NUREG-0972

Draft Environmental Statement

related to the operation of
Shearon Harris Nuclear Power Plant,
Units 1 and 2

Docket Nos. STN 50-400 and STN 50-401

Carolina Power and Light Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

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ABSTRACT

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of the Shearon Harris Nuclear Power Plant, 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 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 of radiation exposure associated with accidental release of radioactivity is very low. The net socio-economic effects of the project will be beneficial. The action called for is the issuance of an operating license for Shearon Harris Plant, Units 1 and 2.

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SUMMARY AND CONCLUSIONS

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

1. This action is administrative.

2. The proposed action is the issuance of operating licenses to Carolina Power and Light Company (applicant) for the operation of Shearon Harris Units 1 and 2 (NRC Docket Nos. 50-400 and 50-401), located in Wake and Chatham Counties, North Carolina, approximately 26 km (16 miles)* southwest of Raleigh, the state capital. The two units will employ three-loop, pressurized-water reactors (PWRs) to produce a rated 2785 MWt of heat generated in the core, which includes 10 MWt from the reactor coolant pumps, and which is converted to produce approximately 900 MW of electricity. The plant employs a closed-cycle cooling system; the primary heat sink is the atmosphere, through a natural draft cooling tower for each unit. Makeup water for the cooling towers is drawn from a manmade reservoir.

3. The information in this statement represents the second assessment of the environmental impacts pursuant to the Commission's regulations as 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). After receiving, in September 1971, an application to construct Shearon Harris Units 1, 2, 3, and 4, the staff carried out a review of impacts that would occur during station construction and operation. That evaluation was issued as a Revised Final Environmental Statement-Construction Permit phase (RFES-CP) in March 1974. After this environmental review, 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-158, 159, 160, and 161 in January 1978. The applicant submitted an application for an operating license (OL) by letter dated June 26, 1980. The NRC conducted a predocketing acceptance review and determined that sufficient information was available to start detailed environmental and safety reviews. The FSAR was docketed on December 22, 1981. The applicant on December 18, 1981 informed the NRC that Units 3 and 4 had been cancelled, and on January 7, 1982 requested that Units 1 and 2 be considered concurrently for operating licenses.

   The applicant has informed the NRC that, as of February 1983, the construction of Unit 1 was about 76% complete, Unit 2 was about 4% complete, and the fuel loading date for Unit 1 is projected to be June 1985.

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*Throughout the text of this document, values are presented in both metric and English units. For the most part, measurements and calculations were origially 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.

4. The staff has reviewed the activities associated with the proposed operation of the station and the potential impacts, both beneficial and adverse. The staff's conclusions are summarized as follows:

   (a) The Shearon Harris station will provide approximately 9 billion kWh of electrical energy annually (assuming that both units will operate at an annual average capacity factor of 55%). The addition of the station will add 1800 MW of operating capacity to the Carolina Power and Light Company system, resulting in increased system and regional reliability (Chapter 6).

   (b) Alteration of about 4251 ha (10,800 acres) of land for the plant has been necessary. This is not significant.

   (c) Operation of the Shearon Harris station will not have a significant adverse impact on any terrestrial or aquatic endangered or threatened species (Section 4.3.6).

   (d) Surface water quality impacts in the main reservoir caused by intermittent chemical discharges from the plant are predicted to be small, based on a reduction in the plant cooling system concentration factor over the previously planned value and on the small incremental concentrations of treated wastes in the plant blowdown (Sections 5.3.1 and 5.5.2).

   (e) Although research is still ongoing on the types and amounts of chlorinated organic chemicals that may be formed during cooling water chlorination, the staff has found no evidence to date to support a conclusion that the biofouling control scheme proposed for the plant will have adverse effects on human health or plant or animal life in the main reservoir, considering its designated water uses (Sections 5.3.1 and 5.5.2).

   (f) Thermal effects of the plant blowdown will be manifest over a very small area of the main reservoir. The staff's thermal analysis concluded that the area needed to comply with the state water quality standards is very much less than that predicted by the applicant, whose calculations were determined to be conservative (Sections 5.3.1 and 5.5.2).

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

   (h) 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).

   (i) 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 5.5.1.4).

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

(k) Creation of the Shearon Harris reservoirs has resulted in habitat suitable for colonization by some nuisance species of aquatic organisms, such as Asiatic clam (*Corbicula*) and the submerged macrophyte *Hydrilla verticillata*. The use of a continuous low-level chlorination scheme for clam control is expected to be effective with minimum impact on the reservoir biotic communities. Some combination of physical, biological, and chemical control measures may be required to control hydrilla if it should become established in the Harris reservoirs (Section 5.5.2.4). The applicant should maintain an awareness of the investigative findings of the North Carolina Interagency Council on Aquatic Weeds Control if future application of hydrilla control measures is found to be necessary for the Shearon Harris reservoirs.

(l) The operation and maintenance of the Shearon Harris station will not adversely impact existing archeological resources or historic sites (Section 5.7).

(m) The overall socioeconomic impact of operating the Shearon Harris station will be beneficial (Section 5.8).

(n) 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 5.9.3.1).

(o) 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) have been evaluated. The risk to Shearon Harris station from such hazards is negligibly small (Section 5.9.4.4(2)).

(p) 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 operation. 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).

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

(r) Noise levels off site during plant operation are predicted by the staff to be above ambient levels by very small amounts. Examination of the predicted broadband noise and the potential for annoyance as a result of audibility of tones indicates that no adverse community reaction would be expected from noise from operation of the plant (Section 5.12).

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 agencies, as specified in Chapter 8.

7. The personnel who participated in the preparation of this statement and their areas of responsibility are identified in Section 7.

8. On the basis of the analyses and evaluations set forth in this statement, after weighing the environmental, economic, technical, and other benefits against environmental and economic costs at the operating license stage, the staff concludes that the action called for under NEPA and 10 CFR 51 is the issuance of operating licenses for Shearon Harris 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 Shearon Harris Units 1 and 2. Monitoring of the aquatic environment shall be as specified in the National Pollution Discharge Elimination System (NPDES) permit.

   (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.

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FOREWORD

This Draft Environmental Statement-Operating License Stage (DES-OL) 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).

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

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

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

- the environmental impact of the proposed action
- any adverse environmental effects that cannot be avoided should the proposal be implemented
- alternatives to the proposed action
- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity

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

An Environmental Report (ER-OL) accompanied the application for an operating license. In conducting the required NEPA review, the staff met with the applicant to discuss items of information in the ER-OL, to seek new information from the applicant that might be needed for an adequate assessment, and to ensure that the staff has thorough understanding of the proposed project. In addition, the staff has obtained information from other sources that have assisted in this evaluation, and visited the project site and the surrounding vicinity. Members of the staff met with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing and other such activities or inquiries as were deemed useful and appropriate, the staff made an independent assessment of the considerations specified in Section 103(2)(c) of the NEPA and 10 CFR 51.

The evaluation led to the publication of this DES, which is being circulated to Federal, state, and local government agencies for comment. A notice of the availability of the ER-OL and the DES is being published in the Federal Register. Interested persons are also invited to comment on the proposed action and on the draft statement.

After receipt and consideration of these comments, the staff will prepare a Final Environmental Statement (FES), which includes a discussion of questions and concerns raised by the commenters and the disposition thereof. This FES also will contain conclusions as to whether--after the environmental, economic, technical, and other benefits are weighed against environmental costs--the action called for, with respect to environmental issues, is the issuance or denial of the proposed license, or its appropriate conditioning to protect environmental values. The format used in the DES also will be used in the FES to facilitate review.

The information to be found in the various sections of this statement updates the environmental statement issued at the construction permit stage in four ways: (1) by evaluating changes to facility design and operation that will result in different environmental effects of operation (including those that would enhance as well as degrade the environment) than those projected during the preconstruction review; (2) by reporting the results of relevant new information that has become available subsequent to the issuance of the construction permit stage environmental statement; (3) by factoring into the statement new environmental policies and statutes that have a bearing on the licensing action; and (4) by identifying unresolved environmental issues or surveillance needs that are to be resolved by means of license conditions.

Copies of this DES are available for inspection at the Commission's Public Document Room, 1717 H Street, NW, Washington, DC 20555 and at the Local Public Document Room at the Wake County Public Library, Fayetteville Street, Raleigh, North Carolina. Single copies may be obtained, free of charge, by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

1 INTRODUCTION

1.1 Resumé

The proposed action is the issuance of operating licenses (OLs) to Carolina Power and Light Company (CP&L, the applicant) for startup and operation of the Shearon Harris Nuclear Power Plant Units 1 and 2 (Docket Nos. 50-400 and 50-401). Each unit will use a pressurized-water reactor (PWR) and will have an initial gross electrical output capacity of 900 MW. Condenser cooling during normal operations will be accomplished by a closed cycle system with cooling towers, with a man-made reservoir serving the needs for makeup and blowdown. In addition to the main cooling system, the plant contains an emergency service water system (ESWS) to provide cooling to critical components if the normal service water system is not available. The ESWS uses cooling water from the auxiliary reservoir created by a separate dam. The applicant has indicated that water from Cape Fear River will be drawn into the main reservoir, if necessary, when both Units 1 and 2 are operational. For the period during which Unit 1 is operational but Unit 2 is under construction, no need for water from Cape Fear River is anticipated.

1.2 Administrative History

In September 1971, CP&L filed an application with the Atomic Energy Commission (AEC), now the Nuclear Regulatory Commission (NRC), for permits to construct Shearon Harris Units 1, 2, 3, and 4. The conclusions resulting from the staff's environmental review were issued as a Revised Final Environmental Statement-Construction Phase (RFES-CP) in March 1974. Following reviews by the AEC regulatory staff and its Advisory Committee on Reactor Safetyguards, public hearings were held before an Atomic Safety and Licensing Board. Construction permits for Units 1, 2, 3, and 4 (CPPR-158, 159, 160, and 161) were issued on January 27, 1978.

In response to applications for operating licenses for the Shearon Harris plants, NRC performed an acceptance review and, on November 25, 1981, issued a letter accepting the applications. On December 18, 1981, the applicant informed NRC that Units 3 and 4 had been cancelled, and on January 7, 1982 the applicant requested that Units 1 and 2 be considered concurrently for operating licenses. The Final Safety Analysis Report (FSAR) was docketed on December 22, 1981.

The applicant has informed the staff that as of February 1983 construction of Unit 1 was about 76% complete, that Unit 2 was about 4% complete, and that the fuel loading date for Unit 1 was projected to be June 1985.

On February 1, 1982, NRC issued a Draft Safety Evaluation Report that presented the current state of the staff safety review.

1.3 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 licenisng difficulties that would significantly delay or preclude the proposed operation of the plant. Pursuant to Section 401 of the Clean Water Act of 1977, the issuance of a water quality certification, or waiver therefrom, by the North Carolina Department of Natural Resources and Community Development (NCDNRCD) is a necessary prerequisite to the issuance of an operating license by the NRC. This certification was received by the applicant on September 14, 1977. The NCDNRCD issued a National Pollutant Discharge Elimination System (NPDES) permit, pursuant to Section 402 of the Clean Water Act of 1977, to the applicant on July 12, 1982 (reproduced in Appendix G of this report).

2 PURPOSE OF AND NEED FOR ACTION

The Commission 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 stage of the regulatory review, where a finding of insufficient need could factor into denial of issuance of a license. At the operating license 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.

The Commission has determined that substantial information exists to support the contention that nuclear plants cost less to operate than do conventional fossil-fueled plants. If conservation, or other factors, lowers anticipated demand, utilities remove generating facilities from service according to their costs of operation, and the most expensive facilities are 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 environmental statement does not consider "need for power."

3 ALTERNATIVES TO THE PROPOSED ACTION

The Commission 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 stage and the construction permit is granted only after a finding that, on balance, no superior alternative to the proposed nuclear facility exists. This conclusion is unlikely to change even if an alternative is shown to be marginally environmentally superior in comparison with operation of the nuclear facility because of the economic advantage that operation of the nuclear plant would have over available alternative sources (46 FR 39440, August 3, 1981 and 47 FR 12940, March 26, 1982). By an 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, according to 10 CFR 2.758. Thus, this environmental statement does not consider alternative energy sources or alternative sites.

4 AFFECTED ENVIRONMENT

4.1 Résumé

This section contains a summary of changes that have occurred since the RFES-CP was issued. The major changes in the facility, as discussed in Section 4.2, resulted from the cancellation of the proposed Units 3 and 4. These are detailed in Sections 4.2.1, 4.2.2, 4.2.3, and 4.2.4. Section 4.2.5 addresses the final design of the station radwaste systems and effluent control measures, and Section 4.2.6 discusses changes in the nonradioactive-waste-management systems. Section 4.3.1 presents updated data on the hydrology of the area, and Section 4.3.2 addresses water use rates, including data for the 1980-1981 low flow period. Recently collected data on water quality are addressed in Section 4.3.3, and revised descriptions of terrestrial and aquatic resources are given in Section 4.3.4. Section 4.3.5 gives updated meteorological data. Section 4.3.6 addresses the state and Federally recognized threatened and endangered species in the site area, and Section 4.3.7 has been updated to include 1980 census data as well as other recent population statistics. Section 4.3.8 gives the present status of properties referred to in the RFES-CP.

4.2 Facility Description

4.2.1 External Appearance and Plant Layout

A general description of these topics is included in Chapters 2 and 3 of the RFES-CP. The major changes from that description have resulted because of the cancellation of Units 3 and 4. All structures associated with those units--including the reactors, the auxiliary building for Units 3 and 4, their two cooling towers, and the turbine generator buildings--will not be built. Also, the previously planned 500-kV switchyard and the Harris-Harnett 500-kV transmission line have been cancelled (ER-OL, RQ 310.8). The ER-OL describes the cooling towers as about 158 m (520 ft) high (Section 3.1). This compares with a 146-m (480-ft) height described in Section 3.3 of the RFES-CP.

4.2.2 Land Use

A description of regional land use within a 64-km (40-mile) radius of the site is in RFES-CP Section 2.3. Land use in the site vicinity is essentially unchanged from that described in the RFES-CP. Since the issuance of the RFES-CP, the applicant has erected the Harris Energy and Environmental Center 3.4 km (2.1 miles) east-northeast of the plant. The center contains a visitor-reception and educational facility, as well as training and environmental testing laboratories (ER-OL Amendment 2).

4.2.3 Water Use and Treatment

4.2.3.1 General

The overall water use scheme proposed for the operational phase of the Shearon Harris plant remains similar to that presented in the RFES-CP. That is, the plant is equipped with a closed cycle cooling system that uses natural draft cooling towers in the condenser circulating and service water cooling systems, and closed loop cooling through the auxiliary reservoir for the plant's emergency service water system during other-than-normal operation. The plant's main reservoir, created by a dam on Buckhorn Creek just below its confluence with White Oak Creek, will supply all of the plant water and will receive all station liquid discharges. The changes to this scheme as presently proposed from that presented in the RFES-CP consist of (1) the modifications in component capacity and design necessitated by the reduction in plant size from four units to two, and (2) the decision by the applicant to delay the construction and operation of the Cape Fear River makeup water pump station and pipeline until Unit 2 becomes operational.

4.2.3.2 Surface Water Use

The volumetric flow rates for the various water systems of the Shearon Harris plant have changed since the issuance of the RFES-CP because of the reduction in plant size from four units to two.

Under normal operation, water will be withdrawn from the main reservoir to meet plant circulating and service water needs, and plant water treatment needs (i.e., potable water and demineralized water for reactor makeup and secondary water system/condensate storage). The cooling water systems are presently projected to require, primarily for cooling tower makeup, an average of 2.8 m^3/sec (99.4 cfs) for two-unit operation, compared to 3.0 m^3/sec (106 cfs) for four units projected in the RFES-CP. The plant blowdown flow rate, primarily from the condenser circulating and service water cooling systems, has also changed as a result of the reduction in plant size from four units to two and a reduction in the plant concentration factor. The blowdown for two units is presently projected to be 1.5 m^3/sec (54 cfs), compared to 0.4 m^3/sec (15 cfs) for four units projected in the RFES-CP. The values listed above are for 100% plant load.

The plant will consume water primarily through evaporation from the condenser circulating and service water systems. The total two-unit consumptive use (based on evaporative loss plus 10% of the evaporative loss for other plant consumption) is projected to average 1.3 m^3/sec (46.3 cfs) at 100% power, compared to 2.1 m^3/sec (75 cfs) for four units projected in the RFES-CP. Monthly maximum two-unit consumptive use is projected to range between 1.3 m^3/sec (47.3 cfs) for January and 1.6 m^3/sec (55.4 cfs) for July. The drift loss component of this consumptive use is very small, and is anticipated to be about 0.001 m^3/sec (0.04 cfs) for two units. Plant water use is shown in Table 4.1 and Figure 4.1. At 100% plant load, the water use rates given above represent an average concentration factor of about 1.8, which is considerably less than the value of 8.5 given in the RFES-CP.

The emergency service water system will be supplied by the auxiliary reservoir, as described in the RFES-CP. The as-built size (128 ha (317 acres)) is slightly smaller than the previously planned 131 ha (325 acres). Maximum water flow between the auxiliary reservoir and the plant is estimated to be 1.3 m^3/sec (46.8 cfs). During normal operation, this flow is zero.

4.2.3.3 Groundwater Use

There will be no withdrawal of groundwater for use by the Shearon Harris plant.

4.2.3.4 Water Treatment

The planned treatment of water for use in the Shearon Harris plant has changed somewhat from that presented in the RFES-CP. Water for the plant condenser and service water cooling systems will be treated with biocide to control biofouling, but it is not likely to be treated with sulfuric acid, as planned in the RFES-CP. This change is a result of the reduction in concentration factor in the condenser circulating water system. The remainder of the water withdrawn for use in the Shearon Harris plant will be routed to the primary filtered makeup water system and to the demineralized water system. In passing through these systems, the water will be filtered, disinfected, or demineralized, as appropriate, for use in the plant's primary and secondary water systems and in the potable water system. These pretreated waters will be treated further to control corrosion in the condensate, feedwater, reactor coolant, and closed water coolant systems. The chemicals proposed for use are the same as those indicated in the RFES-CP: namely hydrazine, ammonia, lithium hydroxide, sodium chromate, and sodium phosphate. Annual chemical usage is shown in Table 4.2. The estimated amounts of chemicals to be used in plant systems have changed from those indicated in the RFES-CP as described below.

The applicant plans to use a liquid hypochloride solution to control biofouling in the condenser circulating and service water systems. Chlorination of the cooling tower/condenser water system is the same as proposed in the RFES-CP: two approximately 30-minute per day per unit applications, with smaller application frequencies or durations possible during the cooler months of the year, depending on biofouling severity (responses to staff questions E291.10 and E291.11). The design objective for this system is the attainment of a 0.5 mg/l free available chlorine (FAC) concentration in the condenser effluent during the chlorination cycle. It is anticipated that the biocide application requirement will be about 3 to 5 mg/l. These values are the same as those presented in the RFES-CP. The application points for this system are in the cooling tower makeup intake structure and in the cooling tower intake structure. Only one unit will be chlorinated at a time.

The plant service water system will also be chlorinated on an intermittent basis. Chlorination is planned for 2 hours per day per unit at the service water system pumps drawing water from either of the plant cooling towers. The applicant has indicated that continuous low level chlorination of the service water system may prove to be necessary, should Asiatic clams become established in the main reservoir (response to staff question E291.10). The rate of biocide application for this type of treatment has not been finalized.

The average amount of chlorine biocide to be used has been estimated at 330 to 550 kg per day per unit (725-1200 lb per day per unit), as compared to 454.5 kg per day per unit (1000 lb per day per unit) estimated in the RFES-CP.

Table 4.1 Shearon Harris water use under various station conditions†

Stream* ††	Flow** at max power operation	Flow** at min anticipated power operation	Flow** at temp. shutdown	Comment
1	21,000 gpm	21,000 gpm	21,000 gpm	Emergency only
2c	12,500 gpm	1,560 gpm	135 gpm	Varies with dissolved solids
3c	22,300 gpm	2,830 gpm	240 gpm	Max flow 26,000 gpm
4c	22,300 gpm	2,830 gpm	240 gpm	Max flow 26,000 gpm
5c	10,170 gpm	1,270 gpm	110 gpm	Average meteorological conditions
6c	483,000 gpm	284,000 gpm	0-284,000 gpm	
7c	483,000 gpm	284,000 gpm	0-284,000 gpm	
18c	50,000 gpm	50,000 gpm	50,000 gpm	
19c	24 gpm	24 gpm	24 gpm	See # 20 and 21
20	208,300	208,300	208,300	
21	16,700	16,700	16,700	
22	666,600	666,600	666,600	
25	62,500	36,765	0-36,765	
26c	60 gpm	60 gpm	60 gpm	
27	666,600	666,600	666,600	
28	666,600	666,600	666,600	
29	330 lb/mo	330 lb/mo	330 lb/mo	Wet sludge
30	1.5 mgm	1.5 mgm	1.5 mgm	
31	1,095,600	1,095,600	1,095,600	
32	15,000	15,000	15,000	
33	0-9,000	0-9,000	0-9,000	Makeup as needed
34	375,000	375,000	375,000	
35	30,000	30,000	0-30,000	
36	0-15,000	0-15,000	0-15,000	

Table 4.1 (continued)

Stream* ††	Flow** at max power operation	Flow** at min anticipated power operation	Flow** at temp. shutdown	Comment
37	7,500	7,500	7,500	
44c	12 gpm	12 gpm	12 gpm	
45c	10 gpm	10 gpm	10 gpm	
46c	10 gpm	10 gpm	10 gpm	
47	258,333	258,333	0-258,333	See # 65 and 66
48	6.0 mgm	6.0 mgm	6.0 mgm	Includes rainwater and fire runoff
49	0-1 mgm			Aux reservoir makeup as needed
50	11,000	11,000	11,000	No fire + 360,000 for 2-hour supply
51				Only in case of fire
52				Only in case of fire
53	2.0 mgm	2.0 mgm	2.0 mgm	Fire runoff
62	9,160	9,160	9,160	In 2,166 cfm solid waste
63	66,600	66,600	66,600	
64	7,500	7,500	7,500	Fire pump test
65	166,600	96,765	96,765	
66	89,540	89,540	437,500	
67c	12 gpm	12 gpm	12 gpm	Makeup

*For streams, refer to Figure 4.1.
**All flows in average gallons per month unless otherwise noted. To convert continuous flow in gpm to cfs, multiply values shown by 0.0022; to convert to m^3/sec, multiply continuous flow values shown by 0.00006. mgm = million gallons per month; each reactor is assumed to operate 85% of the time. This yields a 309-day operating year; a month is considered 1/12th of this 309-day operating year.
†All data based on one unit; double the given values for two units.
††C = continuous flow under normal conditions.

Source: ER-OL Table 3.3-1

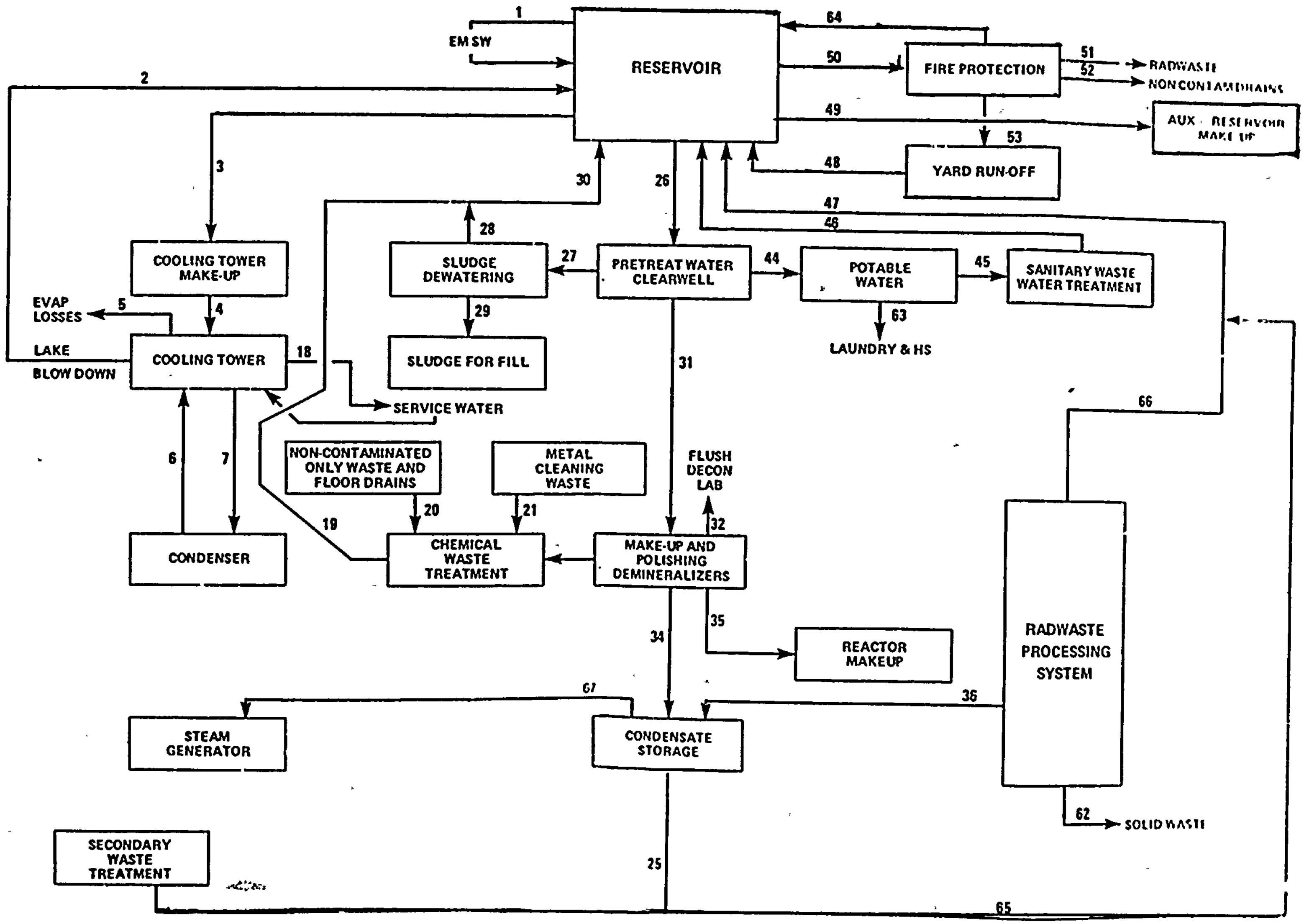

Figure 4.1 Station water use (Source: ER-OL Figure 3.3-1)

Table 4.2 Chemical additives and their annual consumption per unit

				Annual Consumption	
Chemical	System served	Use	Frequency of use	Average	Maximum
Boron	Reactor coolant	Reactivity control	Intermittent	200 lb	--
Hydrazine	Reactor coolant; secondary	Oxygen control Oxygen control	Infrequent; continuous	51 lb 5,000 lb	4600 lb --
Ammonia	Secondary	pH control	Continuous	2,000 lb	--
Polyelectrolyte	Primary water treatment	To induce adsorption	Continuous	165 lb	220 lb
Corrosion inhibitor sodium chromate	Closed cooling water	To inhibit corrosion	At start, then as needed	500 lb	--
Chlorine	Sewage treatment plant	To kill disease-causing organisms; to oxidize organic matter	Continuous	3.9 T	--
Chlorine	Circulating and service system cooling water	To control biofouling	Daily	134-222 T	308 T
Sulfuric acid	Demineralized water	To regenerate demineralizers	Daily	98 T	--
Sodium hydroxide	Demineralized water	To regenerate demineralizers	Daily	49 T	--
Lithium	Reactor coolant	pH control	Intermittent	9 kg	--
Nitrogen	Various primary	Cover gas	Intermittent	300,000 scf	--
Hydrogen	Reactor coolant	Oxygen control	Continuous	8,500 scf	--
Detergent	Laundry	Cleaning	As needed	305 lb	--
Corrosion inhibitor sodium chromate	HVAC chilled water	Corrosion inhibitor	Daily	50 lb	--
Sodium phosphate	Heat exchange equipment	Corrosion inhibitor	As needed	2,100 lb	--

Note: To convert to kg, multiply values in pounds by 0.45.

