooled by contact with the soil, the energy release rate would be very low.

References

U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014), "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975.

---, NUREG/CR-1659, "Reactor Safety Study Methodology Applications Program," Vol. 1, Sandia National Laboratories, February 1981.

Table E.1 Key to PWR accident sequence symbols

A	- Intermediate to large LOCA.
B	- Failure to recover either onsite or offsite electric power within about 1 to 3 hr following an initiating transient which is a loss of offsite ac power.
C	- Failure of the containment spray injection system.
D	- Failure of the emergency core cooling injection system.
H	- Failure of the emergency core cooling recirculation system.
K	- Failure of the reactor protection system.
L	- Failure of the secondary system steam relief valves and the auxiliary feedwater system.
M	- Failure of the secondary system steam relief valves and the power conversion system.
Q	- Failure of the primary system safety relief valves to reclose after opening.
S_1	- A small LOCA with an equivalent diameter of about 2 to 6 in.
S_2	- A small LOCA with an equivalent diameter of about 1/2 to 2 in.
T	- Transient event.
V	- Low-pressure injection system check valve failure.
α	- Containment rupture resulting from a reactor vessel steam explosion.
β	- Containment failure resulting from inadequate isolation of containment openings and penetrations.
γ	- Containment failure resulting from hydrogen burning.
δ	- Containment failure resulting from overpressure.
ε	- Containment vessel melt-through.

APPENDIX F

CONSEQUENCE MODELING CONSIDERATIONS

F.1 Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation" which denotes a postaccident response to reduce exposure from long term ground contamination. The Reactor Safety Study (RSS) (WASH-1400) consequence model contains provision for incorporating radiological consequence reduction benefits of public evacuation. The benefits of a properly planned and expeditiously carried out public evacuation would be well manifested in a reduction of early health effects associated with early exposure; namely, in the number of cases of early fatality (see Section F.2) and acute radiation sickness which would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 as well as in NUREG-0340. However, the evacuation model which has been used herein is a modified version (SAND 78-0092) of the RSS model and is, to a certain extent, oriented toward site emergency planning. The modified version is briefly outlined below.

The model utilizes a circular area with a specified radius (such as a 10-mi plume exposure pathway emergency planning zone (EPZ)), with the reactor at the center. It is assumed that people living within portions of this area would evacuate if an accident should occur involving imminent or actual release of significant quantities of radioactive material to the atmosphere.

Significant atmospheric releases of radioactive material would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the radioactive release from the containment building). For the purpose of calculation of radiological exposure, the model assumes that all people who live in a fan-shaped area (fanning out from the reactor), within the circular zone with the downwind direction as its median--those people who would potentially be under the radioactive cloud that would develop following the release--would leave their residences after a specified delay* and then evacuate. The delay time is reckoned from the beginning of the warning time and is recognized as the sum of the time required by the reactor operators to notify the responsible authorities, time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate, and time required for the people to mobilize and get under way.

---

*Assumed to be of a constant value which would be the same for all evacuees.

The model assumes that each evacuee would move radially out in the downwind direction* with an average effective speed** (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time) over a fixed distance** from the evacuee's starting point.

This distance is selected to be 15 mi (which is 5 mi more than the 10-mi plume exposure pathway EPZ radius). After reaching the end of the travel distance, the evacuee is assumed to receive no further radiation exposure.

The model incorporates a finite length of the radioactive cloud in the downwind direction which would be determined by the product of the duration over which the atmospheric release would take place and the average windspeed during the release. It is assumed that the front and the back of the cloud formed would move with an equal speed which would be the same as the prevailing windspeed; therefore, its length would remain constant at its initial value. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time were less than the warning time, then all evacuees would have a head start, i.e., the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time were more than the warning time, then depending on initial locations of the evacuees there are possibilities that (1) an evacuee will still have a head start, or (2) the cloud would be overhead when an evacuee starts to leave, or (3) an evacuee initially would be trailing behind the cloud. However, this initial picture of cloud-people disposition would change as the evacuees travel depending on the relative speed and positions between the cloud and people. The cloud and an evacuee might overtake one another one or more times before the evacuee would reach his or her destination. In the model, the radial position of an evacuating person, either stationary or in transit, is compared to the front and the back of the cloud as a function of time to determine a realistic period of exposure to airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person who is under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this, at least in part, the revised model assumes that persons are: (1) exposed to the total ground contamination concentration which is calculated to exist after complete passage of the cloud, after they have been completely passed by the cloud; (2) exposed to one-half the calculated concentration anywhere under the cloud; and (3) not exposed when they are in front of the cloud. Different values of the shielding protection factors for exposures from airborne radioactivity and ground contamination have been used.