Source: ER-OL Table 3.6.2-3.

4.2.4 Cooling Systems

4.2.4.1 Intake Systems

The locations of intake systems on the Cape Fear River and the main reservoir are the same as described in the RFES-CP. The designs are essentially the same except for a reduction in size of the cooling tower makeup intake as a result of the cancellation of Units 3 and 4. The portion of the emergency service water and cooling tower makeup water intake structure that was intended to serve the cancelled units will not be completed.

The volumes of water estimated to be required as makeup to the main reservoir and the cooling towers have decreased because of the cancellation of Units 3 and 4. It is now projected that the Cape Fear River intake will not be used until both Units 1 and 2 are in operation.

The Cape Fear River intake will be located on the left bank of the river immediately upstream of Buckhorn Dam. The intake system will consist of four pumps with a total capacity of 9.1 m^3/sec (320 cfs). Two of the pumps each have a capacity of 1.3 m^3/sec (45 cfs), and the other two each have a capacity of 3.25 m^3/sec (115 cfs). Spare locations on either end of the structure are provided for future installation of two additional pumps to increase the capacity of the total intake to 14.2 m^3/sec (500 cfs), if greater capacity is needed. The applicant does not propose to use the larger provisional pumping capacity; thus, the staff has not considered withdrawals of greater than 9.1 m^3/sec (320 cfs) in its assessment. The structure is made up of 10 bays, each provided with a coarse screen, stop log guides, 3/8-in. mesh traveling screen, and guides for two fine screens. The two center bays each serve one of the smaller pumps. Each of the two larger pumps and the two provisional pumps will be served by two adjoining bays.

The applicant estimates a maximum velocity of 0.12 m/sec (0.39 fps) through the screens serving the smaller pumps and 0.3 m/sec (0.98 fps) through one of the two redundant screens serving the larger pumps. In the latter case, one of the screens is assumed to be completely blocked. At the position of the stop log guides, the mean intake velocity is $\leq$0.15 m/sec (0.5 fps) at low water level conditions.

The cooling tower makeup intake system is located at the end of a short approach channel off the Thomas Creek arm of the reservoir. The system is equipped with three makeup pumps (one per unit and one spare). Each pump is sized for 1.6 m^3/sec (26,000 gpm or 57.9 cfs) capacity. Makeup requirements for one-unit and two-unit operation are about 1.3 m^3/sec (46 cfs) and 2.6 m^3/sec (92 cfs), respectively (ER-OL, Section 3.4.2.9). The pumps supply, for two units, an additional 0.04 m^3/sec (600 gpm or 1.3 cfs) of water to the plant water treatment facility. Each pump is served by a separate bay with inflowing water passing through similar screening structures as described for the Cape Fear River intake. The intake was designed to achieve an approach velocity $\leq$0.15 m/sec (0.5 fps) at the stop log guides. The applicant has estimated velocities through the 3/8-in. mesh traveling screens at low water to be 0.22 m/sec (0.73 fps), with flow of 1.8 m^3/sec (63 cfs) (ER-OL Section 3.4.2.9).

Trash removed at both intake structures will be deposited in a landfill located on site. No special provisions are incorporated in the designs to return live fish to the river or reservoir because minimal impingement of fish is anticipated (see Section 5.5.2).

4.2.4.2 Discharge System

Cooling tower blowdown will be discharged to the main reservoir through a single port jet at a point approximately 5.6 km (3.5 miles) south of the plant and about 1.6 km (1 mile) north of the main reservoir dam (see Figure 4.1). Both the location and discharge design are different from those given in the RFES-CP (Section 3.3). The new location is about 1.6 km (1.0 mile) farther south of the plant than the old location. Water depths at the new location are 12.2 to 13.7 m (40 to 45 ft), as compared to depths of 6.1 to 7.6 m (20 to 25 ft) at the old location.

The discharge design reviewed in the RFES-CP consisted of two 14-in.-diameter pipelines and submerged multiport diffusers. The present design consists of on 48-in.-diameter pipe. The centerline of the pipe opening is at el 182 ft, or 11.6 m (38 ft) deep with respect to normal reservoir water level at el 220 ft. The pipe is parallel (zero slope) with respect to the lake bottom at the point of discharge. Discharge velocities for one-unit and two-unit operation are 0.58 m/sec (1.9 fps) and 1.12 m/sec (3.7 fps), respectively; corresponding maximum blowdown rates are 0.66 m^3/sec (15 mgd or 23.2 cfs) and 1.31 m^3/sec (30 mgd) (ER-OL Section 3.4.2.7).

4.2.5 Radioactive-Waste-Management System

Under requirements set by Part 50.34a of Title 10 of the Code of Federal Regulations (10 CFR 50.34a), an application for a permit to construct a nuclear power reactor must include a preliminary design for equipment to keep 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 improvements 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 radiation dose design objectives for light-water-cooled nuclear power reactors (LWRs) 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 provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents ALARA within the requirements of Appendix I to 10 CFR 50. The quantities of radioactive effluents from the Shearon Harris plant were estimated by the staff, based on the description of the radwaste system and its mode of operation. The staff utilized the calculative model of NUREG-0017 to project releases from the plant. Shearon Harris will include a fluidized bed dryer as a part of its solid radwaste system. The dryer will be utilized to reduce the volume of solid radwaste that will be shipped from the plant to a low-level waste burial site. The operation of this equipment will result in airborne effluents and an additional source to the liquid radwaste system with corresponding liquid effluents. The calculative model of NUREG-0017 does not have the capability to calculate the effluents resulting from operation of the fluidized bed dryer. Therefore, it was necessary for the staff to calculate the effluents based upon the staff's estimate of wastes to be treated by the fluidized bed dryer, information contained in Aerojet Energy Conversion Company's topical report AECC-1-A, "Fluid Bed Dryer," and information provided by the applicant.

The NRC staff's detailed evaluation of the radwaste systems and the capability of these systems to meet the requirements of Appendix I will be presented in Chapter 11 of the staff's Safety Evaluation Report (SER), which is to be issued in November 1983. The quantities of radioactive material that the NRC staff calculates will be released from the plant during normal operations, including anticipated operational occurrences, are presented in Appendix D of this statement, along with examples of the calculated doses to individual members of the public and to the general population resulting from these effluent quantities.

The staff's detailed evaluation of the solid radwaste system and its capability to accommodate the solid wastes expected during normal operations, including anticipated operational occurrences, is presented in Chapter 11 of the SER.

As part of the operating license for this facility, the NRC will require Technical Specifications limiting release rates for radioactive material in liquid and gaseous effluents and requiring routine monitoring and measurement of all principal release points to ensure that the facility operates in conformance with the radiation-dose-design objectives of Appendix I.

4.2.6 Nonradioactive-Waste-Management Systems

4.2.6.1 General

Nonradioactive effluents will result from the operation of the Shearon Harris evaporative cooling system, the water treatment systems, and the waste water treatment system. There have been changes in the volume and character of these effluents since the RFES-CP was issued. These changes are discussed below.

4.2.6.2 Cooling Water System (NPDES Outfall Serial No. 001)

The operation of the closed-cycle cooling system for the plant will result in the discharge of water of different composition than that withdrawn from the main reservoir. As indicated in Section 4.2.3 of this statement, the evaporative loss from the natural draft cooling towers will result in a concentration of physical and chemical constituents in the makeup water. The expected average concentration of the constituents in the system blowdown as a result of the operation of the plant cooling water system will be less than twice the intake concentration values. As a result of evaporation, the concentration of dissolved substances will increase over time. Closing of the dam for the main reservoir occurred in December 1980. Water quality data from the reservoir since it reached minimum operating level are not yet available. Estimates of the concentrating effect on total dissolved solids in the reservoir from the operation of the plant cooling water system are based on the preconstruction values of Buckhorn-Whiteoak Streams and the values of the Cape Fear River from data collected upstream of Buckhorn Dam since the RFES-CP was issued. As indicated in the RFES-CP, a steady-state concentrate value would be achieved, if flows to and from the reservoir remained constant, assuming that both units start operation at the same time and that no constituents are removed by chemical or biological means. Using the revised flow rates indicated by the applicant and the revised data on total dissolved solids concentration data in the Cape Fear River, the concentrate is calculated to reach about 95% of the steady-state value in 4 years. Because flows and plant operation will not be constant, the eventual concentration will fluctuate around an average value that would be near the steady-state value computed from average input and output values.

The applicant will control the discharge of total residual chlorine in the cooling tower blowdown by regulating the amount added so that the concentration will not exceed 0.2 mg/l. The applicant has indicated that the concentration of residual chlorine will be monitored at the condenser discharge water box, as well as at each cooling tower. This will enable the operators to determine more precisely (i.e., more precisely than monitoring residual chlorine further downstream at the cooling tower basin) when a sufficient biocide residual level has been attained in the condenser (the critical biofouling control point). This should tend to reduce the amount of chlorine biocide used during each application and to minimize the residual concentration in the cooling tower blowdown. As indicated in the RFES-CP, the capability exists to suspend blowdown during periods of higher than desired concentrations of residual chlorine in the cooling tower basins until acceptable concentrations are measured (response to staff question E291.11). The service water system flow rate is less than 4% of the circulating water flow rate. Chlorination of the service water system (that also passes through the cooling tower where it mixes with the circulating water before discharge in the blowdown) is not anticipated, by itself, to result in a detectable chlorine residual in the cooling tower blowdown.

A final plan for the cleaning (biofouling control) of cooling water systems outside of the condenser and service water systems has not been decided on by the applicant (response to IE Bulletin 81-03). These systems can be isolated so that cleaning waste solutions may be controlled and treated before disposal.

The amount of dissolved solids expected to escape from the plant's cooling towers in the drift during operation has changed since the issuance of the RFES-CP. As indicated in Section 4.2.3.2, the concentration factor in the plant cooling water system has decreased to about 1.8, and the projected drift loss rate for the cooling towers is now 0.002% of the cooling water flow rate, or 37 l per min per tower (10 gpm per tower), compared to 950 l per min per tower (250 gpm per tower) estimated in the RFES-CP. Based on an estimated equilibrium reservoir value for total dissolved solids in the plant intake, a 1.8 plant concentration factor, and the revised drift rate, up to about 16 kg per day per unit (36 lb per day per unit) could be dispersed in the drift.

4.2.6.3 Chemical Waste Systems (NPDES Outfall Serial Nos. 003, 004)

The plant chemical waste systems treat all nonradioactive chemical waste waters except the sanitary wastes. These waste-water types are similar to those described in the RFES-CP and primarily consist of demineralizer regenerants, filter flush wastes, metal cleaning wastes, oily wastes, and floor drainage. All of these waste waters are discharged, after appropriate treatment, to the cooling tower blowdown. There is no planned use or discharge of morpholine from plant systems, as recommended by the staff in the RFES-CP.

Effluent concentrations and yearly waste quantities have changed from those shown in the RFES-CP. Revised average annual discharge concentrations, assuming minimum diluting plant blowdown (i.e., minimum blowdown for one unit for one year), are shown in Table 4.3. Discharge of these wastes is intermittent, however, and, during discharge, pollutant concentrations will be higher than the average values shown. The absolute values for most pollutants shown in the table will still be low. The discharge concentration will be highest for total dissolved solids and sulfates from the demineralized water system regenerative wastes. Depending on plant blowdown flow rates, the incremental increases in these pollutant concentrations are calculated by the staff to be as high as the following, based on the waste concentration shown in Table 4.3 and on a settling basin pump rate of 190 l per min (500 gpm):

Units, blowdown flow rate	Incremental total dissolved solids concentration in plant discharge	Incremental sulfate concentration in plant discharge
1 unit, minimum blowdown	249 mg/l	166 mg/l
2 units, maximum blowdown	77 mg/l	52 mg/l

Preoperational system hydrostatic testing and flushing will not involve the use of acidic or caustic cleaners. Potable or demineralized water with hydrazine, ammonia, and possibly a wetting agent (e.g., a detergent) added will be used for these flushes. Dirt, debris, oil and grease, corrosion products (iron and copper), and small amounts of any flush additives will be present in the wastes from these flushes. The volume and character of this waste is also shown in Table 4.3.

Additional description of the system appears in ER-OL Sections 3.6.2 and 3.6.4.

4.2.6.4 Sanitary Waste Treatment System (NPDES Outfall Serial No. 002)

The sanitary waste treatment system proposed for use during the operational phase of Shearon Harris has changed somewhat since the RFES-CP was issued. The system as presently proposed (an extended aeration package treatment plant with a 95-m^3 per day (25,000-gpd) capacity) will be operated as a secondary treatment system, instead of as a tertiary treatment system as described in the RFES-CP, by eliminating the chemical contact tank. The comparison of expected effluent characteristics presented by the applicant in the ER-OL indicates that this change will result in higher macronutrient levels (nitrogen and phosphorus) and higher biochemical oxygen demand in the treatment plant effluent. However, the projected effluent characteristics meet those required by the North Carolina Environmental Management Commission, the North Carolina Department of Natural Resources and Community Development, and the U.S. EPA effluent limitations for the steam electric power generating point source category.

The sewage treatment plant effluent will be discharged to the main reservoir through the cooling tower blowdown discharge line. Sludge removed from the plant clarifier will be trucked to offsite sewage treatment facilities for disposal.

Table 4.3 Summary of chemical waste compliance with applicable standards per unit

Type of waste	Waste source	Quantity (gal/yr)	Chemical and pollutant content	Estimated avg concentration post-treatm't (ppm)	EPA effluent limitations (40CFR423) (ppm)	Estimated incr in avg water concentration§ (ppm)	North Carolina water qual stds
Reactor coolant	Boron recycle system	685,000	Boron	10	--	0.002	No standards
Nonrecoverable water	Waste management	437,000	Detergent, dirt	30	TSS:Avg-30, Max-100	0.005	**
Detergent waste	Laundry, showers	680,000	Detergent, dirt	30	TSS:Avg-30, Max-100	***	**
Electromagnetic filter flush	Condenser feedwater equipment drains	1,000,000	Hydrazine*	0.05	--	#	†
			Ammonia*	0-1	--	#	†
Turbine bldg drains	Floor drains	1,500,000	Oil and grease	15	O&G:Avg-15, Max-20	***	**
			Total suspended solids	30	TSS:Avg-30, Max-100	***	**
Regenerative solutions	Demineralized water system	10,500,000	Total dissolved solids*	3,318	--	13	†
			Sulfates*	2,212	--	8	†
			pH	6-9	6-9	††	6.5-9.0
Filter flush water	Primary water treatment plant flush water	8,000,000	Suspended solids	30	TSS:Avg-30, Max-100	***	**
			Polyelectrolyte*	1-2**		Trace	†
Sanitary	Sewage treatment plant	4,500,000	Residual chlorine	0-0.5	--	Trace	**
			B O D	30	Avg-30, Max-45	Trace	**
			Total suspended solids	30	Avg-30, Max-100	***	**

Table 4.3 (continued)

Type of waste	Waste source	Quantity (gal/yr)	Chemical and pollutant content	Estimated avg concentration post-treatm't (ppm)	EPA effluent limitations (40CFR423) (ppm)	Estimated incr in avg water concentration§ (ppm)	North Carolina water qual stds
Chemical cleaning solutions	Preoperational flushing and hydrostatic testing	20,000,000	Hydrazine*	Not known	--	†††	†
			Total suspended solids	30	TSS:Avg-30, Max-100	***	**
			Copper	1.0	Avg-1.0, Max-1.0	Max-1.0	**
			Iron	1.0	Avg-1.0, Max-1.0	Max-1.0	**
			pH	6-9	6-9		**
Chemical cleaning solutions	Steam generator blowdown system electromagnetic filter flush	31,700	Total suspended solids	30	30	***	**
			Copper	1.0	Avg-1.0, Max-1.0	#	**
			Iron	1.0	Avg-1.0, Max-1.0	#	**
			pH	6-9	6-9		**

§Values shown assume minimum one unit blowdown (2.74×10^9 gal per year).

*No EPA effluent limitations.

**Same as 40CFR423.

***This quantity has no substantial effect on the total suspended solids in the cooling tower blowdown stream.

†No numerical criteria.

††There will be no perceptible change in pH.

†††Not possible to predict.

#No preceptible change in average concentration.

Source: ER-OL Table 3.6.2-2

4.2.7 Power Transmission System

The RFES-CP lists eight transmission lines as originally planned for Shearon Harris--six 230-kV lines and two 500-kV lines; however, the 500-kV lines have been cancelled. The 230-kV lines follow or closely parallel existing rights of way and have changed in only minor ways since the RFES-CP was issued.

4.3 Project-Related Environmental Description

4.3.1 Hydrologic Description

4.3.1.1 Surface Water

The surface water descriptions presented in Section 2.6 of the RFES-CP are still valid with the additions and discussions below. In addition, Section 5.3.3 of this report contains a discussion of the hydrologic effects of alterations in the floodplain as required by Executive Order 11988, Floodplain Management.

The 16.2-km^2 (4000-acre) impoundment on Buckhorn Creek will supply cooling tower makeup water for a maximum of two units. When only one unit is operating, water will be obtained from the impoundment drainage area alone. When the second unit goes into operation, the natural runoff into the impoundment will be augmented by pumping from the Cape Fear River.

The applicant has increased the flow record for hydrologic analyses to include data through water year 1978 for statistical summaries and through 1981 for flow simulation studies. The average discharge on Cape Fear River at Buckhorn Dam using this increased historical record is 88.6 cms (3125 cfs), and the 7-day 10-year low flow is 2.04 cms (72 cfs). These values are only slightly lower than the values presented in the RFES-CP based on a shorter record. The average discharge determined for Buckhorn Creek at its confluence with Cape Fear River was 2.5 cms (89 cfs); the 7-day 10-year low flow was determined to be about 0.03 cms (1.0 cfs). These values are also approximately the same as those in the RFES-CP. A summary of the synthesized monthly flows for Buckhorn Creek and tributaries for the period January 1922 to September 1981 is in the ER-OL.

The preconstruction 100-year and 500-year return period floods on Buckhorn Creek at the main dam were determined by the applicant to be 250.1 cms (8850 cfs) and 405.2 cms (14,300 cfs), respectively. The applicant determined these values from a Log Pearson III analysis of annual flood peaks for nearby Middle Creek at Clayton, North Carolina, that were adjusted to account for the difference in drainage area. The Middle Creek Basin is adjacent to the east of the Buckhorn Creek Basin and has a drainage area of 209 km^2 (80.7 mi^2).

The applicant did not determine the attenuation of the 100-year and 500-year floods as a result of storage behind the main dam. The staff believes that the attenuation will be significant because of the relatively narrow spillway. Also, for one-unit operation, the reservoir level will probably be below the spillway crest during the most likely period for severe storms.

Sedimentation in the main reservoir during the life of the plant was estimated by the applicant from a regression equation that related instantaneous sediment load measured at Buckhorn Creek near Corinth, North Carolina (the drainage area is 192.2 km^2 (74.2 mi^2)) to instantaneous stream flow rate at the station. The stream gaging station at Corinth is just downstream of the main dam. By simulating 40 years of daily stream flow values in Buckhorn Creek and assuming a trap efficiency of 100%, the applicant estimated a total sediment buildup of 5.7×10^5 m^3 (460 acre-ft) over the life of the plant. This amounts to only 0.7% of the reservoir capacity at normal operating level and will not adversely affect the operation of the plant.

There are no known domestic potable surface water users on Buckhorn Creek within the proposed reservoir area nor downstream of the main dam. The nearest source of potable surface water downstream of the site is Lillington, North Carolina, about 20 km (12 miles) downstream. The applicant has provided in the ER-OL a list of all municipal and industrial water users downstream of the site.

4.3.1.2 Groundwater

The groundwater descriptions presented in Section 2.6 of the RFES-CP are still valid with the additions and discussions below.

The overburden at the plant site consists of sandy loam to a depth of about 0.3 m (1 ft) and clay loam and layers of clay down to bedrock, about 4.6 m (15 ft) below ground surface. Because of the low permeability of this soil, there is very little recharge to the bedrock below. Six site wells located in the proximity of the diabase dikes yielded specific capacity values that ranged from 2.01 lpm/m (0.16 gpm/ft) to 7.31 lpm/m (0.59 gpm/ft). These specific capacity values correspond to transmissivity values of about 3.7 m^2 per day (40 ft^2 per day) to 12.1 m^2 per day (130 ft^2 per day).

In the ER-OL, the applicant provided piezometric-level maps based on water level measurements made in the winter of 1979-1980 and in June 1982. The piezometric maps show cones of depression that have developed as a result of groundwater pumping during plant construction. However, the general direction of groundwater flow is still to the southeast, toward White Oak Creek, as shown in the RFES-CP.

Seepage from the reservoir is expected to be very low because of the low permeability of the underlying soil. Any flow from the reservoir to the aquifer will probably be along the fracture systems of the intrusive dikes in the bedrock; however, the flow path will be narrow and confined to the fractured zone in the dikes. It is possible that measurable changes in the water level may occur a few hundred feet from the reservoir in the fracture system. The reservoir is not expected to produce any observable effects on groundwater levels outside the power plant site, however.

4.3.2 Water Use

Consumptive water use by the plant will consist primarily of forced evaporation from the natural draft cooling towers and natural evaporation from the main reservoir, which supplies makeup water to the cooling towers. Water to the reservoir will consist either entirely of natural runoff from the Buckhorn Creek drainage basin in the case of one-unit operation or from both Buckhorn Creek and the Cape Fear River for two-unit operation.

Groundwater will not be used at the site after construction is completed.

4.3.2.1 One-Unit Operation

For one-unit operation, the applicant performed a simulation study of reservoir operation over a 7-year period from 1973 to 1980. During this period, the average flow in Buckhorn Creek was nearly identical to the synthesized average stream flow in Buckhorn Creek for the period 1924 to 1981. For this simulation study, no makeup capability from the Cape Fear River was assumed. The forced evaporation amounts assumed for one-unit operation, which are based on a load factor of 75%, are tabulated in the ER-OL.

For the one-unit operation simulation, the reservoir level was found to fluctuate over a range of 1.7 m (5.5 ft) during the 7-year period. The minimum and maximum water levels were 216.3 ft msl and 220 ft msl, respectively, and the average reservoir level was 219.4 ft msl. The mean inflow and outflow rates over the period were 1.9 and 1.2 cms (67.6 and 43 cfs), respectively. The staff considers the assumption of a 75% load factor during the driest and probably hotest months to be nonconservative. However, increasing the load factor to 100% during the drought period would increase the maximum drawdown by less than 0.3 m (1 ft).

To determine the maximum expected drawdown over the life of the plant, the applicant used the 100-year drought flow for Buckhorn Creek. This was determined during the CP stage analysis using synthesized flows for Buckhorn Creek for the period 1924 to 1969. The minimum starting reservoir level at the beginning of the drought period was assumed to be the lowest level determined during the 7-year normal flow period (el 216.3 ft msl). The minimum water level determined from the 100-year drought analysis was el 211.0 ft msl. The reservoir did not release any flow over the spillway during the 1-year design drought simulation. The applicant also did a simulation study using historical measured flows during the period May 1980 to May 1982, which had flows in Buckhorn Creek between August 1980 and July 1981 that approached the monthly flows determined for the 100-year drought. As with the 100-year drought simulation, the applicant used el 216.3 ft msl as the starting elevation for the reservior. The minimum reservoir water level determined for this critical 2-year period was el 209.4 ft msl, which is lower than that determined for the 100-year drought simulation.