Results shown in Section 5.9.4.5 for accidents involving significant release of radioactivity to the atmosphere were based on the assumption that all people within the 10-mi plume exposure pathway EPZ would evacuate as per the evacuation scenario described above. It is not expected that detailed inclusion of any special facility near a specific plant site, where not all persons would be

---

*In the RSS consequence model, the radioactive cloud is assumed to travel radially outward only.

**Assumed to be of a constant value which would be the same for all evacuees.

quickly evacuated, would significantly alter the conclusions. For the delay time before evacuation, a value of 1 hour was used. The staff believes that such a value appropriately reflects the Commission's emergency planning requirements. The staff estimated the effective evacuation speed to be 6.7 mph (3 m/sec) based upon the applicant's estimate of the time to clear the 10-mi zone. As an additional emergency measure for the Catawba site for certain sensitivity calculations, it was also assumed that all people beyond the evacuation distance who would be exposed to the contaminated ground would be relocated after the plume passed. For these people outside of the evacuation zone and within 25 mi, a reasonable relocation time span of 8 hours has been assumed, during which each person is assumed to receive additional exposure to the ground contamination. Beyond the 25-mi distance the usual assumption of the RSS consequence model regarding the period of ground exposure was used--which is that if the calculated ground dose to the total marrow over a 7-day period would exceed 200 rems, then this high dose rate would be detected by actual field measurements following the plume passage, and people from those regions would then be relocated immediately. For this situation the model limits the period of ground dose calculation to 24 hours; otherwise, the period of ground exposure is limited to 7 days for calculation of early dose.

Figure F.1 shows a pessimistic case for which no early evacuation is assumed and all persons are assumed to be exposed for the first 24 hours following an accident and are then relocated, and a case for which evacuation, at the same speed as above, was assumed to take place to 15 mi. For evacuation to 20 mi, the calculation would predict near zero early fatalities.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as in the orginal RSS model. For this purpose, the model assumes that for atmospheric releases of durations 3 hours, or less, all people living within a circular area of 5-mi radius centered at the reactor plus all people within a 45° angular sector within the plume exposure pathway EPZ and centered on the downwind direction will be evacuated and temporarily relocated. However, if the duration of release would exceed 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would be evacuated and temporarily relocated. For either of these situations, the cost of evacuation and relocation is assumed to be $125 (1980 dollar) per person which includes cost of food and temporary sheltering for a period of 1 week.

F.2 Early Health Effects Model

The medical advisors to the Reactor Safety Study (WASH-1400) proposed three alternative dose-mortality relationships that can be used to estimate the number of early fatalities that might result in an exposed population. These alternatives characterize different degrees of postexposure medical treatment from "minimal," to "supportive," to "heroic," and are more fully described in NUREG-0340.

The calculational estimates of the early fatality risks presented in the texts of Section 5.9.4.5(3) and Section F.1 of this appendix used the dose-mortality relationship that is based upon the supportive treatment alternative. This implies the availability of medical care facilities and services for those exposed in excess of about 200 rems. At the extreme low probability end of the spectrum, i.e., at the 1 chance in 100 million per reactor-year level, the number of persons involved might exceed the capacity of facilities for such services, in which case the number of early fatalities might have been somewhat underestimated. To gain perspective on this element of uncertainty, the staff has also performed calculations using the most pessimistic dose-mortality relationship based upon minimal medical treatment and using identical assumptions regarding early evacuation as made in Section 5.9.4.5(3). This shows 10 early fatalities at the 1 chance in 1 million per reactor-year level, an increase from 19,000 to 24,000 early fatalities at the 1 chance in 100 million per reactor-year level (see Table 5.12), and an overall doubling of the annual risk of early fatalities (see Table 5.13). The major fraction of the increased risk of early fatality in the absence of supportive medical treatment would occur within 32 km (20 mi) and virtually all would be contained within 137 km (85 mi) of the Catawba site.