The staff does not accept the applicant's 100-year drought simulation study as indicative of the maximum drawdown to be expected from a drought that has a probability of occurrence of 0.01 per year. The reason is that the period of record used to provide data for the low flow frequency analysis was not updated to include the low flows occuring in 1980 and 1981. If these had been included, the staff concludes that the calculated 100-year drought flows would have been lower than those determined by the applicant, especially because simulation of those years (1980 and 1981) resulted in lower reservoir level. However, the staff does accept the applicant's analysis of the flow period May 1980 to May 1982 as being indicative of the drawdown resulting from a drought having an annual probability of no more than 0.02 (50-year recurrence interval). The staff accepts this because the lowest flows determined from a period of 58 years can be expected to have a 69% probability of containing a flow with at least a 50-year recurrence interval. In addition, the applicant assumed an artifically low reservoir level at the start of the analysis rather than the actual reservoir level, which, according to the applicant's 7-year simulation study, would have been normal pool level (el 220 ft msl).

The evaporation rates used by the applicant are termed "worst monthly" in the ER-OL. In comparing these evaporation rates with those used by the applicant for the simulation study of average conditions, the staff concludes that they approximate a load factor of about 81% under normal meteorological conditions. This is considered by the staff to be a reasonable value for evaporative losses during a severe drought period but not necessarily a conservative value.

The staff concludes that normal inflow from Buckhorn Creek is sufficient for one-unit operation without makeup from the Cape Fear River. The staff also concludes that without additional makeup from the Cape Fear River, fluctuation in water level of around 3.3 m (10 ft) may be expected to occur over a 40-year operating period. Additionally, the staff concludes that the reservoir level would not fall below el 205.3 ft msl (minimum operating level) except during the occurrence of an unusually severe drought (more severe than the drought of record) coupled with high power demand.

4.3.2.2 Two-Unit Operation

The applicant's analysis for two units under average conditions is similar to that performed for one-unit operation except that the evaporation from two units (at 75% load) is used to determine water loss, and makeup pumping from the Cape Fear River is used to augment Buckhorn Creek natural inflow.

The same 7-year period used for the one-unit study was also used for the two-unit study, although the Cape Fear River flows for that period were slightly above average. The effect of the above-average flows on the simulation is minor, however, because the makeup pumps withdraw only a small percentage of the water that is actually available. Pumping from the Cape Fear River was assumed to be limited, as specified in the applicant's NPDES permit, not to exceed 25% of the river flow nor reduce the river flow to below 17.04 cms (600 cfs), as measured at the Lillington gage. The maximum pumping capacity assumed was 8.5 cms (300 cfs). Although the applicant did not state assumptions regarding pumping schedule, the analyses indicate that pumping was assumed to occur whenever water was available and the reservoir was below normal operating level.

For the two-unit operation simulation, the reservoir level was found to fluctuate over a range of 1.28 m (4.2 ft) during the 7-year period. The minimum and maximum water levels were el 217.7 ft msl and el 221.9 ft msl, respectively. The mean inflow and outflow rates were 2.6 cms (90 cfs) and 1.6 cms (48 cfs), respectively. For two-unit operation simulation, the reservoir would have been releasing water from the spillway approximately 54% of the time.

To determine the maximum expected drawdown during a coincident 100-year drought in both Buckhorn Creek and the Cape Fear River, the applicant presented the analysis for four-unit operation at a 100% load factor, which is described in the RFES-CP. The lowest reservoir level determined from this analysis is el 205.7 ft msl, which is almost the lowest operating level of the reservoir (el 205.3 ft msl).

The applicant also performed a drawdown analysis for various historical drought periods, which were determined from a examination of the simulated monthly flow record. This latter analysis was updated in the ER-OL to include the low flow period of August 1980 to July 1981. The worst historical period considering both Buckhorn Creek and Cape Fear River flows was found to be February 1925 to January 1926. During this simulation, the reservoir fell to el 214.6 ft msl, under what the applicant refers to as "worst monthly" evaporation rates for four units.

These rates were examined by the staff and found to be somewhat different on a per-unit basis than those also termed "worst monthly" and used in the one-unit analysis. The average annual water use per unit is about the same. These rates are roughly equivalent (on a per-unit basis) to a 75% load factor under normal meteorological conditions for most of the year and a 93% load factor under normal meteorological conditions for the months of June, July, and August. However, the fact that the actual evaporative loss volumes used in the analysis are based on four-unit operation rather than two-unit operation makes the overall analysis conservative.

The staff does not accept the applicant's 100-year drought analysis as completely valid because the frequency analyses were not updated to include recent low flows in Buckhorn Creek. However, there is conservatism in assuming that the 100-year low flow in Buckhorn Creek is coincident with the 100-year low flow in the Cape Fear River. This is demonstrated by the fact that the drawdowns determined for historical low flow periods do not even approach the extreme drawdown resulting from the 100-year drought simulation. Also, the assumption of four-unit evaporation losses at a 100% load factor adds considerable conservatism to the applicant's analysis.

The staff concludes that the water supply including the Cape Fear River makeup system is adequate for two-unit operation at the site. There appears to be little likelihood that the plant will have to shut down or that the reservoir will experience severe drawdown as a result of droughts.

4.3.3 Water Quality

Data on the surface water quality of the Cape Fear River in the vicinity of Buckhorn Dam and on the Buckhorn and Whiteoak Streams were presented as part of the applicant's baseline water quality monitoring program for the period February 1972 to February 1983. This information was supplemented by the applicant with the water quality and water chemistry portion of the aquatic baseline program until 1977 and by the similar portion of the construction monitoring program beginning in 1978. This program is projected to continue throughout the construction period and into the operational period, terminating at the end of the first year after both units are in commercial operation (ER-OL Section 6.2.1). This plan is consistent with the staff recommendations.

The water quality and water chemistry studies collected data from 15 stations located on the Cape Fear River and on the streams of the Buckhorn/Whiteoak watershed in the vicinity of the plant and reservoir sites. Data from the stream stations are not available for the time period after December 1980, when the main reservoir dam was closed and reservoir filling began (water level in the main reservoir was at or above the proposed minimum operating level during 1982). Data from the stream stations during the construction period indicate noticeable effects on water quality parameters from the station construction and reservoir/site clearing activities.

Data on the water quality of the Cape Fear River are in Table 4.4. These data are from samples collected at Station D-2 (the river transect at the proposed river makeup pump station) during the period February 1978 through December 1980.

Different analytical techniques for water quality parameters were used for the period after that of the data presented in the RFES-CP. A rigorous statistical comparison of the data sets would not necessarily yield valid results about the significance of the observed differences. Relative differences based on the mean values and ranges of values for the two periods show higher total aluminum and total iron micronutrient concentrations in the river during the 1978-1980 period than the 1972-1973 period. As with the concentrations reported in the RFES-CP, the latest reported concentrations of iron and manganese in the river were frequently above the state water quality standard values for Class A-II waters. For other total metals analyses, the river data during the 1978 to 1980 period showed concentrations roughly comparable to those shown in the RFES-CP (note: not all metals were analyzed in the RFES-CP data). During the 1978 to 1980 period, the river concentrations for these metals were generally below the detection limit, although concentrations above those established by the North Carolina Water Quality Standards or published U.S. EPA criteria occurred at least once for copper, lead, mercury, nickel, and zinc. Macronutrient levels in the river in the proposed intake vicinity during the 1978 to 1980 period have remained high, although they are judged by the applicant to be typical of the waters of the region. In comparison to the levels shown in the RFES-CP, the total nitrogen levels are about the same, but total phosphorus levels show a decline. The nitrogen-to-phosphorus ratio increased over the RFES-CP ratio, but the river remained nitrogen limited (N:P $<$10:1). The total dissolved solids level in the river during the 1978 to 1980 period was higher than reported in the RFES-CP, but remained well below the criterion established by the state for such waters. Dissolved oxygen concentrations and pH values as measured in the river in the vicinity of the proposed intake location were on occasion below the lower acceptable limit established by state water quality standards. Dissolved oxygen concentrations in the river fell below the state standard of 4.0 mg/l during low flow periods (June to September) of 1978 to 1980, primarily in the subsurface samples. The pH values in the river during the 1978 to 1980 period fell below the North Carolina standard of 6.0 standard units, primarily during the months of January and February. These occurrences were attributed to natural causes and were not construction related.

4.3.4 Terrestrial and Aquatic Resources

4.3.4.1 Terrestrial Resources

The Shearon Harris site occupies approximately 4251 ha (10,800 acres) within the Buckhorn-Whiteoak Creek watershed. The present site vegetation is a mosaic of farmland and cutover forest stands in various stages of ecological succession (RFES-CP Section 2.8.1). The site vegetation is typical of the eastern portion of the Piedmont province. Estimates of vegetation types on the site indicated the following: 78% various forest types, 14% cutover forests, and 8% field (ER-OL Amendment 2).

Fields (old fields) on the site were representative of abandoned farmlands of the area; they have been invaded by various asters and other forbs as well as woody species such as pines, oaks, river birch, and black willow. Loblolly and

Table 4.4 Water quality characteristics of the Cape Fear River (February 1978-December 1980)

Characteristics	Mean	Min	Max
pH (standard units)	NA	5.1	8.5
Dissolved oxygen	NA	0.2	13.8
Total alkalinity	23	5	65
Chloride	9	3	23
Hardness	29	9	42
Ammonia	0.08	0.01	0.44
Kjeldahl nitrogen	0.51	0.07	1.30
Nitrate-N	0.58	<0.05	1.90
Total phosphate-P	0.24	<0.01	1.12
Total orthophosphate-P	0.17	0.005	0.71
Total organic carbon	7.9	2.6	20.3
Chemical oxygen demand	22	4	68
Total suspended solids	31	5	116
Total dissolved solids	137	66	235
Turbidity (NTU)	28	2	160
Silica	7.8	0.5	20
Sulfate	12	4	27
Calcium	6.6	3.1	12.4
Sodium	14.8	4.5	44.6
Aluminum	1.3	0.1	6.6
Magnesium	2.8	1.9	4.3
Manganese	0.11	0.02	0.44
Iron	1.57	0.27	7.33
Copper	0.04	<0.02	0.05
Chromium	<0.05	<0.05	<0.05
Lead	<0.05	<0.05	<0.05
Mercury	<0.001	<0.001	0.001
Nickel	<0.05	<0.05	<0.05
Selenium	0.01	<0.01	0.01
Zinc	<0.05	<0.05	0.12*
Arsenic	<0.01	<0.01	<0.01

Note: all values in mg/l unless otherwise noted.

*Sample thought to be contaminated during transport or analysis.

shortleaf pine are common in cutover forested area. Lowland hardwood forest areas are limited on site to areas along creeks entering the main reservoir. Dominant lowland forest species include American and slippery elm, green ash, American sycamore, and beech. Upland forested areas are dominated by pines, oaks, and hickories, all typical of second-growth forested stands in later stages of secondary succession in this region of North Carolina. A more detailed description of onsite woody vegetation is in RFES-CP Section 2.7.

With the filling of the auxiliary and main reservoirs used for cooling water makeup supply, approximately 1741 ha (4300 acres) of vegetation were inundated. Areas on the slopes adjacent to the reservoir have been seeded with fescue. An additional 409 ha (1000 acres) of vegetation has been cleared for power plant construction. Borrow areas and laydown areas were seeded with pines in 1981 and 1982.

4.3.4.2 Aquatic Resources

The aquatic resources potentially affected by construction and operation of the Shearon Harris plant were described in Section 2.8.2 of the RFES-CP. The descriptive information was based on studies conducted for CP&L in 1972-73 and on earlier baseline surveys conducted by the North Carolina Wildlife Resources Commission and the U.S. Bureau of Sport Fisheries and Wildlife in 1962 and 1969, respectively.

Additional data on the aquatic resources have been collected, since issuance of the RFES-CP in March 1974, as part of CP&L's baseline ecology studies (Aquatic Control, 1975, 1976), preconstruction monitoring programs (CP&L, 1978a, b), and construction phase monitoring programs (CP&L, 1979, 1981a). These data are summarized in ER-OL Sections 2.2.2, 2.2.3, and 4.1.4.

Data are available for the third year of the construction phase monitoring program (CP&L, 1982a), but have not been incorporated in the ER-OL descriptive information. The staff has considered these new data in updating the descriptions of project related aquatic resources. The staff has identified no sources other than the applicant for new information on aquatic resources specific to the Shearon Harris site. References to particular sampling stations are as shown on Figure 4.2. Details of the earlier monitoring programs are in ER-OL Section 6.1.1 and Appendix A of CP&L's annual environmental monitoring program report for Shearon Harris for 1979 (CP&L, 1981). The applicant's current program and plans for the operational nonradiological monitoring program are described in CP&L's 1982 nonradiological environmental monitoring program (CP&L, 1982b).

Three types of freshwater habitat are potentially affected by operation of the Shearon Harris plant: riverine habitat of the Cape Fear River, stream habitat of Buckhorn Creek below the main reservoir dam, and lake (reservoir) habitat. This section summarizes new information on aquatic biota from these three habitats with emphasis on identifying differences from the RFES-CP descriptions. It should be noted that available data were collected during preimpoundment conditions, and some sampling stations were being stressed by construction activities.

Cape Fear River - The riverine areas of specific interest with regard to plant operation are (1) the area of the pumping station that will provide makeup water

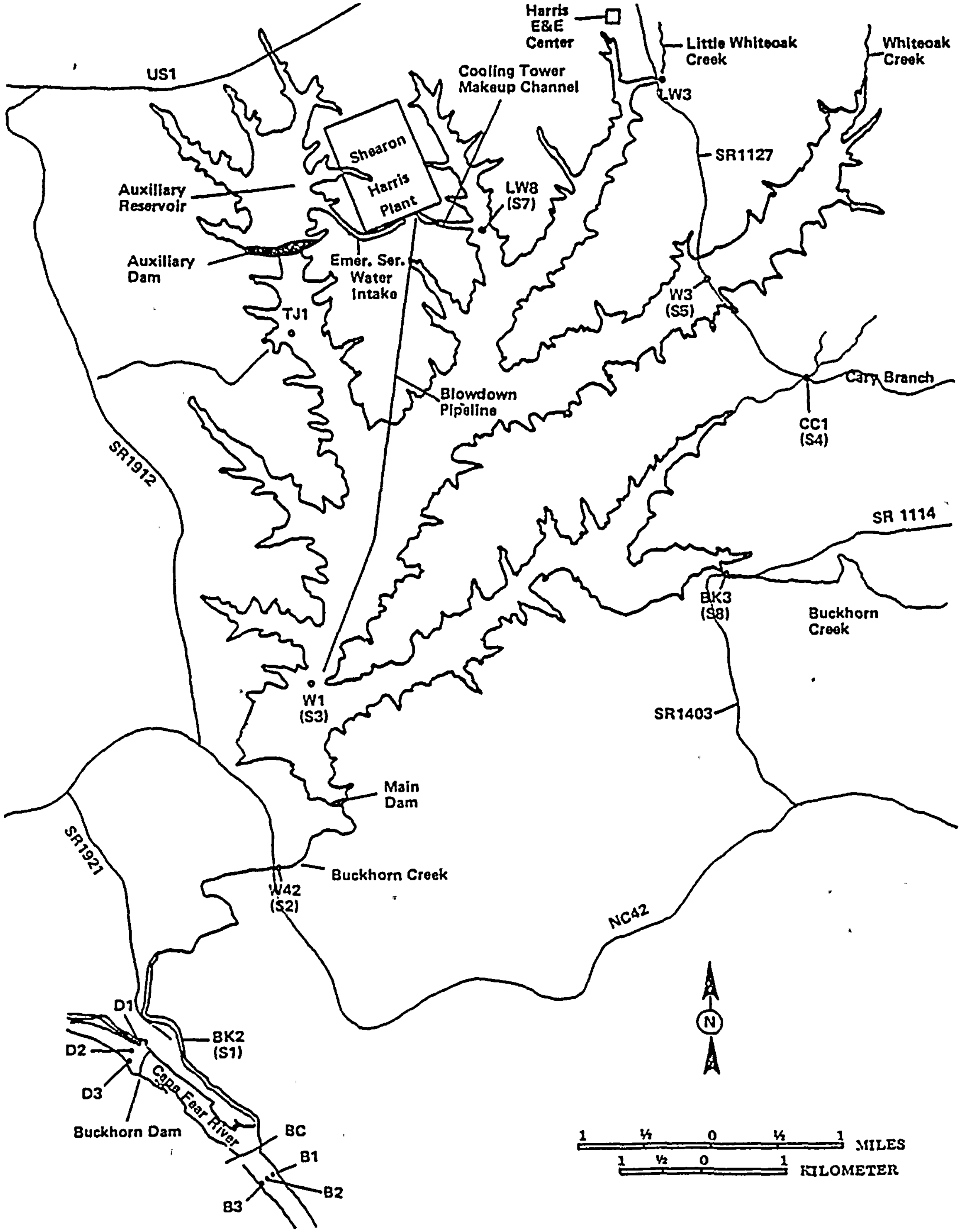

Figure 4.2 Site water quality and aquatic biota sampling stations

to the main reservoir during two-unit operation and (2) the area of the river below the mouth of Buckhorn Creek that will receive discharges from the main reservoir (through Buckhorn Creek).

In the area above Buckhorn Dam where the pumping station will be located (Transect D), the Cape Fear River is characterized as a wide, slow-moving, stretch that combines both lentic (pond-like) and lotic (stream-like) habitats.

The phytoplankton reflects the habitat diversity of this area with a combination of euplankton (true plankton such as *Melosira* and *Synedra*) and detached forms of benthic and epiphytic algae (genera such as *Navicula*, *Diploneis*, and *Achnathes* and *Gomphonema*).

The community of benthic macroinvertebrates in the area of the future pumping station is dominated by worms, midgeflies, and the Asiatic clam (*Corbicula*). The Asiatic clam is of particular interest to plant operation because it may be introduced to the makeup reservoir through pumping from the Cape Fear River (or by other mechanisms) and subsequently could require biocide control to prevent fouling of plant water systems.

The fish community above Buckhorn Dam potentially entrained or impinged at the future pumping station is dominated numerically by gizzard shad, pumpkinseed sunfish, bluegill, and largemouth bass. Carp, gizzard shad, black crappie, and largemouth bass have been major contributors to the dominance by weight.

In the area below the mouth of Buckhorn Creek (Transect B), the biotic communities are characteristic of the rocky substrate and swift, shallow water habitat. The phytoplanktonic community is dominated by diatoms; the benthic macroinvertebrates by snails, caddisflies, mayflies, midges, and worms; and the fish community, numerically, by gizzard shad, bluegill, longnose gar, shiners, darters, and several additional sunfishes. Gizzard shad, carp, and largemouth bass have been large contributors to dominance by weight in this area, as observed above Buckhorn Dam.

Buckhorn Creek - At sampling locations downstream of the Harris Dam site (W42 and BK2), the biota have been stressed by construction activities, primarily because of high turbidity of site runoff water. Dominant periplankton include several species of *Nitzschia* and other species typically found on silt-sand substrates. The applicant has noted that, with the closing of the main dam in December 1980, the water in Buckhorn Creek clarified considerably, and site runoff should no longer be a problem to the phytoplankton below the dam (CP&L, 1982a).

The benthic community in this area reflects the poor habitat characteristics of shifting sands and probable smothering by intermittent silt and sand deposition. Densities were low at stations W42 and BK2 in Buckhorn Creek. The dominant benthic organisms at W42 included worms, midges, and caddisflies, and at BK2, mayflies. The Asiatic clam (*Corbicula*) has been observed in Buckhorn Creek downstream of the main reservoir dam but had not been found in any stream samples above the dam through July 10, 1981 (CP&L, 1981b).

The fish community of Buckhorn Creek (Station BK2) is dominated numerically by shiners, chubs, killifish, and sunfish. Over the 3 years 1978 to 1980, the diversity of fish species at Buckhorn Creek sampling stations was highest of all the stream stations sampled. This finding reflects a diversity of stream habitat.

Harris Reservoir - Filling of the main reservoir began in November 1980 (ER-OL page 2.4.1-1), though some accumulation of water in the lower part of the basin is indicated to have taken place as early as July 1980 as a result of construction activity at the main dam (CP&L, 1982a). By September 30, 1982, the water level was at el 218.5 ft, and a normal operating level of el 220 ft was expected to be reached in March 1983 under average inflow conditions or by early 1985 under drought conditions (ER-OL Table 2.4.1-1).

As previously noted, all available data through 1980 are representative of pre-impoundment conditions. Stations W1, LW8, and TJ1 are located in areas that will be flooded when the reservoir reaches normal pool level; station BK3 is located at the boundary between normal pool and headwater regions; and CC1 is upstream of the boundary. Station W1 is in the immediate vicinity of the cooling tower blowdown discharge, and station LW8 is at the mouth of the cooling tower makeup channel.

With the filling of the reservoir, biota characteristic of small stream habitats will be replaced in dominance by biota that can adapt to reservoir conditions. Phytoplanktonic species will increase as the periphytic and epiphytic diatoms decline. Zooplankton adaptive to reservoir habitat will increase. Stream benthos such as caddisflies and stonflies will be replaced by worms, midges, and possibly *Corbicula*. The fish community is expected to change in numerical dominance from shiners, darters, and chubsuckers to gizzard shad (as a forage base), centrarchids (sunfishes, crappies, and largemouth bass), and catfishes.

As expected of a "young" reservoir, an attractive sport fishery should develop for species such as sunfishes, white crappie, largemouth bass, and catfish. As the reservoir ages, forage fish (gizzard shad) and rough fish (carp) are expected to increase in biomass dominance. Ichthyoplankton of the mature reservoir should be dominated by gizzard shad.

Potential fishery harvests from Harris Reservoir and segments of the Cape Fear River have been estimated by both the applicant and the staff.

The staff's estimate of the maximum annual harvest from the reservoir and an 80-km river segment is 46,600 kg per year (see Appendix I). Of this total, about 45,000 kg per year are projected for the reservoir and 1600 kg per year for the 80-km river segment immediately downstream from the reservoir. The reservoir harvest is made up of 18,600 kg per year from the sport fishery and 26,400 kg per year from the commercial fishery. The harvest from the river segment is all expected to come from sport fishing. No harvesting of shellfish is expected in the vicinity of the Shearon Harris site.

The applicant has estimated the sport fishing harvests to be 22,200 kg per year from the reservoir, 500 kg per year in an 80-km river segment, and 7000 kg per year in the next river segment (from 80 km to 176 km downstream of the site). The commercial fish and shellfish catch is judged by CP&L to be negligible from waters within 80 km of the station discharge (ER-OL Section 2.1.3). The applicant has included estimates of the commercial catch of fish and shellfish from the lower estuarine portion of the Cape Fear River--i.e. 604,900 kg in 1980 and 592,800 kg in 1981. Using the 1981 commercial catch estimate plus estimates for the reservoir and upper river (below the site), the applicant's overall estimate of potential harvest is 622,500 kg per year for the reservoir and Cape Fear River.

The staff's estimate for the potential fish harvest from the Shearon Harris reservoir is about twice the applicant's estimate. The difference is a result of the staff's assumption that a commercial fishery would be allowed to develop in the reservoir, whereas the applicant has not projected that a commercial fishery would develop. The staff's assumption results in a conservative estimate of the reservoir fish production that could potentially be consumed by humans.

Several species of submerged macrophytes may colonize the shallow water areas of the reservoir. These submerged plants contribute to the primary production and to the organic detrital pool of reservoirs; also, they provide support, shelter, and oxygen to other organisms.

Environmental factors that control the establishment of a particular species of an aquatic plant at a given location in the reservoir include water depth, current, wave action, temperature, transparency, substrate characteristics, and water chemistry (Boyd, 1971). Under some conditions, non-native undesirable species of aquatic plants, once-introduced, may become established and cause serious infestations; examples of the latter in southern reservoirs include Eurasian watermilfoil (<u>Myriophyllum spicatum</u>) and hydrilla (<u>Hydrilla verticillata</u>). Hydrilla has been found in lakes of Wake County, North Carolina and is likely to occur in the Shearon Harris reservoir, if it is not already present, according to personal communications between Dr. C. Billups, NRC, and Dr. M. Brinson, East Carolina State University, January 23, 1983, and between Dr. Billups and Mr. J. Stewart, Water Resources Research Institute of the University of North Carolina, Raleigh, March 17, 1983.

Hydrilla is thought to have been introduced to the United States from South America; it was first noticed in Florida around 1960 (Haller, 1977). Until 1965, it was incorrectly thought to be a species of Elodea, a common aquatic plant in the central and northern U.S., and was locally called Florida elodea. In 1965, it was properly identified as a member of the family Hydrocharitaceae (the Frog's-Bit Family), which is made up of about 16 genera and 80 species distributed in waters (fresh and marine) of the warmer parts of the world (Long and Lakela, 1971).

By 1977, hydrilla had spread from Florida into Georgia, Alabama, Mississippi, Louisiana, and Texas, and was also found in Iowa (ibid). It was first discovered in the TVA system in August 1982, according to a personal communication between Dr. Billups and Mr. David H. Webb, TVA Division of Water Resources, Muscle Shoals, Alabama, January 21, 1983. This discovery was made during routine biological sampling of Guntersville Reservoir, on the Tennessee River in northeastern Alabama, as part of the environmental monitoring program near the Bellefonte Nuclear Plant construction site (TVA, 1982).

With the appearance of hydrilla in North Carolina, the state has established an Interagency Council on Aquatic Weeds Control with constituted functions of public education and research and control of aquatic weeds, including hydrilla, according to the March 17, 1983 personal communication between Dr. Billups and Mr. J. Stewart. The Council's Research Committee is directing field studies in three Wake County Lakes (Lake Wheeler, Lake Anne, and Big Lake) according to personal communications between Dr. Billups and Mr. Stewart on March 17, 1983, and Dr. Billups and Mr. G. J. Davis, East Carolina University, March 15, 1983. The council is directing a systems study of the possible combined control of hydrilla via physical (water level drawn down), biological (introduction of herbivorous exotic fish such as the grass carp and Talapia), and chemical (herbicides) methods, according to a personal communication between Dr. Billups and Dr. Ronald Hodson, associate director of the University of North Carolina Sea Grant Program, Raleigh, March 18, 1983.

Observations in the three Wake County lakes during 1982 indicate that hydrilla growth is limited to water depths of 3 m (10 ft) and that the major controlling factor is turbidity (acting to limit light penetration). During October through December, fragmentation of hydrilla was noted to occur under windy conditions. Subsequently, there has been major winter die-back of hydrilla in the three lakes under study, according to the March 15, 1982 personal communication between Dr. Billups and Mr. Davis.

Extrapolation of the information from the three lakes under study to the Shearon Harris reservoirs would suggest that growth of hydrilla would also be limited to water depths of 3 m or less. Turbidity is expected to be a greater limiting factor on light penetration in the "younger" reservoirs associated with the Shearon Harris plant; thus, growth of hydrilla may be limited to even shallower depths during the early years of plant operation. Additional discussion of the control of hydrilla, if it should appear at the Shearon Harris site, is in Section 5.5.2.

4.3.5 Meteorology

The Shearon Harris site is in a zone of transition between the Coastal Plain and the Piedmont Plateau. Climatological data are available at the Raleigh-Durham Airport, which is about 32 km (20 miles) north-northeast of the site. Only minor variations in climate between these locations can be expected, and the Raleigh-Durham data may be considered as representative.

The climate in this region is fairly moderate as a result of the moderating influence of the mountains to the west and the ocean to the east. The mountains partially shield the region from eastward-moving cold air masses in winters; consequently, the mean January air temperature seldom drops below -6.7°C (20°F) on individual days. The last freeze occurs around the first week in April, and the first freeze in the fall occurs about the first of November. Summer weather is dominated largely by tropical air, which results in fairly high temperatures and humidities. Mean monthly air temperatures (at the Raleigh-Durham Airport) and extreme values are given in Table 4.5. The mean daily maximum temperature for July is 31°C (87.7°F). However, the mean daily minimum for the period is 19.5°C (67.2°F), demonstrating the typical diurnal temperature cycle in the summer--hot days and fairly cool nights. The monthly pattern of rainfall varies from year to year. Much of the rainfall in the summer is from thunderstorms, which may be accompanied by strong winds, intense rain, and hail. Approximately 62 thunderstorms per year are recorded at the

Table 4.5 Shearon Harris area normal temperatures, °F*

Month	Daily Maximum	Daily Minimum	Extreme Monthly Maximum	Extreme Monthly Minimum
January	51.0	30.0	79	-1
February	53.2	31.1	84	5
March	61.0	37.4	92	11
April	72.2	46.7	95	23
May	79.4	55.4	97	31
June	85.6	63.1	104	38
July	87.7	67.2	105	48
August	86.8	66.2	101	46
September	81.5	59.7	104	39
October	72.4	48.0	98	19
November	62.1	37.8	88	11
December	51.9	30.5	79	4

*To change °F to °C, subtract 32 and multiply by 5/9.

Sources: Data on climatological normal levels are from "Climatography of the U.S., No. 81, by State," Nat'l Climate Ctr., Asheville, NC, August 1973; data on extreme levels are from "Local Climatological Data, Raleigh, NC, 1980," NOAA, Ashville, NC.

Raleigh-Durham Airport (NUREG/CR-2252). The site is far enough inland that the intense weather of coastal storms is greatly reduced. Although snow and sleet usually occur each year, excessive amounts are rare; the greatest monthly snow total of 43.7 cm (17.2 in.) occurred in February 1979. Additional information on the maximums, minimums, and normals of monthly precipitation is presented in Table 4.6.

4.3.6 Endangered and Threatened Species

4.3.6.1 Terrestrial

Pursuant to Section 7 of the 1978 Amendments to the Endangered Species Act, the NRC asked (Ballard, 1982) the U.S. Fish and Wildlife Service (FWS) to provide a list of Federally recognized threatened and endangered species, both listed and proposed to be listed, and designated critical habitat that might be affected by the licensing of the station. The FWS response (Hickling, 1982) indicates that the site and transmission corridors are within the known distribution in North Carolina of two endangered species, the bald eagle (*Haliaeetus leucocephalus*) and the red-cockaded woodpecker (*Picoides borealis*). The red-cockaded woodpecker was observed at Shearon Harris only in October 1972 (ER-OL

Table 4.6 Shearon Harris area normal precipitation--maximum and minimum monthly, and maximum 24-hour

Month	Normal total, in.	Maximum monthly		Minimum monthly		Maximum 24-hr	
		in.	year	in.	year	in.	year
January	3.22	7.52	1954	1.05	1956	2.79	1954
February	3.32	5.75	1961	1.00	1968	3.22	1973
March	3.44	6.26	1975	1.48	1949	2.51	1952
April	3.07	6.10	1978	0.23	1976	4.04	1978
May	3.32	7.67	1974	0.92	1964	4.40	1957
June	3.67	9.38	1973	0.84	1977	3.44	1967
July	5.08	10.05	1945	0.80	1953	3.89	1952
August	4.93	10.49	1955	0.81	1950	5.20	1955
September	3.78	12.94	1945	0.57	1954	5.16	1944
October	2.81	7.53	1971	0.44	1963	4.10	1954
November	2.82	8.22	1948	0.61	1973	4.70	1963
December	3.08	6.38	1973	0.25	1965	3.18	1958

*To change in. to cm, multiply by 2.54.

Sources: Data on climatological normal levels are from "Climatography of the U.S., No. 81, by State," Nat'l Climate Ctr., Asheville, NC, August 1973; data on extreme levels are from "Local Climatological Data, Raleigh, NC, 1980," NOAA, Ashville, NC.

Amendment 1). Since that time the nearest sighting occurred 8 km (5 miles) from the station (McDuffie, 1982). Sightings of five bald eagles have occurred since 1972, four along the Cape Fear River southwest of the main reservoir and one in 1981 at the main reservoir (McDuffie, 1982) (ER-OL Amendment 1).

The staff does not believe that the Shearon Harris site provides adequate nesting or foraging habitat for the red-cockaded woodpecker. Although the site provides some pine forest of the density (tree basal area 4.6 to 7.4 m^2/acre, CP&L, 1979) reported to provide adequate habitat for woodpecker colonies (Hooper et al., 1980), the trees generally are not large enough for the construction of nest cavities. Most pine stands on the site also are quite dense and contain various hardwood species. Red-cockaded woodpeckers are most successful in maintaining populations in open pine stands with mature trees (Hooper et al., 1980; Scott et al., 1977). Because of the lack of mature pine trees on the site and the invasion of pine stands by various hardwoods, the staff concludes that red-cockaded woodpeckers will not establish reproducing colonies on the site. Station operation is not expected to adversely affect any individuals that may occasionally visit the site.

The bald eagle may be beneficially impacted by station operation. The presence of the main reservoir at the Shearon Harris site and two other large reservoirs within 50 km (31 miles) of the site (B. Everett Jordan Reservoir and Falls of the Neuse Reservoir) may tend to attract bald eagles. When stocked with fish, the main reservoir will provide additional foraging habitat for migrant individuals.

4.3.6.2 Aquatic

There is no aquatic species in the site vicinity that is included on Federal or state lists of endangered or threatened species. The Cape Fear shiner (Notropis mekistocholas) has been identified as being of "special concern" in proceedings of a North Carolina endangered species symposium (Cooper et al., 1977). More recently, the species has also received national attention through its designation as a species of special concern by the Endangered Species Committee of the American Fisheries Society (Deacon et al., 1979). The present threat to the species noted is destruction of habitat.

This species is endemic to several tributaries of the Haw, Deep, and Cape Fear Rivers, but only one specimen has been found in the site vicinity over the sampling period, 1972 to 1980. That specimen was found in the Cape Fear River where its habitat would not be affected by impoundment or plant operation.

4.3.7 Socioeconomic Characteristics

The socioeconomic descriptions of the area--including demography, land use, and community characteristics in general--are in Chapters 2, 4, 5, and 12 of the RFES-CP. The area around the plant remains rural, with a sparse population, and the majority of the land is wooded. The area is zoned so that about 0.8 ha (2 acres) is required for each residence, but because the land is not well suited for septic systems, some homes would require even larger lot sizes.

With regard to demography, the population projections included in the ER-OL (Section 2.1) based on 1980 census data are fairly consistent with the projections in the RFES-CP. There are three cities within 80 km (50 miles) of the plant with 1980 populations greater than 50,000: Raleigh, 149,771; Durham, 100,831; and Fayetteville, 59,507. Of these, Raleigh is the closest, being about 30 km (19 miles) from the plant.

Other recent data not included in the RFES-CP relate to estimated transient populations attracted by educational, industrial, and recreational facilities. Three major institutions of higher learning are within 40 km (25 miles) of the plant. Duke University has an enrollment of just under 10,000, while the University of North Carolina (UNC) at Chapel Hill and North Carolina State University (NCSU) in Raleigh each has an enrollment of about 21,000. The transient population at these colleges can increase greatly for athletic events, especially football games. The capacities of the Duke, UNC, and NCSU stadiums are 38,525, 53,611, and 56,200, respectively (ER-OL, Response to Question 310.12). The largest nonurban area of employment near the plant is Research Triangle Park, about 32 km (20 miles) north-northeast of the site. About 12,000 people work there. The town of Moncure, about 11 km (7 miles) west-southwest, has industries with about 1000 employees, and Apex, 12 km (8 miles) northeast of the plant, has close to twice that number. The Harris Energy and Environmental Center, a little more than 3 km (2.1 miles) east-northeast of the plant, employs about 125 people and may have up to 200 more for training sessions.

Other recreational attractions in the area include the annual State Fair in Raleigh, which drew over 110,000 people in 1 day during its 1981 run, and several parks. The Harris Reservoir on CP&L property will provide boating and fishing opportunities; the B. Everett Jordan Reservoir of the Army Corps of Engineers has greater facilities and is expected to attract more visitors (estimated to be 2.8 million annually by the mid 1980s) than the Harris Reservoir. The Jordan Reservoir is about 8 km (5 miles) north-northwest of the plant. No other significant changes have occurred since the RFES-CP was issued.

4.3.8 Historic and Archeological Sites

Sections 2.4 and 12.5 of the RFES-CP discuss cultural resources. At the time the RFES-CP was issued, there were no listings in the National Register of Historic Places (U.S. Department of the Interior, 1976) within 8 km (5 miles) of the site. The staff has reviewed the Register and notes that there are no listings within 16 km (10 miles) of the site.

Archeological surveys of the dam site, intake pumping station, makeup water pipeline route, and the cooling lake reservoir were conducted by the Research Laboratories of Anthropology of the University of North Carolina (Ward, 1977, 1978, 1979; and Tise, 1978). The results of these surveys indicated that there were no sites that were included or that met minimal criteria for nomination to the Register within these areas.

The Burke, Ragan, and Dupree houses referred to in the RFES-CP have the following status: the Burke house was sold and moved to Fuquay-Varina; the Dupree house was dismantled and moved to Durham County; and the Ragan house remains intact, is inhabited, and is not on CP&L property (ER-OL, Response to Question 40).

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5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

This section evaluates changes in environmental impacts that have developed since the RFES-CP was issued. Section 5.2 describes a newly developed fish and wildlife management plan. Section 5.3.1 discusses changes in the volumes and concentrations of wastes in plant effluents as a result of finalization of plant design and updated environmental data. Section 5.3.2 evaluates the impact of the cancellation of Units 3 and 4 on water use, and Section 5.3.3 addresses effects on Buckhorn Creek floodplains. Section 5.5 addresses terrestrial impacts of operation that were not evaluated at the CP stage, including those resulting from the change from four to two units. Section 5.8 provides socio-economic impacts.

Information in Section 5.9 on radiological impacts has been revised to reflect knowledge gained since the RFES-CP was issued. The material on plant accidents now contains information that has been revised and updated, including actual experience with nuclear power plant accidents beyond design-basis accidents and the lessons learned from the accident at Three Mile Island Unit 2. Information on the environmental effects of the uranium fuel cycle, decommissioning, and operational monitoring programs also is provided.

5.2 Land Use Impacts

Impacts to land use from plant operation are essentially the same as those described in Section 5.1.1 of the RFES-CP. The applicant, in consultation with the North Carolina Wildlife Resources Commission, has developed a fish and wildlife management plan for approximately 1619 ha (4000 acres) of land on the site (McDuffie, 1982b). The plan was developed as a mitigative measure to compensate for wildlife losses in forested land inundated by the makeup water reservoir. In general, the plan is intended to benefit various nongame and game wildlife species and not any particular target species. An exception, however, is the management of certain forested areas for use by wild turkey, which is intended to benefit state efforts in re-establishing a wild turkey population in this portion of North Carolina. As part of the management plan, the applicant has committed to working with the North Carolina Wildlife Resources Commission in specifying no-hunting areas on CP&L property outside the site exclusion boundary.

The staff has reviewed the fish and wildlife management plan and concludes that its implementation will beneficially impact wildlife of the site and site vicinity. The degree of benefit will depend upon the size of areas managed and the type of habitat manipulations, such as tree clearing and planting of food patches.

5.3 Water-Use and Hydrologic Impacts

5.3.1 Water Quality

5.3.1.1 General

Water quality impacts in the main reservoir, downstream Buckhorn Creek, and the Cape Fear River may be caused by chemical and other wastes in the effluent discharged during preoperational cleaning and during operation. The potential for impacts to receiving water quality were assessed during the construction permit review (RFES-CP Sections 5.2 and 5.4 and the NRC Atomic Safety and Licensing Board Initial Decision of January 23, 1978). There have been changes in the volumes and concentrations of wastes in plant effluents as a result of finalization of plant design and updated environmental data (see Sections 4.2.3, 4.2.6, and 4.3.2 of this report). The resulting changes in potential water quality impacts are examined below.

5.3.1.2 Surface Water

5.3.1.2.1 Thermal Impacts of Blowdown Discharge on the Reservoir (NPDES Outfall Serial No. 001)

The applicant has made several modifications to the design of the blowdown-discharge system at since the RFES-CP was issued in 1974. The major modifications include: (1) an increase of blowdown discharge rate from 15 to 46 cfs, (2) use of a single-port discharge pipe instead of two multiple-port diffusers, and (3) relocation of the discharge point to a deeper area of the reservoir about 2.4 km (1.5 miles) downstream from the original discharge location (CP&L, 1982).

As a result of redesigning the blowdown-discharge system, the applicant has reevaluated the thermal-plume predictions to ensure that the system will produce reservoir temperatures in compliance with the water-temperature criteria specified in the NPDES permit. The temperature requirements approved by the North Carolina Environmental Management Commission are included in the NPDES permit, which is reproduced in Appendix G of this report.

In predicting reservoir surface temperatures, the applicant employed a cooling pond model (Patterson et al., 1971) that does not consider dilution and diffusion between the point of discharge and the reservoir surface and assumes that all the excess heat would be dissipated through surface advection and evaporation. The predicted temperature distributions indicate that uniform circular isotherms would prevail at the surface near the point of discharge and that the highest average summer and winter temperatures would be about 33°C (91°F) and 22°C (71°F), respectively. The mixing zone, which is the area of the reservoir in which the temperature would legally be allowed to rise above 32°C (90°F) and/or 3°C (5°F) above the ambient reservoir temperature, would be about 48.5 ha (120 acres) in winter and 8 ha (20 acres) in summer. These areas are smaller than the mixing zone of 80 ha (200 acres) prescribed in the NPDES permit.

The staff has independently calculated the blowdown-discharge plumes for the adverse winter and summer conditions described by the applicant and for both normal (220 ft msl) and extreme low (204.4 ft msl) water levels in the reservoir.

The staff used the method developed by Shirazi and Davis (1972) for predicting the thermal plume for a submerged single jet discharging horizontally into a large, nonstratified, and stagnant body of water. The assumed ambient conditions in the reservoir give conservative results because stratification and natural currents would provide additional mixing of the effluent before it reaches the water surface.

The staff's thermal plume analysis indicates that, for the extreme low water level, the maximum temperatures at the reservoir surface would be about 31°C (87°F) under adverse summer conditions and about 10°C (50°F) under adverse winter conditions. Both these values are less than those predicted by the applicant for the same conditions. Furthermore, the staff's analysis indicates that the reservoir surface area affected by the heated blowdown discharge (i.e., the area that would be above 32°C (90°F) and/or 3°C (5°F) above the ambient reservoir temperature as a result of the blowdown) would be less than 0.3 ha (0.1 acre) at all times. Therefore, based on this analysis, the staff concludes that the applicant's reservoir temperature predictions are reasonable and conservative and that the blowdown-discharge characteristics at Shearon Harris will comply with state water quality standards for temperature.

5.3.1.2.2 Chemical Impacts of Blowdown Discharge on the Reservoir (NPDES Outfall Serial Nos. 001, 003, and 004)

The preoperational cleaning/flushing and hydrostatic testing waste waters are planned as one-time treatments of the plant cooling water systems. The waste characteristics of these waters are shown in Table 4.3, and, for pollutants other than hydrazine, the staff judges they will not cause water quality in the main reservoir to exceed the assigned Class C water quality criteria or create conditions harmful to the aquatic biota expected to reside in the reservoir. Hydrazine addition to these cleaning and testing solutions for oxygen scavenging should not result in adverse effects in receiving waters if the discharge levels are reasonably controlled because (1) these wastes will be sampled, treated as needed, and discharged at a controlled rate for this one time use, and (2) hydrazine is only moderately toxic to warm water organisms (on the order of 5 mg/l or greater for a 24-hr exposures) (WASH-1249). The applicant does not expect to add acidic or caustic substances to these preoperational solutions (ER-OL Section 3.6).

The revised estimates of the amounts and concentrations of wastes to be discharged to the main reservoir by the Shearon Harris chemical waste treatment system during operation are in Table 4.3. These values are for the most part greater than those given in the RFES-CP. These wastes are released into the cooling tower blowdown line after treatment. Treated waste discharges are intermittent and are released at a rate that is small compared to the cooling tower blowdown flow rate. The resultant incremental concentrations in the plant effluent to the main reservoir will, for the most part, be low. For the higher calculated discharge concentrations of total dissolved solids and sulfate during pumping from the settling basin (Section 4.2.6.3), water quality criteria levels identified by EPA (EPA, 1976) for protection of drinking water aesthetics would not be violated at the plant discharge. Dispersion of the plant discharge in the reservoir will reduce the concentration of these pollutants. These characteristics, in combination with the low concentration factor of the cooling systems, are not expected to result in adverse water quality in the main reservoir or violations of the assigned Class C water quality standards. For those wastes that will be treated before release to meet an established EPA effluent guideline or state water quality standard, the applicant has designed a physical/chemical treatment scheme that is expected to produce effluents in compliance with the applicable requirements before release to the blowdown line. Provisions have been made for holdup and sampling of these effluents before release to the blowdown line to ensure compliance with applicable limitations. The staff believes that the effluent concentrations will be within the limits set by the NPDES permit.

The use of chlorine for biofouling control will result in the discharge of chlorine-containing compounds in the cooling tower blowdown (Section 4.2.6.2). The applicant plans to control the addition of chlorine to the cooling systems or alter the blowdown from the unit being chlorinated so that the total residual chlorine (TRC, the sum of the free available chlorine and the combined available chlorine) concentration in the blowdown will not exceed 0.2 mg/l (Response to staff question E291.11). The applicant estimates that this concentration will be reduced to about 0.01 mg/l (a dilution factor of 20) by the time the effluent waters reach the edge of a circular surface area encompassing 2 ha (5 acres). The state-issued NPDES permit currently limits only the free available chlorine (FAC) concentration in the cooling tower blowdown of each unit, as measured in the cooling tower basin. The stated limit (0.2 mg/l FAC average concentration; 0.5 mg/l FAC maximum concentration) allows higher levels of residual chlorine in the blowdown than those expected by the applicant (the applicant's planned maximum concentration is the same as that recommended by the staff in the RFES-CP to avoid adverse impacts on receiving water quality). Available data from operating power plants indicates that residual chlorine in cooling tower blowdown is nearly exclusively comprised of combined available chlorine. The staff believes that the NPDES permit concentration level will be met and that FAC concentrations will likely be below detectable limits in the blowdown from the unit being chlorinated (1) because chlorine biocide addition will be controlled by measurement of residual concentration in the condenser outlet waterbox; (2) the chlorinated cooling water will be exposed to air, sunlight, and biological growths in the cooling towers; and (3) the chlorinated water will be sampled in the cooling tower basin prior to discharge (with provision to terminate blowdown from the unit being chlorinated until the residual chlorine concentration falls within the NPDES limit).

The state-issued NPDES permit prohibits the discharge of detectable residual chlorine from either unit for more than 2 hours in any 1 day, unless a demonstration is made by the permitee that the units cannot operate within the restriction. The applicant's current plans for the chlorination of the condenser circulating cooling water system are for intermittent 30-minute biocide additions for a total of 1 hour per day per unit. The releases from this system (blowdown and drift) are much less than the circulating water flow rate, and the system volume is large compared to the blowdown volume during the application period. A finite time beyond the termination of biocide addition is required to completely change the contents of the system. Thus, assuming complete mixing of a substance added to the system, its presence, although at a reduced concentration, could be expected in the blowdown and drift for periods beyond the time of its addition to the system. Because the practicable field detection limit for residual chlorine is about 0.1 mg/l and the nature of chlorine biocide is nonconservative (i.e., reactive), and assuming the period of addition and expected concentration are as discussed above, the staff believes that it is reasonable to expect that the plant will be able to comply with this discharge time limitation. Chlorination of the service water system is expected to be at least 2 hours a day and possibly continuous, although at a low level (i.e., less than 0.2 mg/l) (Response to staff question E291.10). Chlorination of this system, however, is not expected to be detectable in the unit blowdown because of this low concentration, because the flow rate of the system is small (<5%) compared to the circulating water flow rate, and because the system discharge is mixed with the circulating water before its passage through the cooling tower and subsequent discharge. Based on these factors, the staff does not expect the chlorination of the service water system to conflict with the NPDES limitation on duration of chlorine discharge from the Shearon Harris units.

The applicant currently plans to chlorinate the condenser circulating waters of only one unit at a time. This operating scheme is consistent with the current restrictions in the NPDES permit. However, the recently promulgated EPA final effluent limitations guidelines, pretreatment standards, and new source performance standards for the steam electric power generating point source category (EPA, 1982) do not restrict simultaneous chlorination of individual units at multiple-unit power plants. Employment of the nonsimultaneous chlorination scheme provides residual chlorine reduction in common discharges by dilution with the unchlorinated discharge water and by reaction with chlorine-demanding substances in the unchlorinated waters. Because residual chlorine is toxic to freshwater life and, therefore, is controlled by North Carolina under the Class C water standards (North Carolina, 1979), these reduction mechanisms are important in the attainment of water quality sufficient to meet applicable standards within the mixing zone and in minimizing the volume of water in the vicinity of the discharge that could contain residual chlorine concentrations deleterious to aquatic life.

The NPDES permit also contains a requirement for total residual chlorine discharges in cooling tower blowdown to not exceed 0.14 mg/l (the concentration contained in the published draft EPA regulations) after November 29, 1985 unless the final EPA regulations (EPA, 1982) contain a different provision. The final EPA regulations withdrew the proposed TRC limitation, rendering this requirement moot. (The staff has based its assessment on the applicant's proposed discharge concentration, which is higher than proposed future TRC restriction in the NPDES permit. Implementation of this latter limitation would, if anything, reduce the staff's assessment of environmental impact from this source.)

The NPDES permit establishes an 80-surface-ha (200-surface-acre) mixing zone for chlorine. Outside of this zone, the cooling tower blowdown discharge shall not cause a violation of the Class C water quality standards. According to these standards, deleterious substances are not to be present in amounts that would render the waters injurious to fish and wildlife or affect its potability. A water quality standard for residual chlorine (TRC) for the protection of freshwater organisms, other than salmonid fish, has been established by EPA (1976), under the provisions of the Clean Water Act, at 0.01 mg/l. This level was established based on a review of toxicity studies conducted by EPA researchers and others, and is applicable to a continuous exposure to residual chlorine. Other continuous exposure safe concentrations or chronic toxicity thresholds have been set by Brungs (1973) and Mattice and Zittel (1976) for freshwater organisms. The limitation recommended by these researchers is 0.003 mg/l for both studies. Exposure to residual chlorine at or below this level would not be expected to produce mortality in aquatic organisms. These criteria considered cold water (salmonid) as well as warm water organisms, however, and may be unduly restrictive for the organisms in the main reservoir. For comparison, the EPA limitation for salmonid fish is 0.002 mg/l. Other studies by Dickson et al. (1974) and Brooks and Seegert (1978) examined the effects of intermittent exposures of warm water fishes to residual chlorine. These studies concluded that exposures to not greater than 0.2 mg/l TRC intermittently for a total time of up to 2 hours per day would "probably be adequate to protect more resistant warm water fish such as the bluegill" (Dickson et al., 1974); and that intermittent exposures to combined available chlorine totaling 160 minutes would not produce mortality to the most sensitive of 10 warm water fishes tested at concentrations at or below 0.21 mg/l, respectively. The most sensitive species in the latter study was the emerald shiner. The other species tested were the common shiner, spotfin shiner, bluegill, carp, white sucker, channel catfish, white bass, sauger, and freshwater drum.

The most restrictive chlorine water quality criterion for a fresh warm water fishery is seen to be that presented in the EPA "Red Book" (EPA, 1976), 0.01 mg/l. As stated above, the applicant estimates that the proposed Shearon Harris operation will result in degradation of residual chlorine concentration to 0.01 mg/l in an area well within the 80-ha (200-acre) mixing zone established by the state. Based on the results of the staff's thermal model of the Shearon Harris discharge, and on the applicant's plan to chlorinate only one unit at a time, the staff believes that the applicant's estimate is reasonable.