F.3 References

Sandia Laboratories, SAND-78-0092, "A Model of Public Evacuation for Atmospheric Radiological Releases," June 1978.

U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014), "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975.

---, NUREG-0340, "Overview of the Reactor Safety Study Consequences Model," October 1977.

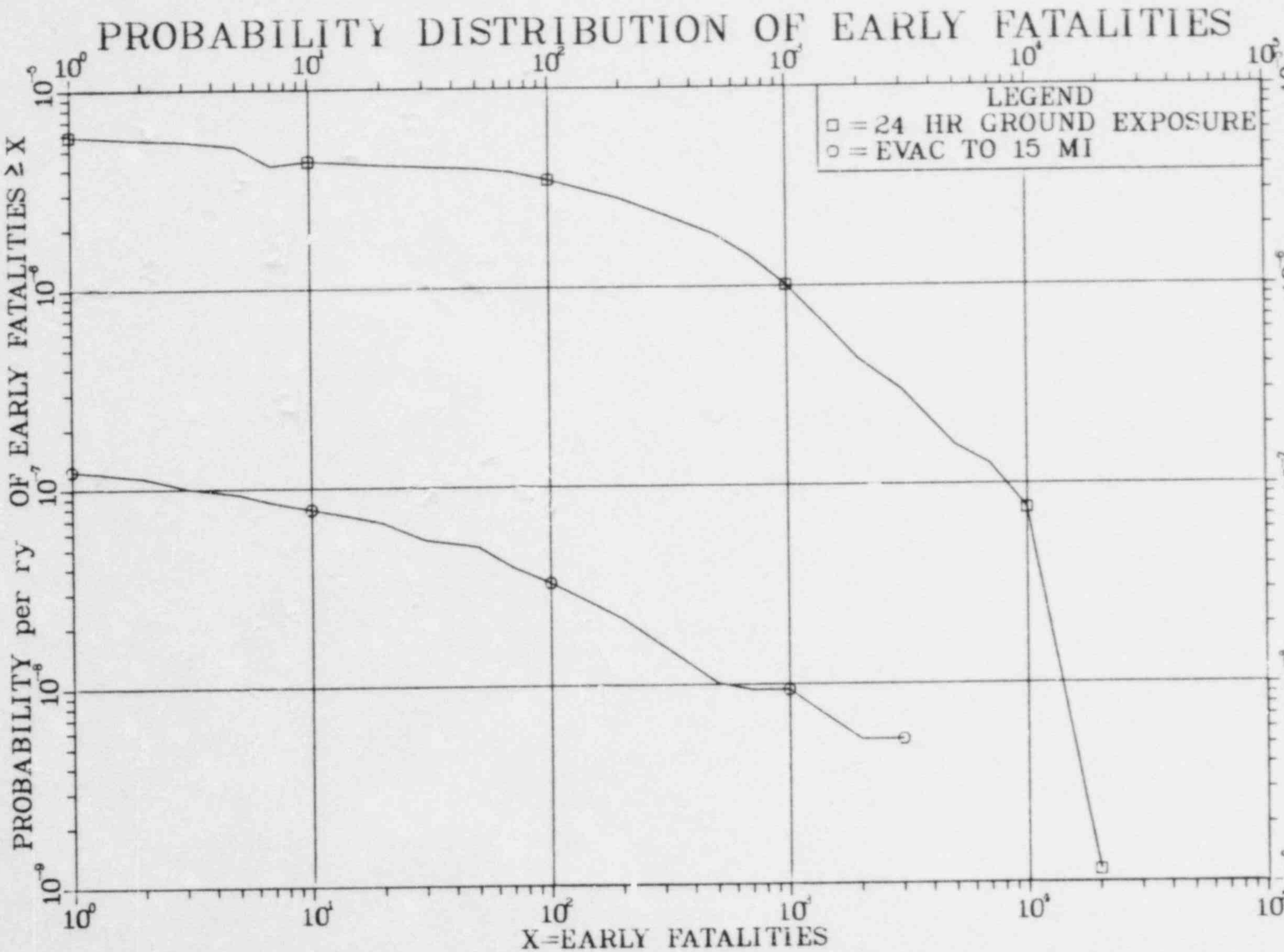

Figure F.1 Probability distribution of early fatalities (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

APPENDIX G

ENVIRONMENTAL IMPACT APPRAISAL FOR TRANSSHIPMENT OF SPENT FUEL FROM OCONEE AND McGUIRE TO CATAWBA NUCLEAR STATION

1 RADIOLOGICAL IMPACTS OF THE TRANSPORTATION OF SPENT FUEL

The radiological impacts of the transporation of spent fuel from Oconee and McGuire to Catawba are considered here. Section 1.1 deals with the possible radiological impacts of the transportation on transportation workers. Section 1.2 considers the radiological impacts on the public.