Chlorination of the plant cooling waters is likely to produce chlorinated compounds in the cooling tower blowdown, in addition to the active chlorine residual, as discussed above. The 1974 EPA National Organic Reconnaissance Survey (NORS) showed that chlorination of natural surface waters supplying drinking water for 80 cities around the country resulted in the formation of chlorinated organic compounds, primarily trihalomethanes (THM). Of these, the predominant compound was chloroform, but including bromodichloromethane, dibromochloromethane, and bromoform. In contrast, studies of 14 different water utilities and their raw water supplies by Arguello et al. (1979) indicate that trihalomethanes are found at only low concentrations (0-15 μg/l), if at all, in nonchlorinated natural surface waters. A study by Young and Singer (1979) on two North Carolina water systems showed similar results for raw waters (typically less than 5 μg/l). This study and the NORS indicate that total organic carbon in the raw water at the time of chlorination and the chlorine dosage are significant parameters governing trihalomethane formation. The study indicated finished water (water ready to be delivered to the consumer) chloroform concentrations of 0.129 mg/l and 0.184 mg/l after chlorination of raw waters with nonvolatile total organic carbon concentrations of 5.1 mg/l and 6.8 mg/l, respectively. The chlorine doses were 5.8 mg/l and 6.5 mg/l FAC, respectively. It should be noted that treatment of these waters after the chlorine addition is likely to have removed THM precursors, holding the finished water THM levels down. For example, Singer et al. (1981), in a study of THM formation during water treatment at nine large cities in North Carolina, found the THM concentrations in chlorinated, but otherwise untreated, raw water after 7 days to be between 3.8 and 5.5 times larger than the THM concentrations in the same raw waters immediately after completion of normal drinking water treatment (which also included chlorination). The total organic carbon concentration in the raw waters ranged from 0.7 mg/l to 7.7 mg/l. Chlorine doses for the finished waters averaged 3.4 mg/l FAC for prechlorination and 2.01 mg/l FAC for postchlorination. For terminal raw water THM determinations, the residual was much higher, ranging between 15 and 20 mg/l. The pH has also been shown in a study by Stevens et al. (1976) to affect chloroform formation in chlorinated natural waters. The results indicate that the rate of formation of chloroform (the predominant THM found) increases with increasing pH.

Although the applied chlorine doses in these studies are much higher than those expected to be employed in the Shearon Harris cooling systems, the results are useful in that they indicate (1) that the observed levels of THM in chlorinated North Carolina surface waters tend to be higher than THM values from similarly treated waters reported in the NORS, and (2) that chlorination of these raw waters without additional treatment (without THM precursor removal) may result in higher THM concentrations than would be expected for finished water (the THM formation reactions continue beyond the chlorine contact period). Another of the study conclusions is that the presence of free chlorine residuals in concentrations greater than 0.4 mg/l enhances the formation of trihalomethanes. Staff experience indicates that typical target FAC concentrations for biofouling control in plant heat exchangers are 0.5 to 1.0 mg/l for the duration of the application period. Thus, this practice would be indicated by the previously cited water utility studies to be conducive to THM formation in the cooling water. Total organic carbon (TOC) concentrations in the Cape Fear River from 1978 to 1980 have ranged from 2.6 mg/l to 20.3 mg/l, averaging 7.9 mg/l, which encompasses the range of TOC values in the water utility studies. Characteristics of the power plant system that are not present in the water utility systems and that may serve to reduce the THM-forming potential of the cooling water are the short chlorine contact time and the possible THM removal by air stripping (volatilization loss of chloroform) during passage through the plant cooling tower, as observed by Jolley et al. (1981). In that study, for chloroform the loss was about 84%.

Additional preliminary information is available from an NRC-sponsored study (Bean, Mann, and Neitzel, 1980 and 1981; Bean, 1982) in the form of measures of trihalomethane concentrations in intake and discharge samples collected from operating nuclear power plants. The plants sampled have closed-cycle cooling systems, one with a natural draft cooling tower and two with mechanical draft cooling towers. The cooling water systems of the plants were chlorinated to 1 to 5 mg/l total residual chlorine. Dechlorination was not practiced at any of the plants, although blowdown was held up in one mechanical draft cooling tower-equipped plant until the residual chlorine concentration fell below 0.05 mg/l. This resulted in an extensive period of aeration (8 to 12 hours was typical) at this plant, while the natural draft cooling tower plant had a residence time for chlorinated waters of 30 minutes. The results are shown in Table 5.1. The discharge samples show chloroform and total trihalomethane concentrations on the order of one part per billion (1 μg/l) or less. Where measured, intake total organic carbon concentration was 12 to 15 mg/l, which is within the range of values observed in the Cape Fear River at the proposed location for the Shearon Harris intake.

The EPA has published water quality criteria (EPA, 1980a, b, c) chloroform and halomethanes that will, "when not exceeded, reasonably protect human health and aquatic life" (EPA, 1980a). The chloroform LC50 for Daphnia magna is 28,900 μg/l, while that for Lepomis machrochirus (Bluegill) is 100,000 μg/l. For halomethanes, the LC50 for bluegill is stated to be 11,000 μg/l, based on brominated compounds. A no-adverse-effect threshold test was conducted for Daphnia magna, the corresponding chloroform concentration, and it was found to be between 1800 μg/l and 3600 μg/l. With regard to human health effects, based

Table 5.1 Trihalomethane concentrations at operating nuclear power plants (preliminary information)*

	Intake			Discharge		
	Plant A**	Plant B†	Plant C†	Plant A	Plant B	Plant C
Chloroform	††	0.2	0.30-0.52	0.38-0.68	0.7	0.61-1.09
Bromodichlor-omethane	††	††	0.16	††	0.7	0.16
Dibromochlor-omethane	††	††	††	††	0.7-0.8	††
Bromoform	††	††	††	††	0.2-0.3	††

*Values in μg/l; from Singer, 1981; Jolley, 1978; and Bean, 1981.
**Plant with mechanical draft cooling towers.
†Plant with natural draft cooling tower.
††Not detected.

only on consumption of aquatic organisms (appropriate for the Shearon Harris case because the main reservoir is not classified for or used as a potable water supply), the level that has been identified to result in no more than a 10^{-6} risk of incremental cancer is 15.7 μg/l chloroform or other halomethane.

The likely concentration of trihalomethanes in the Shearon Harris discharge and equilibrium concentration in the main reservoir cannot be predicted at this time. The results to date of the NRC research program on trihalomethane concentrations in the discharges of operating closed-cycle nuclear power plants indicate concentrations about an order of magnitude lower than the most restrictive of the criteria given above. The studies of North Carolina drinking water systems could be interpreted to indicate that Shearon Harris discharge concentrations could be somewhat higher than those at power plants in other parts of the country. The staff believes that these levels will not be so much greater than those found to date that the EPA water quality criteria would be exceeded, even immediately beyond the plant discharge pipe.

5.3.1.2.3 Sanitary Wastes Impacts on the Reservoir (NPDES Outfall Serial No. 002)

The Shearon Harris sanitary waste system utilizes a readily available, conventional, secondary level of treatment. The system has a large capacity for a facility such as Shearon Harris because the system is sufficient to treat the wastes (at 132 l per person per day (35 gal per person per day)) of more than 700 persons. The effluent limitations set by the NPDES permit are readily attainable by this treatment technology, if the system is properly controlled by a qualified operator. Small sewage treatment plants operated in the extended aeration mode often suffer periodic upsets as a result of hydraulic overloading and sudden increases in influent organic loading. These upsets would lead to degraded effluent quality. However, because of the large capacity and flexible waste handling capabilities of the Shearon Harris system (flow equilibrium tank with automatic bypass; two aeration chambers with isolation capability) as described in the ER-OL and because of a modification to the extended aeration treatment scheme (the addition of a final clarifier), this system would not be expected to suffer upset.

The discharge of the Shearon Harris sanitary waste treatment facility will be less than 1% of the plant blowdown stream to which it is released. The biochemical oxygen demand and suspended solids contribution of the sewage treatment system to the plant discharge will be small. Adverse effects in the vicinity of the discharge pipe from this source will be undiscernable. The sewage treatment system will not remove nutrients (nitrogen and phosphorus) and will be a contributor to the eutrophication in the main reservoir. This contribution is judged to be small by the staff because the nutrient loading by this source is very small compared to that of the streams of the Buckhorn/Whiteoak watershed feeding the reservoir.

5.3.2 Water Use

5.3.2.1 Surface Water

In Section 5.2.4 of the RFES-CP, the staff concluded that the applicant's anticipated average annual consumptive water use of 2.1 cms (75 cfs), for four-unit operation, would not adversely affect other downstream water users. Because two of the four units have now been cancelled, the amount of water consumptively used will be less than the 2.1 cms (75 cfs) estimated in the RFES-CP.

As described in Section 4.3.1.1, during the time before completion of Unit 2, when only Unit 1 is operating, the only source of makeup water for the cooling towers will be the Buckhorn Creek impoundment. When the second unit becomes operational, the natural runoff into the impoundment will be augmented by pumping from the Cape Fear River. The applicant has determined that the natural runoff into the Buckhorn impoundment will average about 1.9 cms (67.6 cfs). Of this amount, about 0.7 cm (24.6 cfs) will be consumptively used (includes seepage, and natural and forced evaporation) by the plant during one-unit operation at a 75% load factor under normal meteorological conditions. The remainder--1.2 cms (43 cfs)--will pass through the spillway of the main dam that forms the Buckhorn Creek impoundment.

For two-unit operation, approximately 1.2 cms (42 cfs) will be consumptively used at a 75% load factor under normal meteorological conditions. Although the natural inflow into the Buckhorn Creek impoundment is greater than this amount, makeup water from the Cape Fear River will be required during low flow periods. The applicant has determined that an average of about 0.6 cm (22.4 cfs) will be required from the Cape Fear River. Because the natural inflow into the Buckhorn Creek impoundment is about 1.9 cms (67.6 cfs), the total inflow during two-unit operation will be about 2.6 cms (90 cfs). Of this total amount, about 1.2 cms (42 cfs) will be consumptively used. The remainder--1.4 cms (48 cfs)--will pass through the spillway of the main dam. Although the flow in Buckhorn Creek will be reduced downstream of the main dam, there are no known users of Buckhorn Creek water who will be affected by this reduction.

As stated in Section 4.3.1.1, the average flow in the Cape Fear River is about 88.6 cms (3125 cfs). Of this amount, less than 1% (0.6 cm (22.4 cfs)) will be used by the plant. Not all of the flow in the Cape Fear River is available for use by the Shearon Harris plant. During periods of low flow, withdrawal of makeup water will be restricted, as stated in the applicant's NPDES permit, so that net withdrawals will not exceed 25% of the river flow nor reduce the flow below 17 cms (600 cfs), as measured at the Lillington gage. With this restriction, the flow in the Cape Fear River available for use by the plant is about 23.1 cms (815 cfs) on an annual basis. The plant will consumptively use about 3% of this available flow.

As stated above, less than 1% of the average flow in the Cape Fear River will be used by the plant. Thus the staff's conclusion in the RFES-CP that the consumptive water use by a four-unit plant would not adversely affect other downstream water users is valid for a two-unit plant.

5.3.2.2 Groundwater

The groundwater discussion in Section 5.2.6 of the RFES-CP is still valid. Operation of the Shearon Harris plant will be sustained by water from the Buckhorn Creek impoundment. No groundwater will be used for operation of the plant.

5.3.3 Floodplain Aspects

The objective of the Executive Order 11988, Floodplain Management, 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...."

Construction of the main and auxiliary dams will reduce the magnitude of flood flows downstream of the main dam because of the storage capacity created by the dams. Upstream of the dams, however, flood elevations will be higher for a given flood and the extent of inundation will be greater. Figure 5.1 shows floodplains for both preconstruction and postconstruction conditions. The elevations of the 100-year and 500-year floods in the Buckhorn Creek impoundment behind the main dam for postconstruction conditions are 234 ft msl and 239 ft msl, respectively. Both the preconstruction and postconstruction floodplains are entirely within the site boundary, which is encompassed by the 243-ft contour of the main reservoir and the 260-ft contour of the auxiliary reservoir. The plant grade at 260 ft msl is also above the floodplains.

The U.S. Army Corps of Engineers has estimated the 100-year and 500-year flood levels in the Cape Fear River just upstream of Buckhorn Dam to be 165.5 ft msl and 182.0 ft msl, respectively.

A makeup water intake structure will be located in the Cape Fear River floodplain just upstream of Buckhorn Dam. However, this structure has been designed to function when water levels in the Cape Fear River are as high as el 185 ft msl, which is higher than the 500-year flood level of 182 ft msl. Because of this, the staff concludes that the Cape Fear River makeup intake structure will not be affected by flooding in the Cape Fear River. The staff further concludes that the intake structure will have negligible effects on postconstruction water levels in the Cape Fear River because the portion of the structure that encroaches on the floodplain will be small in comparison to the storage area of the Buckhorn Dam impoundment.

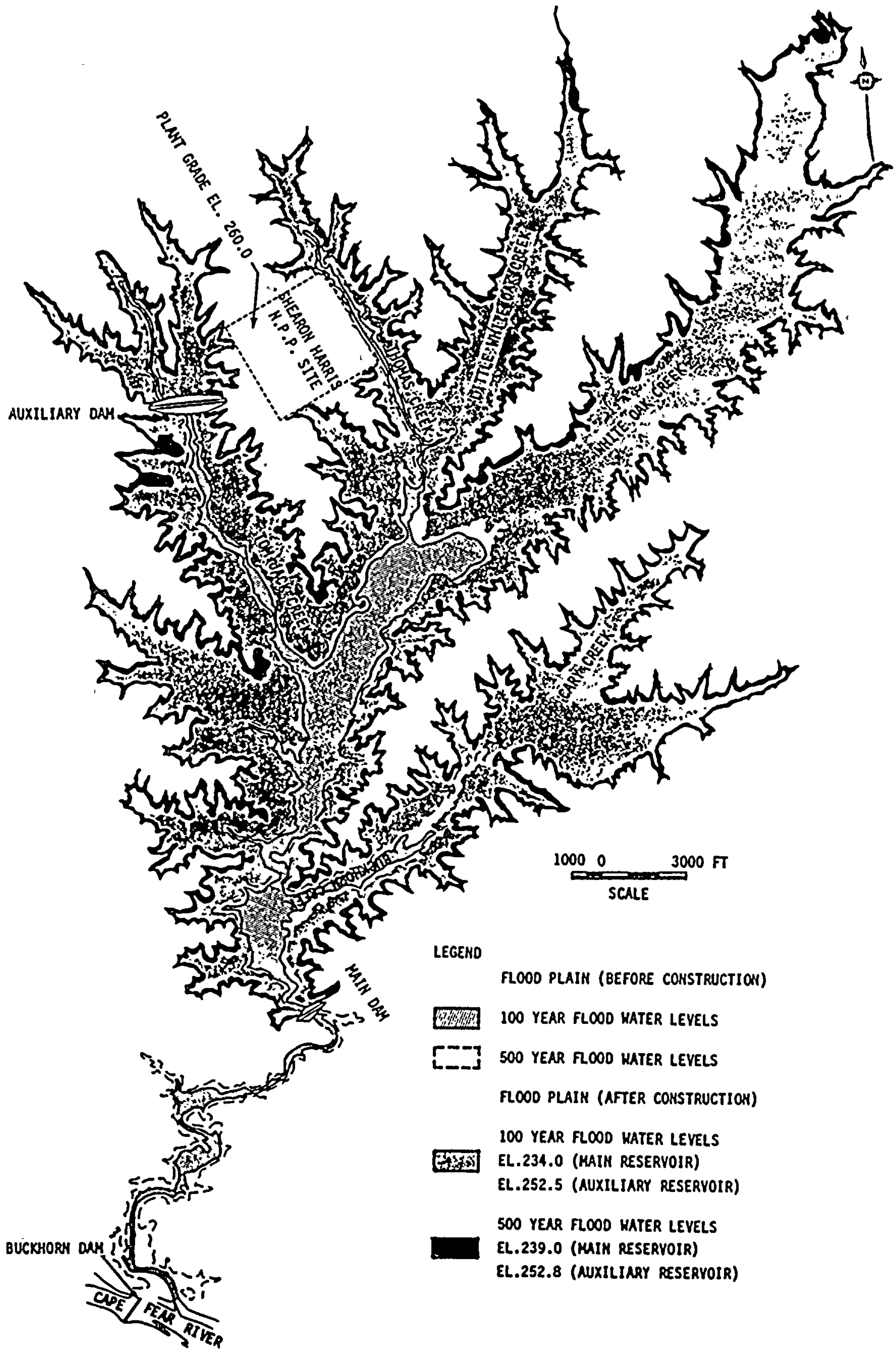

Figure 5.1 Buckhorn Creek floodplains

5.4 Air Quality

In the site area, air quality is at acceptable levels compared to pollutant levels identified in the National Ambient Air Quality Standards, according to "Environmental Quality" (Council on Environmental Quality, 1978).

Plant operation is not expected to affect this situation because the infrequent and limited use of such pollutant sources as plant diesels and auxiliary boilers will result in small amounts of effluents. The releases will produce photochemical oxidants, suspended particulates, and oxides of carbon, nitrogen, and sulphur, all of which will have minimal impact on local air quality because of their limited releases.

Other plant emissions include water vapor plumes from the natural draft cooling towers, the impact of which will be dependent on ambient meteorological conditions that determine plume extent and visibility. The cooling tower effects were described in the ER-CP and are not expected to produce any major impact on meteorology conditions in the area.

5.5 Terrestrial and Aquatic Resources

5.5.1 Terrestrial

The impacts to terrestrial biota expected from operation of the plant were discussed in RFES-CP Section 5.3. Additional impacts that were expected to occur during operation but that were not considered previously and impacts that were reevaluated in light of changes in plant design are considered below. The permanent loss of terrestrial habitat from the presence of the Shearon Harris units is about 1777 ha (4400 acres). Of this, approximately 1741 ha (4300 acres) is needed for the main reservoir and 40 ha (100 acres) is occupied by plant buildings, cooling towers, roadways, sidewalks, etc.

5.5.1.1 Cooling Tower Emissions

Terrestrial impacts resulting from the condenser cooling system were re-evaluated in light of the applicant's design change from four natural draft cooling towers to two towers. New information concerning the effects of operating the Shearon Harris natural draft towers is presented below.

5.5.1.2 Drift Deposition

The applicant provided calculations of the predicted salt drift for four natural draft cooling towers (McDuffie, 1982a) assuming an electrical generating capacity of 3800 MW. Using onsite meteorological data, a maximum deposition rate of 0.15 kg/ha/yr (0.8 lb/acre/yr) is anticipated at locations of 1 to 2 km (3280 to 6562 ft) north-northeast and south of the cooling towers. Salt deposition from two natural draft towers will be much less, considerably below the levels of 10 to 20 kg/ha/mo that are known to produce visible damage to leaves (NUREG-0555). Because of the diluting effect of rainfall, the staff does not believe salts will accumulate in the soil to levels potentially harmful to vegetation. Based on the staff's knowledge of drift studies at plants having freshwater natural draft cooling towers, expected drift levels from operation of the Shearon Harris units are not likely to adversely impact terrestrial biota.

5.5.1.3 Bird Impaction

Bird kills from collisions with cooling towers and other manmade structures have been reviewed by Avery et al. (1980) and Jaroslow (1979). Based upon these reviews and results of monitoring programs at operating nuclear power plants having similar-size natural draft cooling towers, the staff concludes that the numbers of birds killed will be insignificant relative to bird populations migrating through the Shearon Harris plant area.

5.5.1.4 Transmission Lines

The proposed transmission line network is essentially the same as that described in RFES-CP Section 3.7. The transmission network is shown in Figures 5.2 through 5.5. One change in the network since the FES-CP was issued is the shortening of the 230-kV line from the Shearon Harris plant to the Method substation. The line will now extend only to the Cary substation, a distance approximately 9 km (5 miles) shorter than the originally proposed line (ER-OL Section 3.9).

The staff has reviewed the environmental impacts that could be associated with the operation of the Shearon Harris transmission system. The potential sources of impact are (1) corridor maintenance, (2) ozone production, and (3) electric fields and induced electrical currents.

The applicant's policy of selective clearing of trees along the corridor (FES-CP Section 3.7) should create a more suitable vegetative cover of higher utility for more wildlife species than when corridors are clear-cut. The applicant's commitment not to use herbicides in corridor maintenance eliminates one source of potential adverse impact to resident wildlife species.

Ozone produced from corona discharge along the Shearon Harris transmission lines will not reach levels injurious to vegetation or humans. The applicant indicates that corona discharges will be minimized using present engineering design in constructing the 230-kV lines.

The staff recently conducted an indepth analysis of the literature related to electric field effects from operating transmission lines (NUREG-0895). Based on this analysis, the staff does not expect electric field strengths along the Shearon Harris 230-kV-line corridors to reach levels injurious to humans or terrestrial biota. The staff estimates maximum electric field gradients of approximately 2 kV/m under the 230-kV lines. At the edge of the right-of-way, electric fields will be considerably lower.

The staff does not believe the human population will be exposed to potential shock hazards from contacting ungrounded metal objects along the right-of-way. The applicant's line design and line clearance should reduce the potential for electrical shocks. The applicant has committed to investigating and resolving any situations or problems which may result from operation of the Shearon Harris 230-kV lines.

5.5.2 Aquatic Resources

The potential effects of plant operation on aquatic biota are of the same types as described in the RFES-CP. As a result of relocation of the blowdown discharge (see Section 4.2.3.2) and cancellation of Units 3 and 4, the level of potential

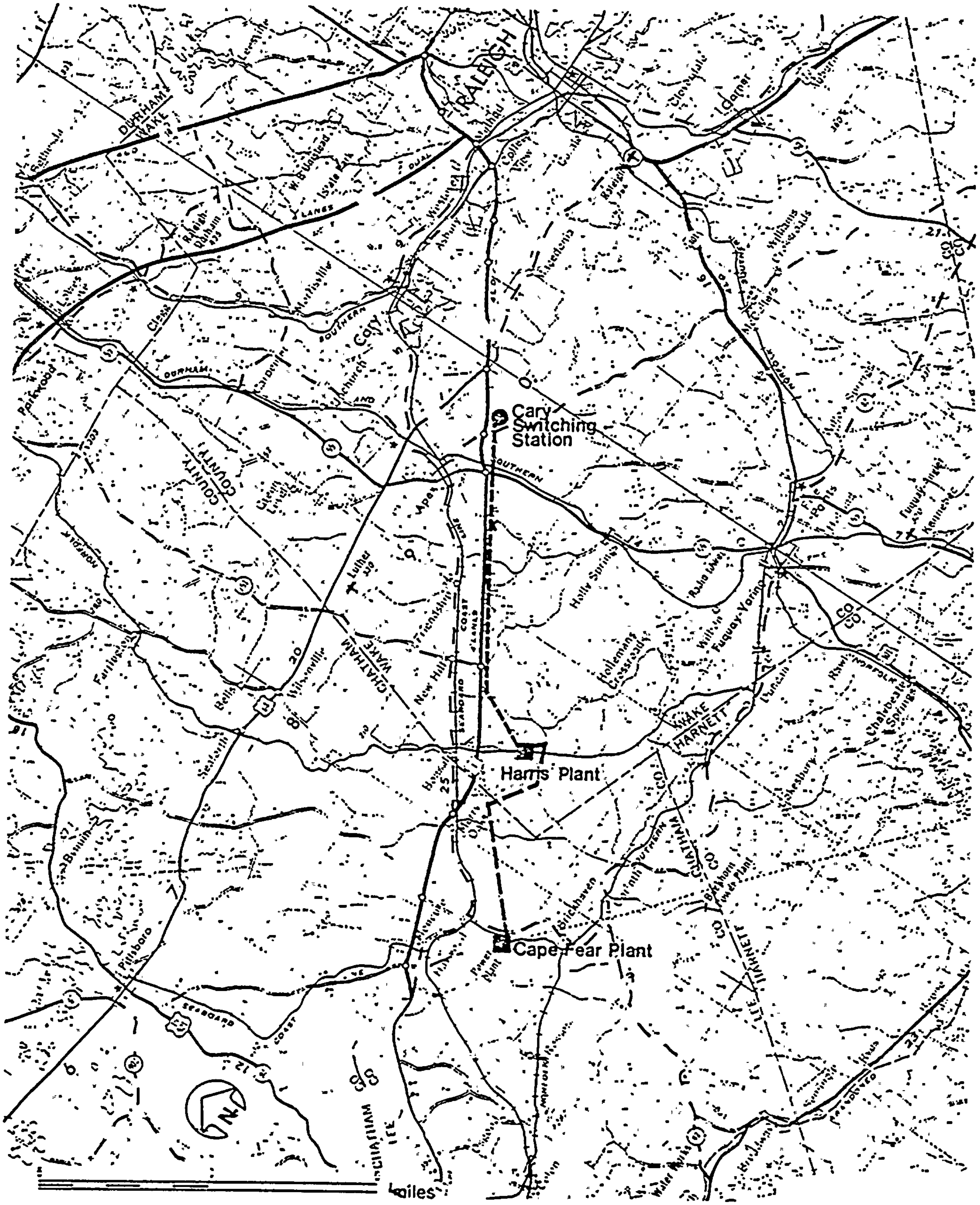

Figure 5.2 Harris-Carey switching 230-kV line and Harris-Cape Fear 230-kV line (Source: Environmental Report, Figure 3.9.0-1, Amendment 3)