The transportation of Oconee and McGuire spent fuel to Catawba falls under the provisions of 49 CFR 170-189 and 10 CFR 71. The Department of Transportation (DOT) regulation in 49 CFR 173.393(j), which encompasses the proposed shipments, limits the dose rate for radioactive materials during transportation to 10 mrems/hr at any point 2 m (6 ft) from the vertical planes projected from the outer edges of the vehicle. Radiological impacts for truck shipments are discussed below. Radiological impacts for rail shipments are less than for truck shipments because of fewer shipments (more fuel elements per cask) and greater isolation of the shipment from transportation workers.

1.1 Radiological Impacts on Transportation Workers

The longest proposed truck route from Oconee to Catawba is 310 km (193 mi) and from McGuire to Catawba is 130 km (80 mi) (Parker, April 2, 1982). On each 310-km trip, two drivers would probably not spend more than 6 hr in the truck cab, and on each 130-km shipment would probably not spend more than 3 hours in the cab. In addition, about 1 hr would be spent outside the truck visually checking safety-related items at an average distance of 1 m (3 ft) from the truck bed. Based on DOT regulations, radiation levels 2 m (6 ft) from the truck bed will not exceed 10 mrems/hr. A radiation level of 2 mrems/hr is permitted in the truck cab. Under these conditions each truck driver could receive about 32 mrems during each shipment. Three hundred shipments of Oconee spent fuel elements to Catawba each year would result in an annual cumulative exposure to the drivers of about 19 person-rems. Likewise 300 shipments of McGuire spent fuel elements to Catawba would result in a cumulative exposure of 16 person-rems. This cumulative exposure would be distributed among several drivers. Operating experience has indicated that the calculations tend to overestimate actual cumulative exposure (WASH-1238).

1.2 Radiological Impacts on the Public

Members of the general public are excluded from loading and unloading operations, but some exposures might occur at truck stops en route. A member of the general public who spends 3 min at an average distance of 1 m (3 ft) from the truck bed might receive a dose of 1.0 mrem. If 10 persons, on the average, were exposed during each shipment, the cumulative dose to such onlookers for 300 shipments would be about 3.0 person-rems distributed among 3,000 persons.

The dose rate of 10 mrems/hr at 2 m (6 ft) from the vehicle was used to calculate the dose to those persons in an area between 30 m (100 ft) and 800 m (2600 ft) on both sides of the shipping route (WASH-1238). It was assumed the shipment would travel the 310 km (193 mi) in 6 hours. The average population density along the route was stated by the applicant to be 232 persons/km^2 (602 persons/mi^2), which is more than the 96 persons/km^2 calculated for the Oconee to McGuire route (USNRC, 1978). Approximately 120,000 persons who live within 0.8 km (0.5 mi) of the longest route over which Oconee spent fuel may be transported might received a cumulative dose of about 2.0 person-rems from 300 shipments, which is equivalent to less than 0.02% of the dose received annually from background radiation. If both Oconee and McGuire shipments follow the same route for any portion of the distance traveled, a person living on that portion would be exposed to 600 shipments per year: 300 from Oconee and 300 from McGuire. The maximum exposed individual along that portion (defined as a person who is 30 m (100 ft) from the roadway as each of the 600 shipments pass) would receive a cumulative annual dose of 0.35 mrem from the 600 shipments. This dose is equivalent to about 0.3% of the dose received annually from background radiation.

An additional consideration for exposure of the public in nonaccident situations involves a vehicle closely following the cask over a major portion of the route. If a car is assumed to travel directly behind the truck carrying the cask for 4 hours at a distance of 30 m (100 ft), the dose is calculated to be 1.6 mrems to each occupant. This dose is less than 2% of the annual dose received from background radiation.