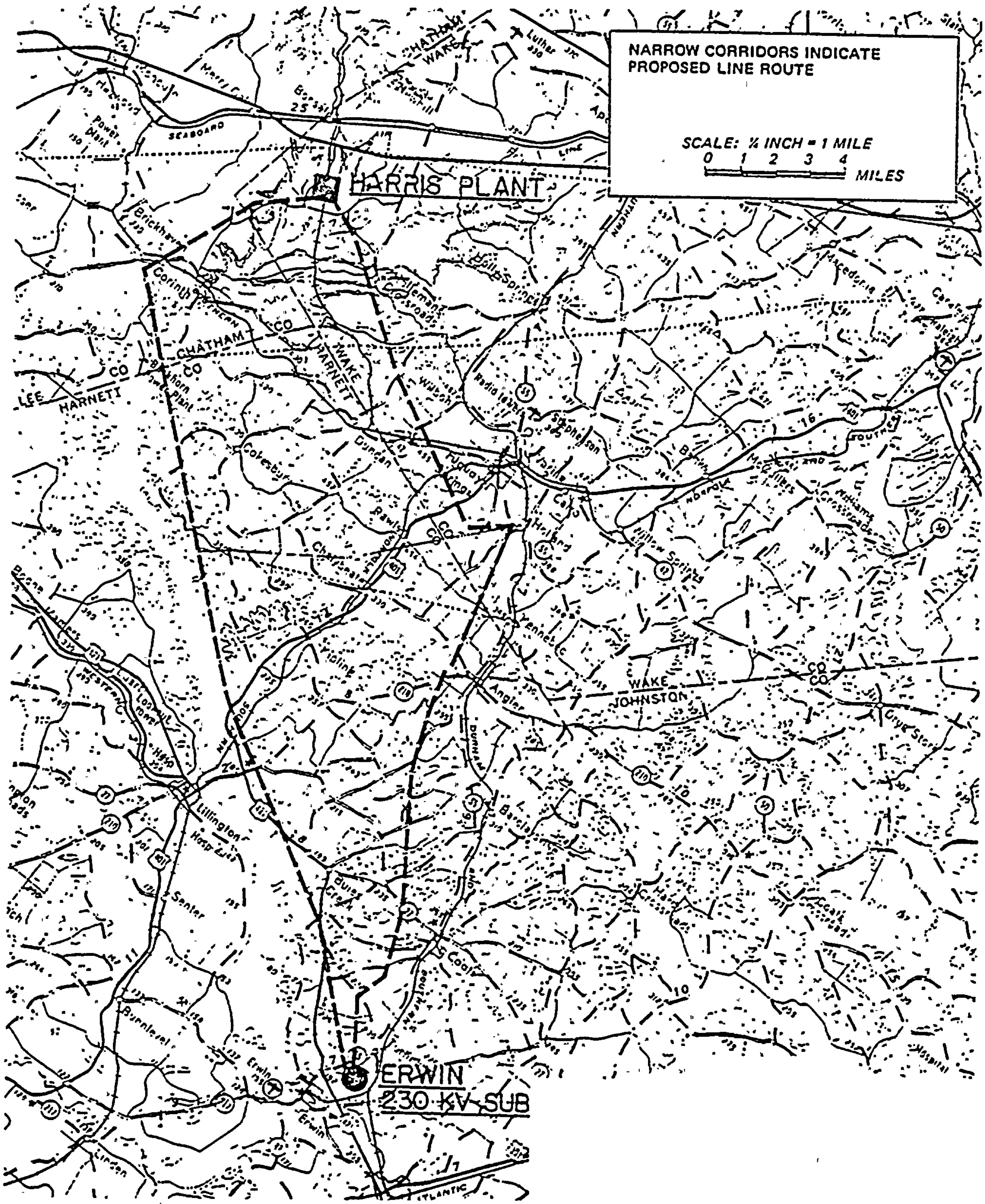

Figure 5.3 Harris-Lillington-Erwin South (proposed) and Harris-Fuquay-Erwin North 230-kV lines (Source: Environmental Report, Figure 3.9.0-2, Amendment 3)

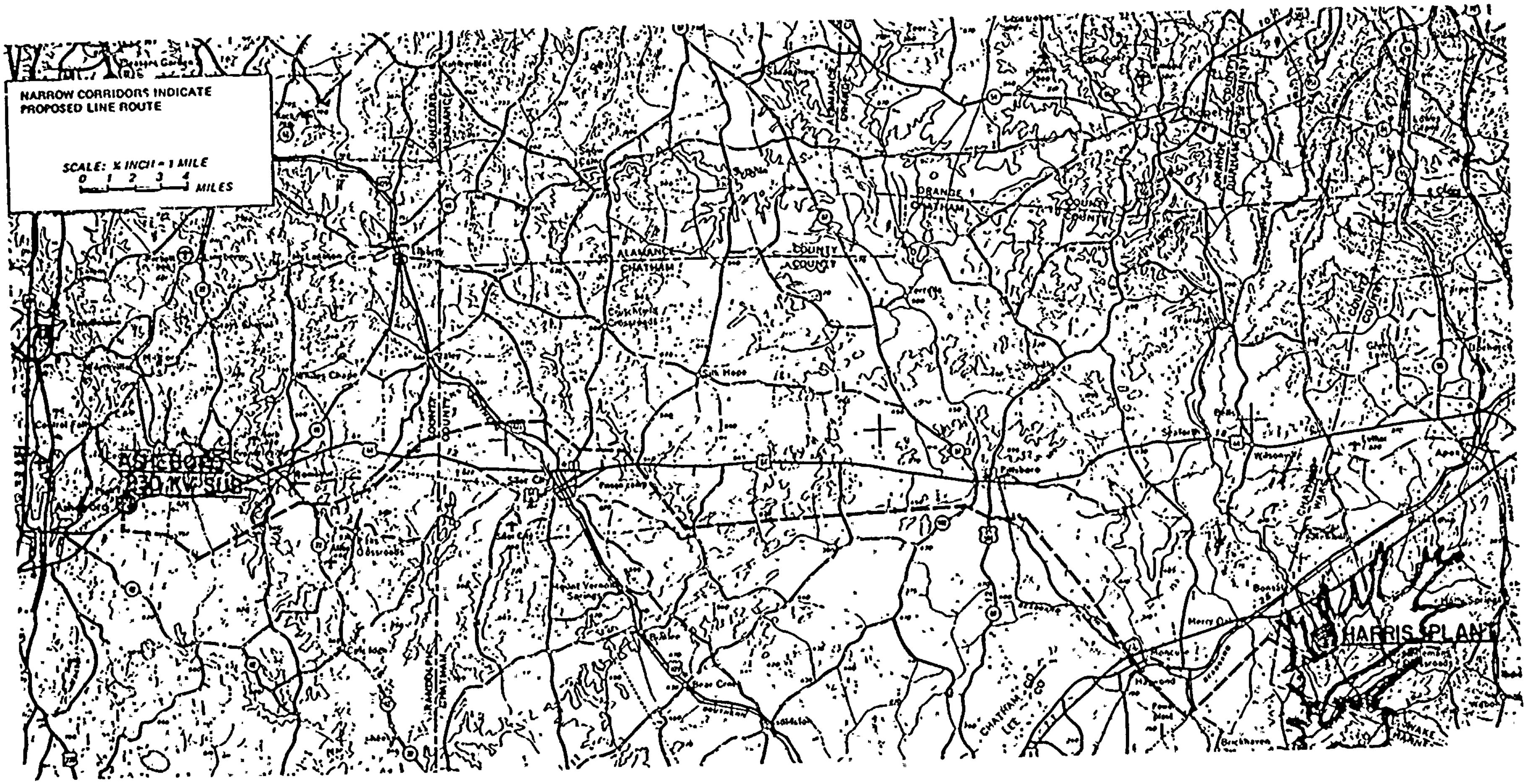

Figure 5.4 Proposed location of Harris-Asheboro 230-kV line (Source: Environmental Report, Figure 3.9.0-4 Amendment No. 3)

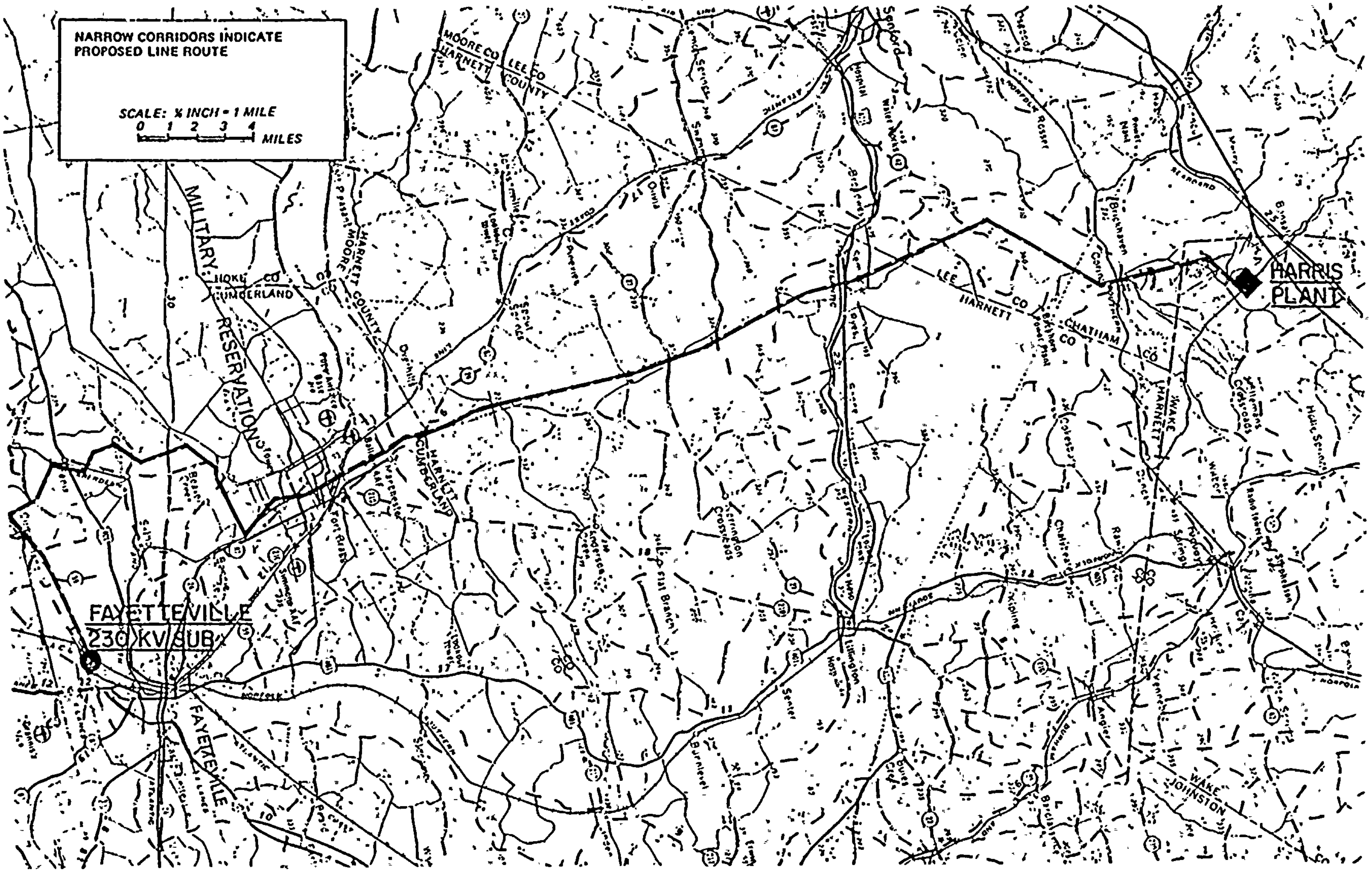

Figure 5.5 Proposed location of Harris-Fayetteville 230-kV line (Source: Environmental Report, Amendment No. 3, Figure 3.9.0-4)

impact to aquatic biota has been reduced from the staff's previous assessments (RFES-CP Section 5.4 and Hickey, 1977), as discussed in the Atomic Safety and Licensing Board Decision at the CP stage. Also addressed in this section are the potential consequences if Corbicula and Hydrilla should become established in Shearon Harris reservoir.

Those effects that have been reduced in level of potential impact are

(1) impingement of fish on intake screens

(2) entrainment of organisms in reservoir makeup and cooling tower makeup water

(3) thermal and chemical discharge effects

(4) main reservoir drawdown effects

5.5.2.1 Intake Effects

Some losses of fish are expected on the intake screening structures to be located on the Cape Fear River and on the main reservoir. The Cape Fear River intake will not be needed for makeup to the main reservoir until both Units 1 and 2 are operational. Also, the makeup requirements to the cooling towers will be cut in half as a result of cancellation of Units 3 and 4.

As described in Section 4.2.3.1, the Cape Fear River intake incorporates design features to minimize entrapment/impingement of fish (flush shoreline placement and low approach velocity ($\leq$0.5 fps)). The species in the vicinity of the river intake that are most susceptible to impingement are the gizzard shad (particularly during winter) and juvenile sunfishes (during summer). Populations of these species will not be impacted by the expected impingement losses because the species are distributed throughout the river and tributary streams. The cooling tower makeup intake, also, is designed with low approach velocity ($\leq$0.5 fps); and, although the design includes an approach channel that could be attractive to some species, the low velocity should minimize entrapment of fish. The anticipated losses (predominantly of gizzard shad) will not impact the species population nor the populations of piscivorous game species that will utilize shad as their reservoir forage base.

Some organisms will be withdrawn from the Cape Fear River and introduced to the main reservoir through the makeup pumping station to be located above Buckhorn Dam. Although a portion of these entrained organisms may be killed by the mechanical effects of pumpage, most are likely to survive to become "seed stock" in the main reservoir. Those species adaptable to reservoir conditions will contribute to the reservoir biotic community.

Withdrawals from the river are limited to 25% of the river flow, except that none is allowed when river flow is $\leq$ 17 m^3/sec ($\leq$ 600 cfs) nor when withdrawal would reduce the flow to less than 17 m^3/sec as measured at the U.S. Geologic Survey Lillington gage (Part III.G of the NPDES permit; Appendix B). Based on an analysis of flow records, the applicant expects that the 17 m^3/sec Cape Fear River flow would be exceeded 74% of the time (ER-OL Figure 2.4.2-2). Taking into account the U.S. Army Corps of Engineers comprehensive plan for water resources in the Cape Fear River basin, a minimum continuous flow of 17 m^3/sec at the Lillington gage will be furnished after completion of the proposed U.S. Army Corps of Engineers dams (ER-OL Table 2.4.2-5). Thus, the 17 m^3/sec limiting requirement would be met or exceeded 100% of the time, except in years of severe drought (ER-OL page 2.4.2-10).

On an annual average basis, less than 1% of the Cape Fear River flow will be used by the Harris plant (Section 5.3.2.1). Entrainment losses of this relative magnitude on an annual basis should not impact the river biota. To evaluate seasonal effects of entrainment, the staff compared the expected maximum withdrawal rate of 8.5 m^3/sec (300 cfs) with average monthly river flows during April and May. The average monthly flows were computed using the estimated flows at Buckhorn Dam for a 58-year record (ER-OL Table 2.4.2-1). April and May were selected for consideration because they represent the major period of susceptibility of larval fish to intake entrainment. For April and May, the averages are 122 m^3/sec (4316 cfs) and 68 m^3/sec (2391 cfs), respectively; thus, the 8.5 m^3/sec (300 cfs) withdrawal represents about 7 and 12.5% of the average river flows for April and May, respectively. Losses of larval fish at these rates should not significantly affect the riverine populations. The species most susceptible are gizzard shad and Lepomis sunfishes. These species have widely distributed spawning habitat and high reproductive success.

All organisms entrained in the cooling tower makeup flow from the main reservoir are assumed to be killed. The required flow is about one-half that considered for the four-unit plant; thus, the potential entrainment loss is about one-half of the previously expected level, which had been judged acceptable by the staff. Makeup for the two-unit plant will be 2.6 m^3/sec (93 cfs), which represents an average daily withdrawal of 0.05 to 0.1% of the total reservoir storage volume (ER-OL Section 5.1.3.4). Aquatic biota of the reservoir will not be impacted by this low level of entrainment loss.

5.5.2.2 Thermal and Chemical Discharge Effects

Evaluation of the thermal impacts of the blowdown discharge to the receiving waterbody is in Section 5.3.1.2.1 of this report.

The staff's analysis indicates that the applicant's modeling of the mixing zone presents conservatively high predictions. The applicant predicts a mixing zone of about 48.6 ha (120 acres) in winter and 8.1 ha (20 acres) in summer. In comparison, the staff's analysis indicates that the reservoir surface area affected by the blowdown discharge would be less than 0.04 ha (0.1 acre) at all times.

Based on the staff's prediction, no detrimental effects on the aquatic biotic community of the reservoir are expected. The potential for cold shock effects, as a result of reactor shutdown during winter, is judged to be negligible because of the small area of the reservoir affected (0.04 ha (0.1 acre) compared to 1620 ha (4100 surface acres)).

The staff's evaluation of impacts on the water quality of the receiving waterbody from plant chemical discharges is in Section 5.3.1.2.2. Potential effects of the discharges on reservoir biota are expected to be minimal on the basis of the discharge location in deep water (where biota will be less concentrated) and the small mixing zone.

5.5.2.3 Reservoir Drawdown Effects

The applicant estimates an annual water level fluctuation of 1.3 m (4.3 ft) in the main reservoir for normal two-unit operation (ER-OL Section 2.5.2.3). The staff calculated that a yearly decline in the water level from the normal elevation of 220 ft msl to 217.7 ft msl (ER-OL Section 2.4.2.3) will expose approximately 116 ha (287 acres) of the reservoir bottom, affecting both emergent and submerged macrophytes. Based on reservoir morphometry (ER-OL Figure 2.4.2-24), areas most likely to be impacted are along Tom Jack Creek, Cary Creek, Little White Oak Creek, and White Oak Creek.

Plant groups expected to be affected by drawdown are cattails (Typha spp.), sedges (Carex spp.), and various grasses. The extent of impact to wetland vegetation will depend, in part, on the season when drawdown occurs. Typically, lowest reservoir levels would occur during the period near the end of the growing season, August through October.

Reservoir drawdown will eliminate cover for wildlife such as various migratory waterfowl, song birds, amphibians, and reptiles. No offsite impacts to wildlife are anticipated from fluctuating water levels except for migratory waterfowl. A 0.7- to 1-m (2- to 3-ft) decline in reservoir level each fall would result in waterfowl habitat lacking in suitable cover and food items. The staff believes impacts to migratory waterfowl will be minimal, however, based on conversations with personnel from the North Carolina Wildlife Resources Commission during the staff site visit. The Shearon Harris site is not in the portion of North Carolina that has high fall concentrations of migratory waterfowl.

5.5.2.4 Consequences of the Introduction of Nuisance Species

With the creation of the Shearon Harris reservoirs, suitable habitat has been created for the colonization by nuisance species such as the Asiatic clam (Corbicula) and the submergent macrophyte, hydrilla (Hydrilla verticillata). The Asiatic clam has been found by the applicant in Buckhorn Creek below the main dam and may be expected to be introduced to the main and auxiliary reservoirs by various transport mechanisms. The most plausible transport mechanism is the planned withdrawal of makeup water from the Cape Fear River during two-unit operation. Hydrilla has been found in water bodies located in Wake County, NC, and it too is likely to appear in the Harris reservoirs during the operational life of the Shearon Harris plant.

The occurrence of Corbicula in a source water body creates concern regarding the fouling of power plant water systems. The applicant indicates that, if Corbicula presents a potential problem, a continuous low-level chlorination scheme would be used to prevent fouling of the service water sysetm (ER-OL page 3.4.3-2). Because the volume of the service water system is small compared to the circulating water system and to the cooling tower blowdown, no detectable chlorine residuals are expected in the discharge to the main reservoir. On this basis and on the basis that a small area (and volume) of the main reservoir is affected by the discharge, the staff concludes that no detrimental impacts on aquatic biota of the reservoir should result from biofouling control of the Asiatic clam. Additional treatment of the safety aspects of plant water systems is in SER Section 5.4.7.

Several species of submerged aquatic vegetation are expected to colonize the shallow shoreline areas of the reservoirs. Environmental factors that control the establishment of a particular species at a given location in the reservoir include the water depth, current, wave action, temperature, transparency, substrate characteristics, and water chemistry (Boyd, 1971). Under some combinations of environmental conditions, once undesirable species of aquatic plants are introduced to an aquatic system, they may become established and cause serious infestations; examples of the latter in southern U.S. reservoirs include Eurasian water milfoil (*Myriophyllum spicatum*) and *Hydrilla verticillata*.

If hydrilla appears in the Harris reservoir, there is the potential for degradation of environmental values of the reservoir for recreational use. Some mitigative measures may be required in the control of hydrilla to restore recreational values. Boyd (1971) points out that where habitat for plant growth occurs, nothing short of removing the habitat will prevent vegetational development. One way of removing habitat is drawdown of reservoir water level, and it is expected that the operation of the Shearon Harris plant will result in water level drawdown of about a meter annually. This mechanism of habitat removal may be only partially successful in limiting hydrilla because of the timing of the drawdown (in late fall to early winter after the growth period) and the extent of drawdown (because hydrilla may grow to water depths greater than the amount of drawdown). Other measures, such as the use of herbicides and mechanical harvesting, may be more appropriate for hydrilla control. The applicant has not proposed a control scheme for the prevention of hydrilla infestation because the plant has not appeared in the Shearon Harris reservoirs; hence, the staff cannot presently evaluate the consequences to reservoir biota of control measures that may be instituted at some future time.

The State of North Carolina has established the Interagency Council on Aquatic Weeds Control to investigate the hydrilla problem. The staff recommends that the applicant maintain an awareness of the council's investigative findings if application of hydrilla control measures is found to be necessary for the Shearon Harris reservoir.

On the basis of present information, the staff does not believe that hydrilla, if it should occur in the Harris reservoirs, will affect operation of the plant. The average depths of the main and auxiliary reservoirs--5.7 m (18.7 ft) and 6.1 m (20 ft)--suggest that colonization, if any, will be limited to near shoreline areas in water depths less than 3 m. Also, the moderately high turbidity expected to occur in the "young" reservoirs will reduce transparency thus limiting growth to shallower water. In Guntersville Reservoir on the Tennessee River, hydrilla has been distributed in shoreline areas out to water depths of 3 to 3.6 m (10 to 12 feet) according to Mr. D. Webb, of the TVA, at Muscle Shoals, Alabama, in a personal communication to Dr. C. Billups, NRC, January 21, 1983. In North Carolina lakes, growth of hydrilla appears to be limited to even shallower waters (i.e., less than 3 m). Because the makeup water intake is located in deep water (approximately 12 m (40 ft) deep), the staff does not expect hydrilla to become established in this area. Incidental fragments that may break off and float into the intake will be removed by the vertical traveling screens.

5.6 Endangered and Threatened Species

See the discussion in Section 4.3.6 above.

5.7 Historic and Archeological Impacts

The staff concludes that there will be no significant impacts on historic and archeological resources caused by the operation of the Shearon Harris plant. A letter from the Deputy State Historic Preservation Officer (Appendix H) indicates that no adverse effects on cultural resources will result from the operation of the facility.

5.8 Socioeconomic Impacts

Socioeconomic impacts of the Shearon Harris plant are described in Chapters 4 and 8 of the RFES-CP. The estimate of the total number of operating personnel for Units 1 and 2 has been revised to 622. These employees are estimated to have an annual payroll of $9.4 million (in 1981 dollars) (ER-OL Response to Question 310.5). The staff does not expect these employees or their families to have any significant impact on traffic patterns or on the demand for private and public facilities and services in the area.

Although the applicant has provided estimates of operation and maintenance costs (ER-OL Response to Question 310.6) for both units, the applicant did not estimate the amount of purchases being made locally. The 1981 ad valorem taxes on Shearon Harris property, as of December 31, 1981, were $6,336,418. The applicant estimates the annual taxes will be about $15.5 million (in 1981 dollars) when both units are completed (ER-OL Response to Question 310.11).

The staff anticipates no other significant socioeconomic impacts 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, Standards for Protection Against Radiation. 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 recorded in 10 CFR 50.36a license requirements 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 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 facility radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR 51 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 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 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 Shearon Harris, 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 of the plant boundaries as a result of 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 plant design and the development of a program that will be implemented at the facility to contain and control all radioactive emissions and effluents. Radioactive-waste management systems incorporated into the plant are designed to remove most of the fission product radioactivity that is assumed to leak from the fuel, as well as most of the activation product radioactivity produced by neutrons in the reactor-core vicinity. (The activated material includes corrosion products.) The effectiveness of these systems will be measured by process and effluent radiological monitoring systems that permanently 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 are to be recorded and published semiannually in the Radioactive-Effluent-Release Reports for the facility.

Airborne effluents will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, waterborne effluents released will be diluted with plant waste water and then further diluted as they mix with the waters of the Harris main reservoir, Buckhorn Creek, and the Cape Fear River beyond the plant boundaries.

Radioisotopes in the facility'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 of 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 Shearon Harris, provides measurements of radiation and radioactive contamination levels that exist outside of 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 Radiological Technical Specifications for the Shearon Harris facility.

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 5.6.