2 NONRADIOLOGICAL IMPACTS OF TRANSPORTATION

Because the fuel will be cooled at least 5 years before shipment (Parker, April 2, 1982), the only heat released to the environment of any consequence is that produced by the truck's engine of 3.93 MJ/km (6000 Btu/mi). The truck estimate is based on a 100-hp engine (WASH-1238). The heat that would be released to the environment as a result of transport of fuel assemblies is not considered to be significant when compared with heat generated by other traffic.

3 ACCIDENT ANALYSES

Although it is unlikely that an accident would occur, a range of accidents is evaluated to take into account any adverse effects. The accidents are postulated based on assumptions contained in the "Environmental Impact Appraisal Related to Spent Fuel Storage of Oconee Spent Fuel at McGuire Nuclear Station--Unit 1 Spent Fuel Pool" (USNRC, 1978). The accidents considered in Section 3.1 are (a) undetected leakage of coolant from the cask cavity, (b) loss of neutron water shield, (c) cask overpressurization, and (d) a collision or overturning of the truck.

3.1 Postulated Transportation Accidents

Casks used by licensees for truck shipment of spent fuel must be certified by the NRC to meet 10 CFR 71 requirements for Type B packages under both normal transportation conditions and transportation accident test conditions. The 10 CFR 71 accident test standards are considered to be equivalent to the conditions for severe accidents given in Table 1 (WASH-1238). The 10 CFR 71 acceptance standard for these tests is no release of radioactive contents except for radioactive gases and contaminated coolants containing total radioactivity not exceeding specified small quantities (10 CFR 71.36). More severe accident conditions could happen, but the probability of their occurrence is about one-ten thousandth of that for the severe category of accidents (WASH-1238).

Undetected leakage of coolant is considered a minor accident. The loss of the neutron water shield or cask overpressurization would present moderate accident conditions, and drastic impact and fire would present extreme accident conditions.

For further classification of accident severity, refer to Table G.1. As the accident severity increases the consequences increase, but because of decreasing probability, the risk (probability x consequences) remains small for all accident conditions.

Transportation accidents noted above were previously analyzed for the shipment of spent fuel from Oconee to McGuire (USNRC, 1978). In each case the risk was found to be small. The fuel shipped to McGuire was assumed to have been cooled for 270 days. Because the spent fuel shipped to Catawba will have been cooled at least 5 years, the radiological consequences of accidents during the proposed shipments from Oconee and McGuire to Catawba will be no greater than those calculated in the Environmental Impact Appraisal (USNRC, 1978).

4 REFERENCES

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

Parker, William O., Jr., Duke Power Co., letter to Harold R. Denton, NRC, Subject: Catawba Nuclear Station, April 2, 1982.

U.S. Nuclear Regulatory Commission, "Environmental Impact Appraisal Related to Spent Fuel Storage of Oconee Spent Fuel at McGuire Nuclear Station--Unit 1 Spent Fuel Pool," Docket No. 70-2623, December 1978.

Table G.1 Classification of accident severity*

Accident severity category	Vehicle speed at impact (mph)	Fire duration (hr)	Probability per vehicle mile (truck)
Minor	0-30 30-50	0-1/2 0	1.3×10^{-6}
Moderate	0-30 30-70	1/2-1 <1/2	3.0×10^{-7}
Severe	0-50 30-70 >70	>1 1/2-1 0-1/2	8.0×10^{-9}
Extra severe	50-70 >70	>1 1/2-1	8.0×10^{-13}
Extreme	>70	>1	2.0×10^{-14}

*WASH-1238

APPENDIX H

LETTERS FROM STATE ARCHEOLOGIST,
UNIVERSITY OF SOUTH CAROLINA, AND
STATE HISTORIC PRESERVATION OFFICER,
SOUTH CAROLINA DEPARTMENT OF
ARCHIVES AND HISTORY

UNIVERSITY OF SOUTH CAROLINA

COLUMBIA, S. C. 29208

INSTITUTE OF ARCHEOLOGY AND ANTHROPOLOGY

(803) 777-8170

May 28, 1981

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

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

Dear Mr.Lee:

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

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

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

Sincerely yours,

Robert L. Stephenson

Robert L. Stephenson
Director and State Archeologist

RLS:dsw

Enclosure

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

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S. C.

P.O. Box 11,669
Capitol Station 29211
803-758-5816

RECEIVED
NOV 10 1981
U.S. NUCLEAR REGULATORY COMMISSION

November 5, 1981

Mr. Robert L. Tedesco
Assistant Director for Licensing
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Re: Catawba Nuclear Station,
Units 1 and 2
Docket Nos: 50-413 and 50-414
York County

Dear Mr. Tedesco:

Thank you for your letter of July 29, 1981, which we received on September 21, 1981, regarding operation of the Catawba Nuclear Station. We have also received under separate cover from the Institute of Archeology and Anthropology a copy of the archeological survey report for the transmission line corridor.

Our letter of January 26, 1973, stated that "the reactor project will have no adverse effects from the historical viewpoint." Since in the immediate vicinity of the proposed project there are no properties included in the National Register of Historic Places or determined eligible for inclusion by the Secretary of the Interior, we have not altered this opinion.

The report prepared by the Institute (Brockington, 1980) indicated that twenty-seven archeological sites were located in the transmission line corridor. Of these only one, 38YK72 was recommended as potentially eligible for inclusion in the National Register of Historic Places. Additional testing of 38YK72 indicated that the site does have the potential for yielding additional information, but since the site will be avoided during construction, additional investigation seems unnecessary. We recommend that corridor maintenance take care to avoid possible future effects.

The Federal procedures for the protection of historic properties (36CFR800) require that the Federal agency official in charge of a federally funded or licensed project consult with the appropriate State Historic Preservation Officer. The procedures do not relieve the Federal agency official of the final responsibility for reaching an opinion of his own as to whether or not historic values have been adequately taken into account in allowing the project to proceed. The opinion of the State Historic Preservation Officer is not definitive, either by law or by established Federal procedure. In reaching a conclusion of his own,

C002
5
1/0

the Federal agency official may well wish to consult other experts.

Sincerely,

Charles E. Lee
State Historic Preservation Officer

CEL/vdw
CC: Mr. Andrew R. Cloninger
Environmental Affairs
Duke Power Company
P.O. Box 33189
Charolotte, N. C. 28242

Dr. Robert L. Stephenson, Director
Institute of Archeology and Anthropology
University of South Carolina
Columbia, S. C. 29208

APPENDIX I

PRELIMINARY DRAFT NPDES PERMIT

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S.C. 29201

Permit No. SC0004278

AUTHORIZATION TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Pollution Control Act of South Carolina (S.C. Sections 48-1-10 et seq., 1976) and with the provisions of the Federal Clean Water Act (PL 92-500, as amended by PL 95-217, Titles III, IV and V) 33 U.S.C. 1251 et seq., the "Act,"

Duke Power Company/Catawba Nuclear Station

is authorized to discharge from a facility located at

Lake Wylie, York County, South Carolina

to receiving waters named

Lake Wylie

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on JUN 29 1981

This permit and the authorization to discharge shall expire at midnight,

June 30, 1981

signed: JUN 29 1981

Robert G. Gross P.E.
Bureau of Wastewater and Stream
Quality Control

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s) 001, cooling tower blowdown and other once through non-contact cooling water (service water) discharged to Lake Wylie.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations kg/day (lbs/day)		Other Units (Specify)		Monitoring Requirements	
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type
Flow m^3/Day (MGD)	-	-	-	-	Hourly	Recorder or Pump log
Temperature °C (°F)	-	-	-	-	1/Week	Grab &/or calculati
Chlorine Residual	-	-	See Below		1/Week	Multiple grabs

After start up free available chlorine shall not exceed an average concentration of 0.2 mg/l and a maximum instantaneous concentration of 0.5 mg/l at the cooling tower discharge.

Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than two hours in any one day and not more than one unit may discharge free available or total residual chlorine at any one time unless the permittee can demonstrate to the S.C.D.H.E.C. that the unit(s) cannot operate effectively at or below this level of chlorination.