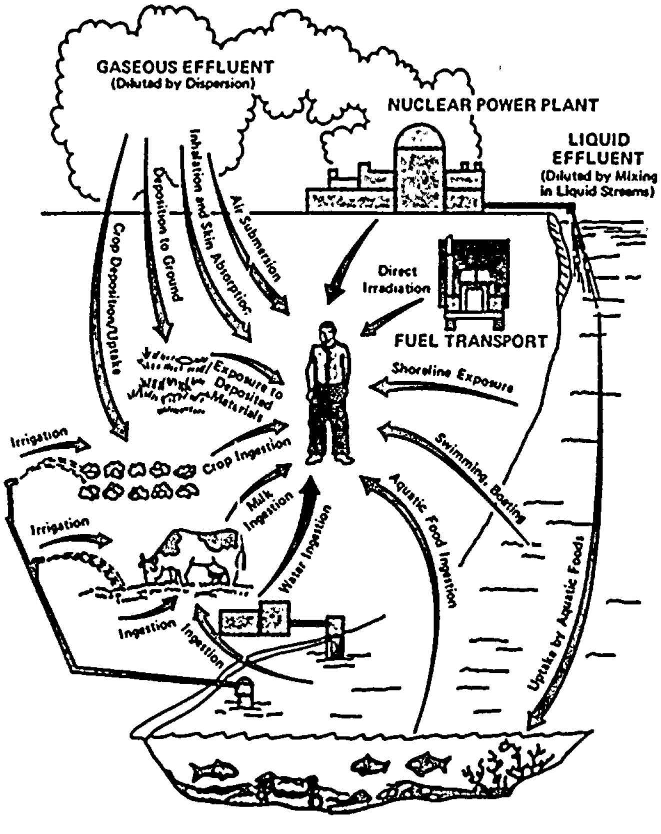

Figure 5.6 Potentially meaningful exposure pathways to individuals

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 20 years after the station begins operation. (Calculation for the 20th year, or 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 Shearon Harris site on members of the general public living and working outside of 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 miles). 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 limitations 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 of 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 (SRP) Chapter 12 (NUREG-0800), and Regulatory Guide (RG) 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 prior to 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 (ibid) 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/yr, 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 Shearon Harris 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 Shearon Harris will be 440 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 3.25 years, will be about 22.4 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 Table 12.4.2-11 (Section 12.4) of the FSAR.

The average annual dose of about 0.8 rem per nuclear-plant worker at operating boiling-water reactors (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 5.2 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 Science's 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).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (derived from BEIR I, page 57). 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 1982).

The risk of potential fatal cancers in the exposed work-force population at the Harris facility is estimated as follows: multiplying the annual plant-worker-

Table 5.2 Incidence of job-related mortalities

Occupational Group	Mortality Rates (premature deaths per 10^5 person-years)
Underground metal miners*	~1300
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

*The President's Report on Occupational Safety and Health, "Report on Occupational Safety and Health by the U.S. Department of Health, Education, and Welfare," E. L. Richardson, Secretary, 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 non-radiation-related risk for 7 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, DC, September 22-23, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths describes a potential risk rather than an observed statistic.)

population dose (about 326 person-rems) by the somatic risk estimator, the staff estimates that about 0.04 cancer death may occur in the total exposed population. The value of 0.04 cancer death means that the probability of 1 cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 4 chances in 100. The risk of potential genetic disorders attributable to exposure of the workforce is a risk borne by the progeny of the entire population and is thus properly considered as part of the risk to the general public.

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 5.3. 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.

Table 5.3 (Summary Table S-4) Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear 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.

• 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 due primarily to 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/yr).

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 due to the direct radiation from the plant.

• Radioactive-Effluent Releases: Air and Water

Radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Plant-specific radioisotope-release rates were developed on the basis of estimates regarding fuel performance and on the descriptions of radwaste systems in the applicant's FSAR, and by using the calculational models and parameters described by the NRC staff in NUREG-0017. 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 activated 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 at or beyond 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--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 strontium 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; corrosion products, such as iron and cobalt; 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 rates 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 RG 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 of this report. 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 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 ventilation and radwaste treatment systems, the NRC staff has concluded that the systems as now proposed are capable of controlling effluent releases to meet the dose-design objectives of Appendix I to 10 CFR 50.

Operation of the Shearon Harris facility 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 doses from 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/yr) or the dose limits (500 mrems/yr - 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 the Shearon Harris facility.

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 the Shearon Harris facility 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 the Shearon Harris facility 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 miles) 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 the Shearon Harris facility.

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*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.

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, 56 person-rems) by the preceding somatic risk estimators, the staff estimates that about 0.008 cancer death may occur in the exposed population. The significance of this risk can be determined by comparing it to the natural incidence of cancer death in the U.S. population. Multiplying the estimated U.S. population for the year 2000 (~260 million persons) by the current incidence of actual cancer fatalities (~20%), about 52 million cancer deaths are expected (American Cancer Society, 1978).

For purposes of evaluating the potential genetic risks, the progeny of workers are considered members of the general public. Multiplying the sum of the U.S. population dose from exposure to radioactivity attributable to the normal annual operation of the plant (that is, 56 person-rems), and the estimated dose from occupational exposure (that is, 326 person-rems) by the preceding genetic risk estimators, the staff estimates that about 0.1 potential genetic disorder may occur in all future generations of the exposed population. Because BEIR III indicates that the mean persistence of the two major types of genetic disorders is about 5 generations and 10 generations, in the following analysis the risk of potential genetic disorders from the normal annual operation of the plant is conservatively compared with the risk of actual genetic ill health in the first 5 generations, rather than the first 10 generations. Multiplying the estimated population within 80 km of the plant (~1,750,000 persons in the year 2000) by the current incidence of actual genetic ill health in each generation (~11%), about 193,000 genetic abnormalities are expected in the first five generations of the 80-km population (BEIR III).

On the basis of the preceding comparison, the staff concludes that the risk to the public health and safety from exposure to radioactivity associated with the normal operation of the Harris facility 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 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 facility. 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, page 3, item 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 are conducted to verify the effectiveness of inplant 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 Specification conditions that relate to the control of doses to individuals.

These programs are discussed in greater detail in RG 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 RFES-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 5.4.

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

The staff has reviewed the applicant's preoperational environmental monitoring plan 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-mile) 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; these will be reviewed by NRC.

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

Table 5.4 Radiological envronmental monitoring program summary*
(adapted from ER-OL Table 6.1.5-1, Amendment 4)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Airborne particulates and radio-iodines	1	0.3 mi S on Rd 1134 from Rd 1011 intersection, 2.5 mi N sector of site	Continuous operating sampler with sample collection as required by dust loading, but at least once every 7 days	Weekly Weekly Quarterly	Gross beta** I-131 (charcoal canisters)*** Gamma isotopic† Composite by location
	2	1.6 mi S on Rd 1134 from Rd 1011 intersection, 1.5 mi NNE sector of site	Continuous operating sampler with sample collection as required by dust loading, but at least once every 7 days	Weekly Weekly Quarterly	Gross beta** I-131 (charcoal canisters)*** Gamma isotopic† Composite by location
	3	0.9 mi S on Rd 1135 from US 1 intersection, 2.6 mi NE sector of site	Continuous operating sampler with sample collection as required by dust loading, but at least once every 7 days	Weekly Weekly Quarterly	Gross beta** I-131 (charcoal canister)*** Gamma isotopic† Composite by location
	4	New Hill, 3.5 mi NNE sector of site	Continuous operating sampler with sample collection as required by dust loading, but at least once every 7 days	Weekly Weekly Gamma	Gross beta** I-131 (charcoal canisters***) Gamma Isotopic† Composite by location

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Airborne particulates and radioiodines (continued)	5	Pittsboro, ≥12 mi WNW sector of site (control station)††	Continuous operating sampler with sample collection as required by dust loading, but at least once every 7 day	Weekly Weekly Quarterly	Gross beta I-131 (charcoal canisters)*** Gamma Isotopic† Composite by location
Direct radiation	1	0.3 mi S on Rd 1134 from Rd 1011 intersection, 2.5 mi N sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	2	1.6 mi S on Rd 1134 from Rd 1011 intersection, 1.5 mi NNE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	3	0.9 mi S on Rd 1135 from US 1 intersection, 2.6 mi NE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	4	New Hill, 3.5 mi NNE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	5	Pittsboro, ≥ 12 mi WNW sector of site (control station)††	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	6	Intersection of Rd 1134 & 1135, 0.9 mi ENE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Direct radiation (continued)	7	House ruins on Rd 1134, 0.8 mi E sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	8	Dead end of Rd 1134, 0.7 mi ESE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	9	1 mi W of Hollomans Rd, 2.3 mi SE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	10	Train crossing under Rd 1130, 2.2 mi SSE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	11	0.3 mi E of intersection Rd 1131 & 1134, 0.7 mi S sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	12	Intersection of Rd 1131 & 1133, 0.8 mi SSW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	13	1.0 mi S of R/R on Rd 1131, 0.7 mi SW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	14	Dead end of Rd 1191, 1.1 mi WSW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	15	Cemetery on Rd 1191, 1.8 mi W sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Direct radiation (continued)	16	1.2 mi E of intersection of US 1 and Rd 1011, 1.7 mi WNW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	17	Intersection of US 1 and Aux Res, 1.4 mi NW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	18	0.6 mi N on US 1 from Station 17, 1.3 mi NNW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	19	Triple H Dairy, 4.9 mi NNE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	20	Intersection Rd 1149 & US 1, 4.7 mi NE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	21	1.3 mi E of intersection of Rd 1152 & 1153 on Rd 1152, 4.8 mi ENE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	22	Ragan's Dairy Farm, 4.6 mi E sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Direct radiation (continued)	23	Holloman Cemetery, 5.0 mi ESE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	24	Sweet Springs Church, 4.7 mi SE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	25	0.23 mi W of intersection of Rd 1401 & 1402 on Rd 1402, 4.8 mi SSE sector of site	Continuous measurement with an integrated readout at least once a quarter once a quarter	Quarterly	Gamma dose
	26	Spillway on Main Res, 4.6 mi S sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	27	Buckhorn Church, 4.8 mi SSW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	28	0.6 mi from Intersection of Rd 1916 & 1924 on Rd 1924, 4.8 mi SW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	29	Industrial waste pond on Rd 1916, 5.6 mi WSW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Direct radiation (continued)	30	Exit intersection of Rd 1700 & US 1, 5.1 mi W sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	31	Intersection of Rd 1910 & 243, 4.5 mi WNW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	32	Intersection of Rd 1008 & 262, 4.8 mi NW sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	33	1.6 mi E of intersection of Rd 1008 & 1903 on Rd 1903, 4.5 mi from site NNW sector	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	34	Apex (population center), 8.6 mi NE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	35	Holly Springs, 6.9 mi E sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
	36	Intersection of Rd 1393 & 1421, 11.2 mi E sector of site (control station)††	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Direct radiation (continued)	37	Fuquay-Varina (population center), 9.7 mi ESE sector of site	Continuous measurement with an integrated readout at least once a quarter	Quarterly	Gamma dose
Waterborne					
Surface water	26	Spillway on Main Res, 4.6 mi S sector of site	Composite sample† collected over a period of ≤ 31 days	Monthly Monthly Quarterly	Gross beta Gamma isotopic Tritium
	38	Cape Fear Steam Electric Plant intake structure (control station)††, 6.1 mi WSW sector of site	Composite sample† collected over a period of ≤ 31 days	Monthly Monthly Quarterly	Gross beta Gamma isotopic Tritium
	40	Lillington's Water Municipality, 15.0 mi SSE sector of site	Composite sample† collected over a period of ≤ 31 days	Monthly Monthly Quarterly	Gross beta Gamma isotopic Tritium
Groundwater	39	Onsite deep well in the proximity of the diabase dikes	Grab sample Quarterly	Quarterly Quarterly	Gamma isotopic†† Tritium
Drinking	38	Cape Fear Steam Electric Plant intake structure (control station)***, 6.1 mi WSW sector of site	Composite sample† over 2-week period if I-131 analysis is performed, monthly composite otherwise	I-131 on each composite when dose††† calculated for the consumption of the water is greater than 1 mrem per yr. Monthly Monthly Quarterly	I-131 Gross beta Gamma isotopic Tritium

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Waterborne (continued)					
Drinking (continued)	40	Lillington's Water Municipality, 15.0 mi SSE sector of site	Composite sample† over 2-week period if I-131 analysis is performed, monthly composite otherwise	I-131 on each composite when the dose†† calculated for the water is greater than 1 mrem per yr.	I-131
				Monthly	Gross beta
				Monthly	Gamma isotopic
				Quarterly	Tritium
Sediment from shoreline	41	Shoreline of mixing zone of cooling towers, 2.8 mi SSW sector of site	Surface soil sample semiannually	Semiannually	Gamma Isotopic††
Ingestion					
Milk	42	Louis Fish Res (single cow), 1.9 mi NW sector of site	Grab samples semimonthly when animals are on pasture, monthly at other times	Each sample	I-131 & Gamma Isotopic††
	19	Triple H Dairy, 4.9 mi NNE sector of site	Grab samples semimonthly when animals are on pasture, monthly at other times	Each sample	I-131 & Gamma Isotopic††
	43	Goodman's Farm, 2.3 mi N sector of site	Grab samples semimonthly when animals are on pasture, monthly at other items	Each sample	I-131 & Gamma isotopic††

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Ingestion (continued)					
Milk (continued)	22	Ragan's Dairy Farm, 4.6 mi E sector of site	Grab samples semimonthly when animals are on pasture, monthly at other times	Each sample	I-131 & Gamma Isotopic††
	5	Pittsboro (control station)††, $\geq$12 mi WNW sector of site	Grab samples semimonthly when animals are on pasture, monthly at other times	Each sample	I-131 & Gamma Isotopic††
Fish	44	Site varies within the Harris impoundment	One sample of each of the following semiannually: Free Swimmers Bottom Feeders	Semi-annually	Gamma isotopic†† on edible portion for each
	45	Site varies above Buckhorn Dam on Cape Fear River (unaffected by site) (control station)††	One sample of each of the following semianually: Free Swimmers Bottom Feeders	Semi-annually	Gamma isotopic†† on edible portion for each
Food products	46	Behind nursing home, 2.3 mi NE sector of site	Broad leaf vegetation at time of each harvest	At time of each harvest	Gamma isotopic††
	47	Plant access Rd, 1.7 mi NNE sector of site	Broad leaf vegetation at time of each harvest	At time of each harvest	Gamma isotopic††
	43	Goodman's Farm, 2.3 mi N sector of site	Broad leaf vegetation at time of each harvest	At time of each harvest	Gamma isotopic††

Table 5.4 (Continued)

Exposure pathway and/or sample	Sample point	Sample point, description distance, direction*	Sampling and collection frequency	Analysis frequency	Analysis
Ingestion (continued)					
Food products (continued)	5	Pittsboro, ≤ 12 mi WNW sector of site (control station)***	Broad leaf vegetation at time of each harvest	At time of each harvest	Gamma isotopic††

Note: To change mi to km, multiply by 1.609.

*Sample locations are shown on ER-OL Figure 6.1.5-1, Amendment 4.

**Particulate samples will be analyzed for gross beta radioactivity 24 hours or more following filter change to allow for radon and thorium daughter decay. If gross beta activity is greater than 10 times the yearly mean of the control sample station activity, gamma isotopic analysis will be performed on the individual samples.

***Control sample stations (or background stations) are located in areas that are unaffected by plant operations. All other sample stations that have the potential to be affected by radioactive emissions from plant operations are considered indicator stations.

†Composite samples will be collected with equipment (or equivalent) that is capable of collecting an aliquot at very short intervals (every 2 hours) relative to the compositing period (monthly).

††Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the plant operations.

†††The dose will be calculated for the maximum organ and age group, using the methodology contained in RG 1.109, Rev. 1 and the actual parameters particular to the 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 RG 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 prior to plant 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 Shearon Harris plant site, in accordance with the June 13, 1980 Statement of Interim Policy issued by the NRC. The discussion below 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 the consequences should accidents occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and societal impacts associated with actions to avoid such health effects are also 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 Shearon Harris facilities and of the site that act to mitigate the consequences of accidents.

The results of calculations of the potential consequences of accidents that have been postulated in the design basis are then given. Also described are the results of calculations for the Shearon Harris 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 in 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 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 the Shearon Harris plant are in the applicant's FSAR. 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) Fission Product Characteristics

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 are also 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. Table 5.5 lists the inventories of radionuclides in a Shearon Harris reactor core.

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 on 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 on 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

Table 5.5 Activity of radionuclides in a Shearon Harris reactor core at 2910 MWt

Group/radionuclide	Radioactive inventory in millions of curies	Half-life (days)
A. NOBLE GASES		
Krypton-85	0.5	3,950
Krypton-85m	22	0.183
Krypton-87	42	0.0528
Krypton-88	62	0.117
Xenon-133	166	5.28
Xenon-135	31	0.384
B. IODINES		
Iodine-131	77	8.05
Iodine-132	110	0.0958
Iodine-133	160	0.875
Iodine-134	171	0.0366
Iodine-135	137	0.280
C. ALKALI METALS		
Rubidium-86	0.024	18.7
Cesium-134	6.8	750
Cesium-136	2.7	13.0
Cesium-137	4.2	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	5.4	0.391
Tellurium-127m	1.0	109
Tellurium-129	28.9	0.048
Tellurium-129m	4.8	34.0
Tellurium-131m	11.0	1.25
Tellurium-132	110	3.25
Antimony-127	5.6	3.88
Antimony-129	30	0.179
E. ALKALINE EARTHS		
Strontium-89	86	52.1
Strontium-90	3.4	11,030
Strontium-91	100	0.403
Barium-140	149	12.8
F. COBALT AND NOBLE METALS		
Cobalt-58	0.7	71.0
Cobalt-60	0.26	1,920
Molybdenum-99	149	2.8
Technetium-99m	126	0.25
Ruthenium-103	100	39.5
Ruthenium-105	65	0.185
Ruthenium-106	23	366
Rhodium-105	44	1.50

Table 5.5 (Continued)

Group/radionuclide	Radioactive inventory in millions of curies	Half-life (days)
G. <u>RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS</u>		
Yttrium-90	3.6	2.67
Yttrium-91	110	59.0
Zirconium-95	137	65.2
Zirconium-97	137	0.71
Niobium-95	137	35.0
Lanthanum-140	149	1.67
Cerium-141	137	32.3
Cerium-143	114	1.38
Cerium-144	77	284
Praseodymium-143	114	13.7
Neodymium-147	54	11.1
Neptunium-239	1487	2.35
Plutonium-238	0.05	32,500
Plutonium-239	0.02	8.9×10^6
Plutonium-240	0.02	2.4×10^6
Plutonium-241	3.1	5,350
Americium-241	0.0016	1.5×10^5
Curium-242	0.45	163
Curium-244	0.02	6,630

Note: The above grouping of radionuclides corresponds to that in Table 5.7.

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 they may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release from the fuel. If the radionuclides are 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") on 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 they are transported to a lower temperature region and/or dissolve in water when it is present. The former mechanism can result in production of 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 (fallout) or by precipitation (washout or rainout), 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. 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 renders the radioactive materials hazardous.

(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 5.6. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 5.6. 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 inviduals 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 (CONAES, p. 515-34, 1979; Land, 1980), but these relationships have been more exhaustively studied than they have been for 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 may also constitute a health risk, but the ability to define a direct cause-and-effect relationship between a known exposure to radiation and any given health effect 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 occurrence of cancer itself is not necessarily indicative of fatality. The health consequences model currently being used is based on the 1972 BEIR Report (BEIR I). 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 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 Shearon Harris units are designed for an electric power output of 951 MWe each.) The combined experience with these operating units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities (Bertini, 1980; NUREG-0651). Some of these accidents 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 (mostly xenon-133), it has been estimated that approximately 15 curies of radioiodine were also released to the environment at TMI-2 (Rogovin, 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 millirems (Rogovin, 1980; President's Commission, 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 (Rogovin, 1980; President's Commission, 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 have also 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-rems) are a small fraction of the exposures experienced during normal routine operations; these exposures average about 440 to 1300 person-rems in a PWR and 740 to 1650 person-rems in a BWR per reactor-year.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries (Bertini, 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 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. The Fermi 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 (characteristic of a graphite-moderated 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-moderated-and-cooled reactor like Shearon Harris, however.

5.9.4.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the staff has conducted a safety evaluation of the application to operate Shearon Harris. Although that evaluation contains more detailed information on plant design, the principal design features are presented in the following section.

(1) Design Features

The Shearon Harris plant 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.

The steel-lined reinforced concrete containment building is a passive mitigating feature that 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 containment spray system is designed to spray cool water into the containment atmosphere. The operation of the spray system after a loss-of-coolant accident (LOCA) would prevent containment-system overpressure by quenching the steam generated as a result of reactor coolant flashing into the containment atmosphere. The spray water also contains an additive (sodium hydroxide) that will chemically react with any airborne radioiodine to remove it from the containment atmosphere and prevent its release to the environment.

The mechanical systems mentioned above are supplied with emergency power from onsite diesel generators if normal offsite station power is interrupted.

The fuel-handling area located in the fuel building also has accident mitigating systems. The ventilation system contains both charcoal and high efficiency particulate filters. This ventilation system is also designed to keep the area around the spent-fuel pool below the prevailing barometric pressure during fuel-handling operations to prevent exfiltration through building openings. If radioactivity were to be released from the building, it would be drawn through the ventilation system and most of the radioactive iodine and particulate fission products would be removed from the flow stream before exhausting to the environment.

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, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or power-operated relief valves can significantly reduce the amount of radioactivity released to the environment. In this case, the fission-product-removal capability of the normally operating water-processing system would come into play.

Much more extensive discussions of the safety features and characteristics of the Shearon Harris plant are found in the applicant's FSAR. The staff evaluation of these features will appear in the SER being prepared by the staff.

The implementation of the lessons learned from the TMI-2 accident--in the form of improvements in design, procedures, and operator training--will significantly reduce the likelihood of a degraded core accident that could result in large releases of fission products to the containment. Specifically, the applicant is expected to follow the guidance on TMI-related matters in NUREG-0737. No credit has been taken in this evaluation for these actions and improvements in establishing the radiological risk of accidents at the Shearon Harris plant.

(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 Shearon Harris site characteristics and how they meet these requirements.

First, the site has an exclusion area, as required by 10 CFR 100. The total site area is about 4370 ha (10,800 acres). The exclusion area, located within the site boundary, is an area with a minimum distance of 1997 m (6550 ft) from Unit 2 to the exclusion boundary. The applicant owns all surface and mineral rights in the exclusion area, and has the authority, required by 10 CFR 100, to determine all activities in this area. Several state-maintained roads traverse the area, allowing access to the plant and to the reservoir. No public railroads or water transportation routes traverse the exclusion area. Recreational use of land and reservoirs within the exclusion area by the general public is permitted.

Second, beyond and surrounding the exclusion area is a Low Population Zone (LPZ), also required by 10 CFR 100. The LPZ for the Shearon Harris site is a circular area with a 4.8-km (3-mile) radius. Within this zone, the applicant must ensure that there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents in the event of a serious accident. The applicant has indicated that 321 persons lived within a 4.8-km radius in 1980 and projects that the population will increase to 472 in the year 2000. The major sources of transients within a 4.8-km radius of the site will be those in the Shearon Harris Energy Center and in a private nursing home.

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 nuclear plant (see also the following section on emergency preparedness).

Third, 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. Because 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 requirement in 10 CFR 100 to provide for protection against excessive doses to people in large centers. The nearest population center is the city of Raleigh, North Carolina, with a 1980 population of 149,771, which is 26 km (16 miles) northeast of the site. The population center distance is at least one and one-third times the LPZ distance. The population density within a 48-km (30-mile) radius of the site was 552 people/km^2 (213 people/mi^2) in 1980 and is projected to increase to about 932 people/km^2 (360 people/mi^2) by the year 2020.

The safety evaluation of the Shearon Harris site has also included a review of potential external hazards, that is, activities offsite that might adversely affect the operation of the nuclear plant and cause an accident. The review encompassed nearby industrial and transportation facilities that might create explosive, fire, missile, or toxic gas hazards. The risk to the Shearon Harris station from such hazards has been found to be negligible. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards will be included in the SER.

(3) <u>Emergency Preparedness</u>

Emergency preparedness plans including protective action measures for the Shearon Harris facility and environs are in an advanced but not yet fully completed stage. In accordance with the provisions of 10 CFR 50.47 and 10 CFR 50, Appendix E, 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 miles) in radius and an ingestion exposure pathway EPZ of 80 km (50 miles) 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.

The NRC findings will be based (1) on a review of the Federal Emergency Management Agency (FEMA) findings and determinations as to whether state and local government emergency plans are adequate and capable of being implemented, and (2) on the NRC assessment as to whether the applicant's onsite plans are adequate and can be implemented. The NRC staff findings will be reported in the SER. Although adequate and tested emergency plans cannot prevent the occurrence of an accident, it is the judgment of the staff that they can and will substantially mitigate the consequences to the public if one 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 Shearon Harris plant meet acceptable design and performance criteria, the applicant has 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 on 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 Shearon Harris plant, three categories of accidents have been considered by the applicant. These categories are based upon their probability of occurrence and include (1) incidents of moderate frequency (events that can reasonably be expected to occur during any year of operation); (2) infrequent accidents (events that might occur once during the lifetime of the plant); and (3) 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 similar to the consequences from normal plant operations that are discussed in Section 5.9.3. Initiating events postulated in the second and third categories for Shearon Harris are shown in Table 5.6. These are designated design-basis accidents in that specific design and operating features, as described in Section 5.9.4.4(1), are provided to limit their potential radiological consequences. Approximate radiation doses that might be received by a person at the boundary of the plant's exclusion area during the first 2 hours of the accidents were calculated by the applicant and are shown in Table 5.6. The results shown in the table reflect the expectation that ESFs 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 are dominated

Table 5.6 Approximate radiation doses from design-basis accidents at the Shearon Harris plant*

	Dose at 2024 m** (rems)	
Design-basis accident	Thyroid	Whole body
Infrequent accidents		
Rod-ejection accident	0.01	<0.001
Steam generator tube rupture	<0.001	0.004
Fuel-handling accident	0.001	<0.001
Limiting faults		
Main steamline break	<0.001	<0.001
Large-break LOCA	0.1	0.002

Source: ER-OL Table 7.1.2.2

*Duration of release less than 2 hours.