Permittee shall conduct an internal evaluation of practicable methods to reduce total residual chlorine levels fromthe combined discharge of cooling tower blowdown, conventional service water and nuclear service water. A summary of this evaluation shall be submitted to the S.C. Department of Health & Environmental Control and the Environmental Protection Agency fifteen months after the commercial operation of Unit I.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored: once per week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s). Chlorine at the discharge from the cooling tower prior to mixing with other waste streams. Flow, temp., and pH prior to discharge to Lake Wylie.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s) 002, Wastewater treatment system discharged to Lake Wylie.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type
Flow-m^3/Day (MGD)	-	-	-	-	1/Week	Weir or Recorde
Oil and Grease (mg/l)	16.3(36.0)	21.8(48.0)	15 mg/l	20 mg/l	2/Month	Grab
Total Suspended Solids	32.7(72.0)	109(240)	30 mg/l	100 mg/l	2/Month	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored: once per week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): discharge from the wastewater treatment system prior to mixing with any other waste stream.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s) 003, Sewage treatment plant discharged to Lake Wylie.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type
Flow-m^3/Day (MGD)	-	-	-	-	1/Month	during sampling
BOD_5	-	-	30 mg/l	45 mg/l	1/Quarter	Grab
Total Suspended Solids	-	-	30 mg/l	45 mg/l	1/Quarter	Grab
Fecal Coliform Bacteria	-	-	200/100 ml	400/100 ml	1/Quarter	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored; 1/Week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Sewage treatment plant discharge prior to mixing with any other waste stream.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date,
the permittee is authorized to discharge from outfall(s) serial number(s) 005, Radwaste system discharged to Lake Wylie via 001.

Such discharges shall be limited and monitored by the permittee as specified below:

This discharge is regulated by the Nuclear Regulatory Commission and is monitored and reported to the Nuclear Regulatory Commission.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date and lasting through the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s) 006* - Metal cleaning discharged from station settling basin(s) (Discharge 002).
Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic		Discharge Limitations		Monitoring Requirements	
		Daily Avg.	Daily Max.	Measurement Frequency	Sample Type
Flow-m^3/Day (MGD)		-	-	1/Batch	Instantaneous and/or calculatic
Copper	Quantities shall not exceed the concentrations shown to the right multiplied by the flow.	1.0 mg/l	1.0 mg/l	1/Batch	Grab
Iron		1.0 mg/l	1.0 mg/l	1/Batch	Grab

Metal cleaning wastes shall mean any cleaning compounds, rinse waters, or any other waterborne residues derived from cleaning and metal process equipment including, but not limited to steam generator tube.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Settling basin(s) discharge prior to mixing with any other waste streams.

*Serial number assigned for monitoring and identification purposes.

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   N/A

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. *Representative Sampling*

   Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. *Reporting*

   Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period. The first report is due on OCT 2 8 1981 Duplicate signed copies of these, and all other reports required herein shall be submitted to the state at the following address:

   South Carolina Department of Health and Enviornmental Control
   ATTN: NPDES Permits Section
   2600 Bull Street
   Columbia, S.C. 29201

3. *Definitions*

   a. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

   b. The "daily maximum" discharge means the total discharge by weight during any calendar day.

4. *Test Procedures*

   Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

5. *Recording of Results*

   For each measurement or sample taken pursuant to the requirements of this perm the permittee shall record the following information:

   a. The exact place, date, and time of sampling;

   b. The dates the analyses were performed;

   c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. *Additional Monitoring by Permittee*

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods are specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

7. *Records Retention*

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Department of Health and Environmental Control.

A. MANAGEMENT REQUIREMENTS

1. *Change in Discharge*

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. *Noncompliance Notification*

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the Department of Health and Environmental Control with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. *Facilities Operation*

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee.

4. *Adverse Impact*

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. *Bypassing*

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Department of Health and Environmental Control in writing of each such diversion or bypass.

6. *Removed Substances*

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. *Power Failures*

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. *Right of Entry*

The permittee shall allow the Commissioner of the Department of Health and Environmental Control, the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. *Transfer of Ownership or Control*

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department of Health and Environmental Control.

3. *Availability of Reports*

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department of Health and Environmental Control and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. *Permit Modification*

After notice and opportunity for a hearing, this permit may be modified suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that required either a temporary or permanent reduction or elimination of the authorized discharge.

5. *Toxic Pollutants*

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutan which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. *Civil and Criminal Liability*

Except as provided in permit conditions on "bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothidg in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. *Oil and Hazardous Substance Liability*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. *State Laws*

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties established pursuant to any applicable State law of regulation under authority preserved by Section 510 of the Act.

9. *Property Rights*

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

10. *Severability*

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

A. This permit shall be modified, or alternatively, revoked and reissued, to comply with any applicable effluent standard or limitation issued or approved under sections 301 (b) (2) (C), and (D), 304 (b)(2), and 307 (a) (2) of the Clean Water Act, if the effleunt standard or limitation so issued or approved:

(1) Contains different conditions or is otherwise more stringent than any effluent limitation in the permit; or

(2) Controls any pollutant not limited in the permit.
The permit as modified or reissued under this paragraph shall also contain any other requirements of the Act then applicable.

B. In the event that waste streams from various sources are combined for treatment or discharge, the quantity of each pollutant or pollutant property attributable to each controlled waste source shall not exceed the specified limitation for that waste source.

C. If the permittee, after monitoring for at least six months, determines that he is consistently meeting the effluent limits contained herein, the permittee may request of the S. C. D. H. E. C. that the monitoring requirements be reduced to a lesser frequency or be eliminated.

D. There shall be no discharge of polychlorinated byphenyl compounds such as those commonly used for transformer fluid.

E. The company shall notify the S. C. D. H. E. C. in writing not later than sixty (60) days prior to instituting use of any additional biocide or chemical used in cooling systems, other than chlorine, which may be toxic to aquatic life other than those previously reported to the Environmental Protection Agency. Such notification shall include:

1. Name and general composition of biocide of chemical.
2. Frequency of use.
3. Quantities used.
4. Proposed effluent limitations.
5. EPA registration number.

F. Intake screen wash water may be discharged without limitations or monitoring requirements.

G. Copies of Environmental Reports required by the Nuclear Regulatory Commission which are pertinant to water quality in Lake Wylie or the Catawba River shall be submitted to the Regional Administrator and the State.

H. Yard drains may be discharged without limitations or monitoring requirements.

I. Low volume wastes (wastewater from all sources except those for which specific limitations are otherwise required in this permit, including, but not limited to waste waters from wet scrubber air pollution control systems, ion exchange water treatment systems, water treatment evaporator blowdown, laboratory and sampling streams, floor drainage, cooling tower basin cleaning wastes and blowdown from recirculating house service water systems) shall be discharged to the wastewater treatment system. Permittee shall continue established procedures designed to minimize oil and grease discharges.

NRC FORM 335 (7-77) U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET**	1. REPORT NUMBER *(Assigned by DDC)* NUREG-0921
4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)* Draft Environmental Statement related to operation of Catawba Nuclear Station, Units 1 and 2	2. *(Leave blank)*
	3. RECIPIENT'S ACCESSION NO.
7. AUTHOR(S)	5. DATE REPORT COMPLETED — MONTH: August; YEAR: 1982
9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)* U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D. C. 20555	DATE REPORT ISSUED — MONTH: August; YEAR: 1982
	6. *(Leave blank)*
	8. *(Leave blank)*
12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)* Same as 9 above	10. PROJECT/TASK/WORK UNIT NO.
	11. CONTRACT NO.
13. TYPE OF REPORT	PERIOD COVERED *(Inclusive dates)*
15. SUPPLEMENTARY NOTES Docket Nos. 50-413 and 50-414	14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of the Catawba Nuclear Station, Units 1 and 2, pursuant to the National Environmental Policy Act of 1969 (NEPA) and 10 CFR 51, as amended, of the NRC regulations. This statement examines: the affected environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Land use and terrestrial and aquatic-ecological impacts will be small. Operational impacts to historic and archaeological sites will be negligible. The effects of routine operations, energy transmission, and periodic maintenance of rights-of-way and transmission facilities should not jeopardize any populations of endangered or threatened species. No significant impacts are anticipated from normal operational releases of radioactivity. The risk associated with accidental radiation exposure is very low. The net socioeconomic effects of the project will be beneficial. The action called for is the issuance of operating licenses for Catawba Nuclear Station, Units 1 and 2.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT	19. SECURITY CLASS *(This report)*	21. NO. OF PAGES
Unlimited	Unclassified	
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE $

NRC FORM 335 (7-77)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

FIRST CLASS MAIL
POSTAGE & FEES PAID
USNRC
WASH D C
PERMIT No G67

120555078877 1 AN
US NRC
ADM DIV OF TIDC
POLICY & PUBLICATIONS MGT BR
PDR NUREG COPY
LA 212
WASHINGTON DC 20555