**The site boundary distance.

by noble gases and radioiodines and that any other radioactive materials (for example, in particulate form) are not released in significant quantities. The results also use the meteorological dispersion conditions that are average values determined by actual site measurements. To contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 5.6 are sometimes referred to as "realistic" doses. These values indicate that the risk of incurring any adverse health effects as a consequence of these accidents is exceedingly small.

The staff is carrying out calculations to estimate (in the SER) the potential upper bounds for individual exposures from the initiating accidents listed in Table 5.6 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 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

*However, the containment system is assumed to prevent leakage in excess of that demonstrable by testing, as provided in 10 CFR 100.11(a).

person jogging for a period of 2 hours. The health risk to an individual receiving 300 rems to the thyroid is the 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 will also evaluate (in the SER) the potential upper bounds for individual exposures at the outer edge of the LPZ. These exposures, in general, are not limiting. However, a license to operate will not be issued unless the calculated exposures are not likely to exceed 25 rems to the whole body and 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 the individual or population 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, both for the plant itself and for the environment. These 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 (WASH-1400, now designated NUREG-75/014). Because this report has been subject to considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 5.9.4.5(7). 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 Shearon Harris units are Westinghouse-designed PWRs having design and operating characteristics similar to the RSS prototype PWR. Therefore, the present assessment for Shearon Harris 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 5.7. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events and those that could be initiated by

Table 5.7 Summary of atmospheric 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}	0.8	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 of WASH-1400 (NUREG-75/014).

**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: Refer to Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.

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 criteria relating to effects of natural phenomena in 10 CFR 50, Appendix A, and safeguards requirements in 10 CFR 73, ensuring that these potential initiators 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 or sabotage events 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.

The calculated probability per reactor-year associated with each accident sequence or release category used is shown in the second column in Table 5.7. 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 (ibid.). The probability of accident sequences at the Surry plant was used to give a perspective of the societal risk at Shearon Harris because, although the probabilities of particular accident sequences may be different and even lower for Shearon Harris, the overall effect of all sequences taken together is likely to be within the uncertainties (see Section 5.9.4.5(7) for 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 5.7 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 5.5 for a Shearon Harris unit at a core thermal power level of 2910 MWt, the power level used in the safety evaluation. Of the hundreds of radionuclides present in the core, the 54 listed in the table were selected as significant contributors to the health and the economic risks of severe accidents. The core radionuclides were selected on the basis of (1) half-life, (2) approximate relative offsite dose contribution, and (3) health effects of the radionuclides and their daughter products.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS (NUREG-0340), and adapted and modified as described below to apply to a specific site. The essential elements are shown in schematic form in Figure 5.7. Environmental parameters specific to the site of the Shearon Harris facility 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 2010 extending throughout regions of 80-km (50-mile) and 563-km (350-mile) radii from the site
- the habitable land fraction within the 563-km (350-mile) 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 North Carolina and each surrounding state within the 563-km (350-mile) region

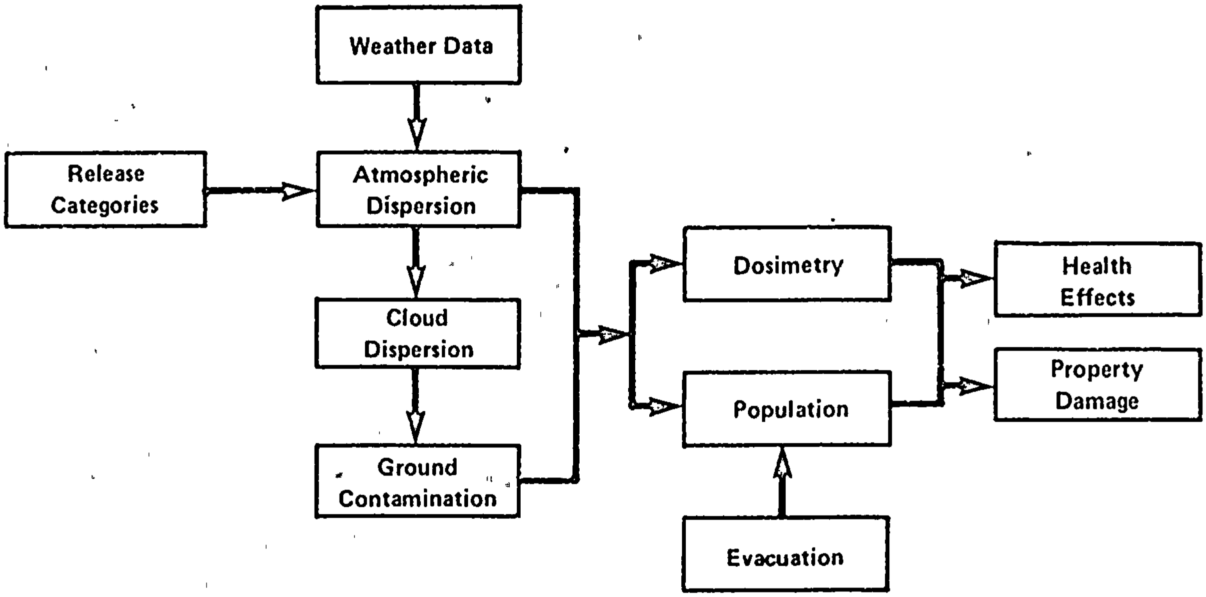


Figure 5.7 Schematic outline of atmospheric pathway consequence model

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 (1) the site-specific hourly meteorological data, (2) the population projections for the year 2010 out to a distance of 800 km (500 miles) around Shearon Harris site, and (3) 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. These terms have been defined in Appendix F. 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 Shearon Harris site are estimates made by the staff (Appendix F). There normally would be some facilities near a plant, such as schools or hospitals, where special equipment or personnel may be required to effect evacuation, and some people near a site who may choose not to evacuate. Such facilities (including Fuquay Varina Hospital, Apex High School, and Baucum School) have been identified near the Shearon Harris site. Therefore, actual evacuation effectiveness could be greater or less than that characterized, but it would not be expected to be very much less, because special consideration will be given in emergency planning for the Shearon Harris plant to any unique aspects of dealing with special facilities.

The other protective actions include: (1) 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, (2) decontamination of a 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 (3) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced to such values by radioactive decay and weathering that land and property can be economically decontaminated as in (2) 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 zone (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 Shearon Harris 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 5.7).

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 Shearon Harris facility and site are presented in the form of probability distributions in Figures 5.8 through 5.11 and are included in the impact summary table, Table 5.8. All of the accident sequences and release categories shown in Table 5.7 contribute to the results, the consequences of each being weighted by its associated probability.

Figure 5.8 shows the probability distribution for the number of persons who might receive whole-body doses equal to or greater than 25 rems, bone marrow doses equal to or greater than 200 rems, and thyroid doses equal to or greater than 300 rems from early exposure,* all on a per-reactor-year basis. The 200-rem bone marrow dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body dose (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 5.8 shows in the left-hand portion that there are approximately 7 chances in 1,000,000 (7×10^{-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

*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.

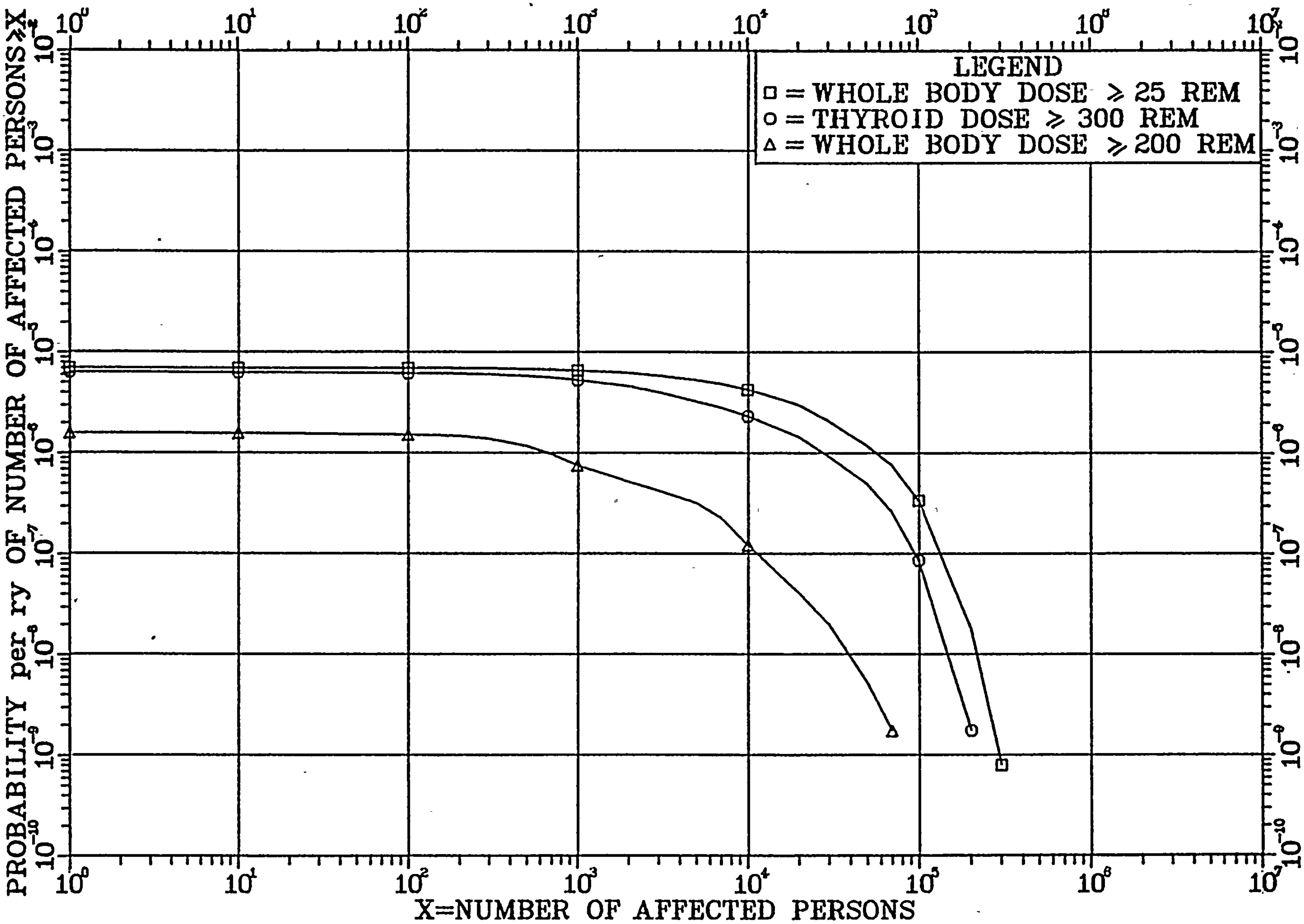


Figure 5.8 Probability distributions of individual dose impacts (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

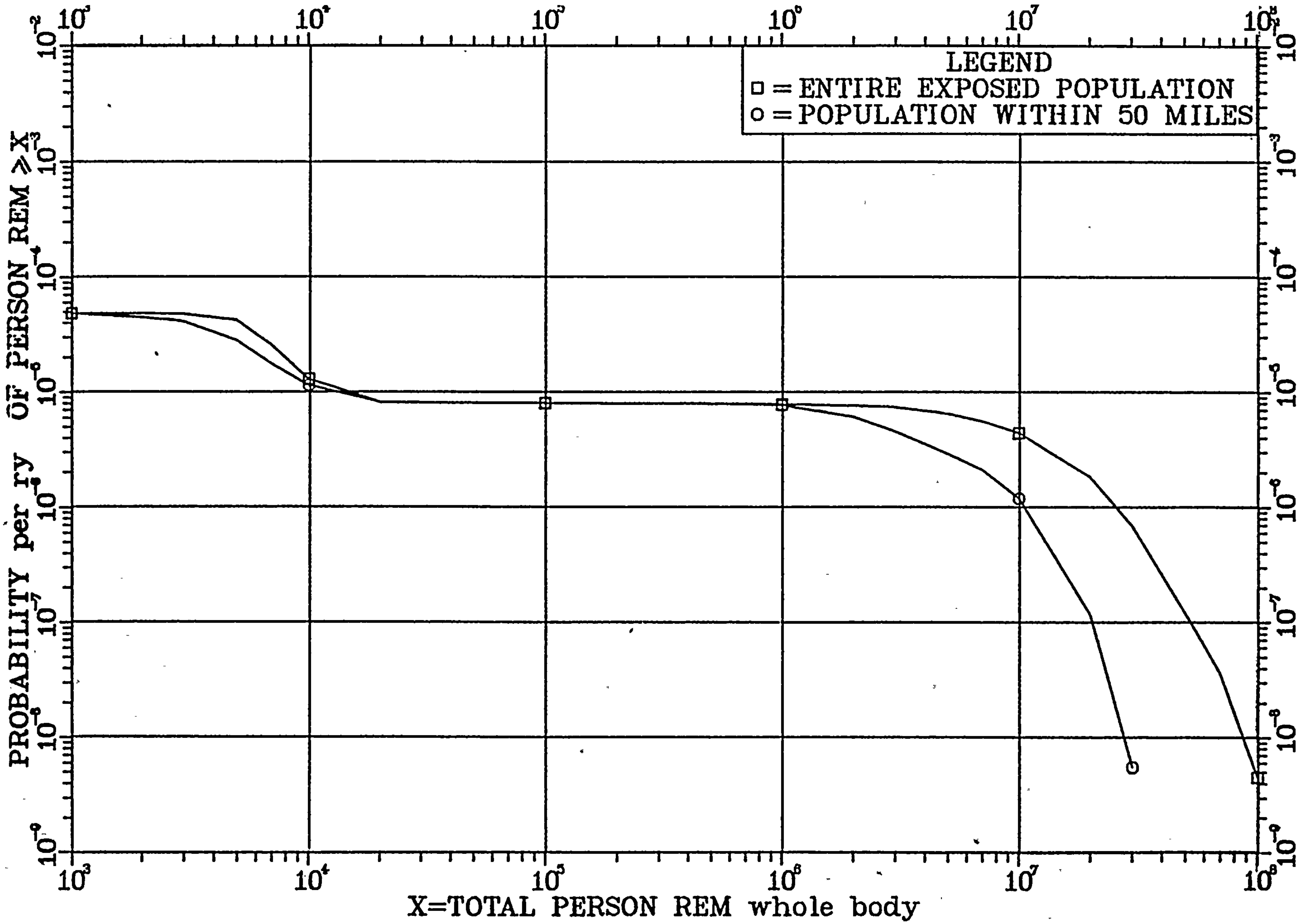


Figure 5.9 Probability distributions of population exposures (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimate) (50 mi = 80 km)

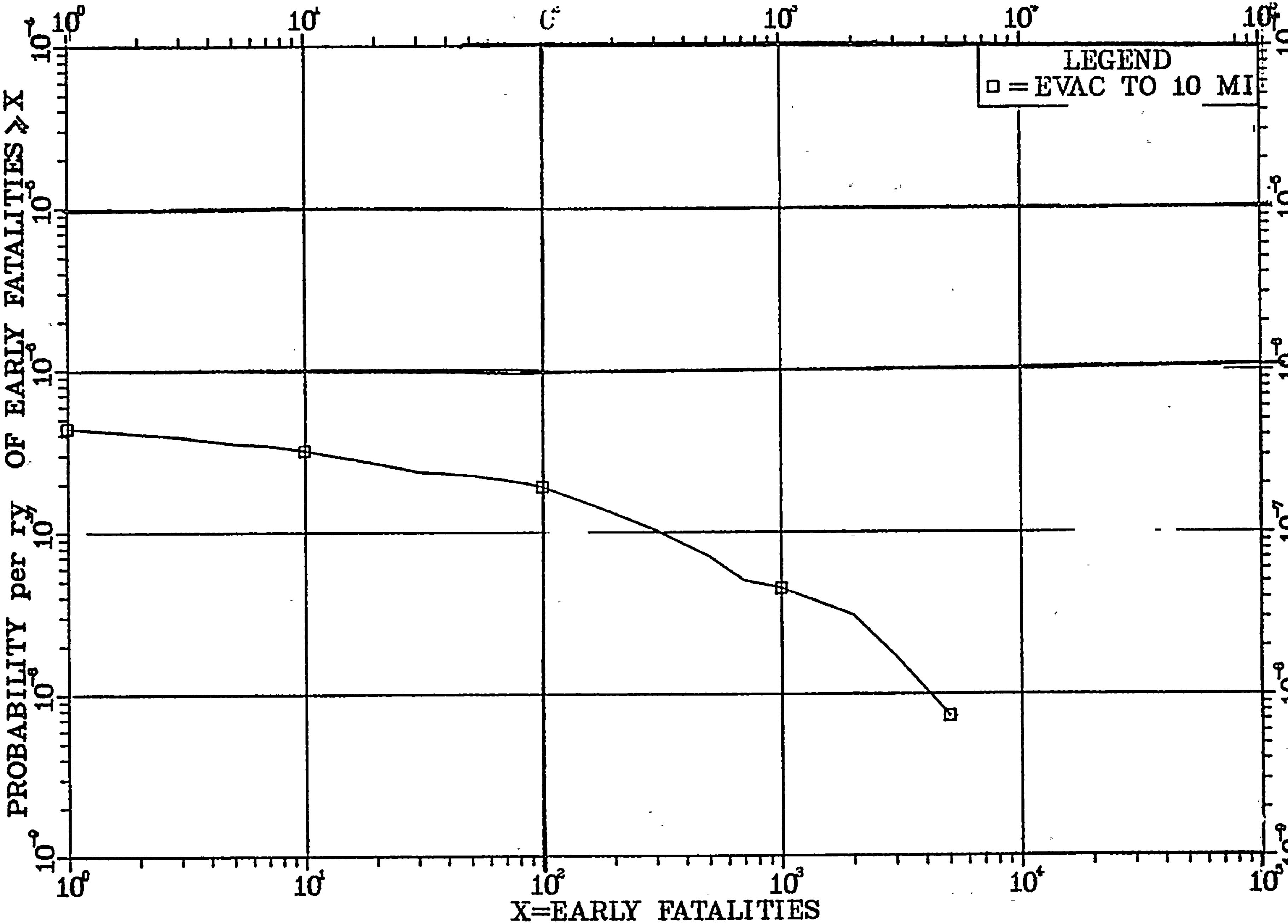


Figure 5.10 Probability distribution of early fatalities (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates) (10 mi = 16 km)

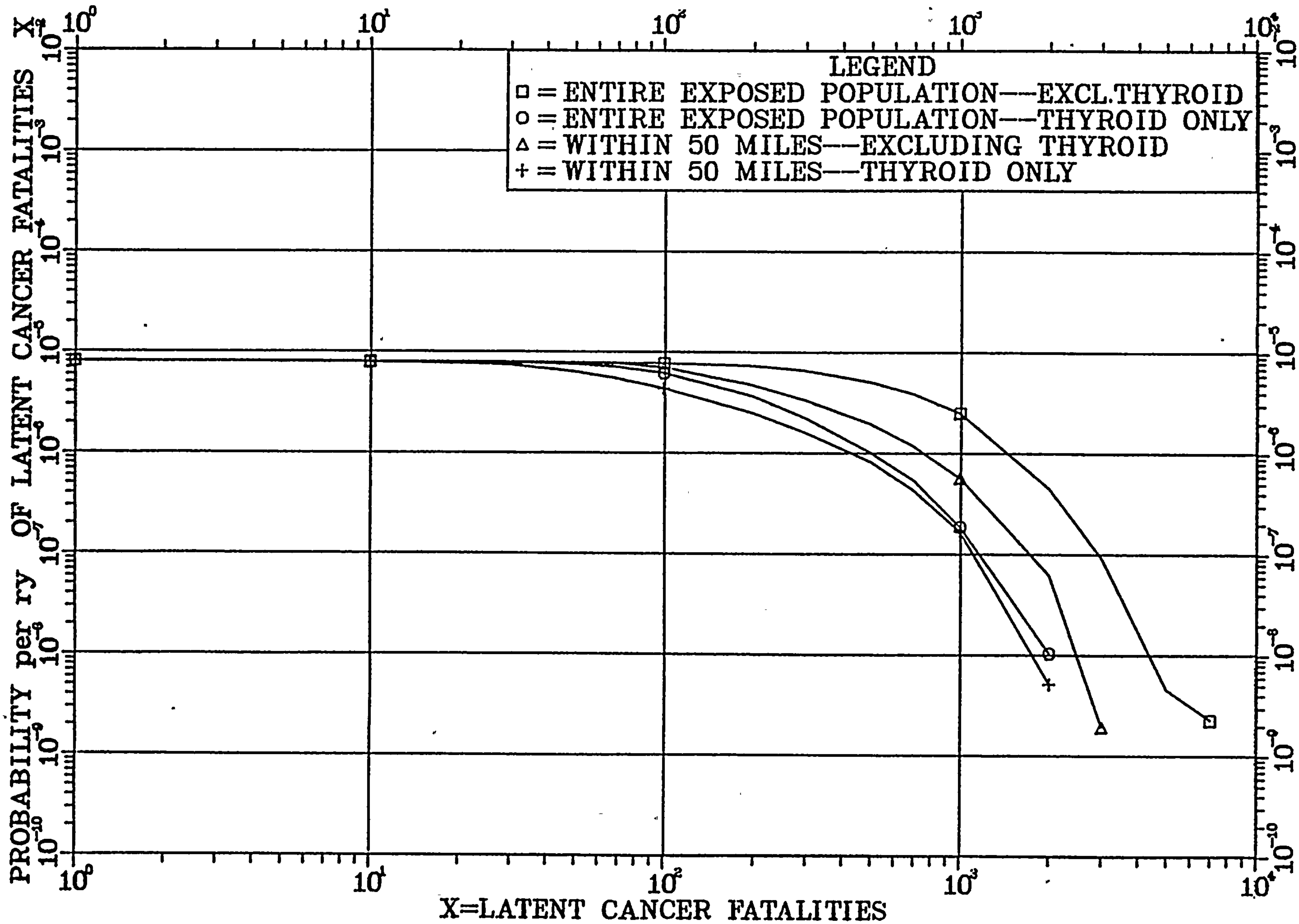


Figure 5.11 Probability distribution of cancer fatalities (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates) (50 mi = 80 km)

Table 5.8 Summary of environmental impacts and probabilities

Probability of impact per reactor-year	Persons exposed over 200 rems	Persons exposed over 25 rems	Early fatalities	Population exposure, millions of person-rems, 80-km (50-mi) total	Latent* cancers, 80-km (50-mi) total	Cost of offsite mitigating actions, $ millions
10^{-4}	0	0	0	0/0	0/0	0
10^{-5}	0	0	0	0.0013/0.0015	0/0	4
5×10^{-6}	0	6000	0	2.6/8.3	260/640	500
10^{-6}	670	57000	0	10.5/25.7	1200/1900	1200
10^{-7}	11000	130000	310	20.4/52.5	2800/4000	2000
10^{-8}	39000	220000	4200	27.7/87.0	4200/4400	3000
Related Figure	5.9	5.9	5.11	5.10	5.12	5.13

*Consists of fatal latent cancers of all organs. There would be a larger number of nonfatal cancers. Genetic effects would be approximately twice the number of latent cancers.

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

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 hundreds to thousands 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 10,000,000 (1×10^{-7}) that 10,000 or more people might receive bone marrow doses of 200 rems or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 40-km (25-mile) radius of the plant. Virtually all would occur within a 160-km (100-mile) radius.

Figure 5.9 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 miles), but the more severe releases (as in the first two accident sequences in Table 5.7) would result in exposure to persons beyond the 80-km range as shown.

For perspective, population doses shown in Figure 5.9 may be compared with the annual average dose to the population within 80 km of the Shearon Harris site resulting from natural background radiation of 180,000 person-rems, and to the anticipated annual population dose to the general public (total U.S.) from normal plant operation of 56 person-rems (excluding plant workers) (Appendix D, Tables D-7 and D-9).

Figure 5.10 shows the probability distributions for early fatalities, representing radiation injuries that would produce fatalities within about 1 year after exposure. All of the early fatalities would be expected to occur within a 9.6-km (6-mile) radius and the majority within a 3.2-km (2-mile) radius. The results of the calculations shown in this figure and in Table 5.8 reflect the effect of evacuation within the 16-km (10-mile) plume exposure pathway zone. Figure F.1 shows the sensitivity of the early fatalities to the emergency response variations including (1) no evacuation and relocation after 1 day, (2) evacuation to 16 km, (3) evacuation to 24 km, and (4) evacuation to 16 km and relocation of people between 16 and 40 km.

Figure 5.11 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 are shown separately. Further, the fatal latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

(4) Economic and Societal Impacts

As noted in Section 5.9.4.2, the various measures for avoidance of 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 the Shearon Harris facility and environs have also been made. Unlike the radiation exposure and health effect impacts discussed above, impacts associated with adverse health effects avoidance are more readily transformed into economic impacts.

The results are shown as the probability distribution for costs of offsite mitigating actions in Figure 5.12 and are included in Table 5.8. 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 attributable to 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 5.12 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 hundred million per reactor-year.

Additional economic impacts that can be monetized by the RSS consequence model 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 pathway for radiation exposure to the public and environmental contamination that would be unique for severe reactor accidents was identified in Section 5.9.4.1 above. Consideration has been given to the potential environmental impacts of this pathway for the Shearon Harris plant. The penetration of the basemat of the containment building can release molten core debris to the geologic strata beneath the plant. The soluble radionuclides in the debris can be leached and transported with groundwater to downgradient domestic wells used for drinking water or to the surface water bodies used for drinking water, aquatic food, and recreation. Releases of radioactivity to the groundwater underlying the site could also occur through depressurization of the containment atmosphere or the release of radioactive emergency core cooling system and sump water through the failed 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 a floating nuclear plant for which the nuclear reactor would be mounted on a barge and moored in a water body. Parameters for each generic land-based site were chosen to represent averages for a wide range of real sites and were thus

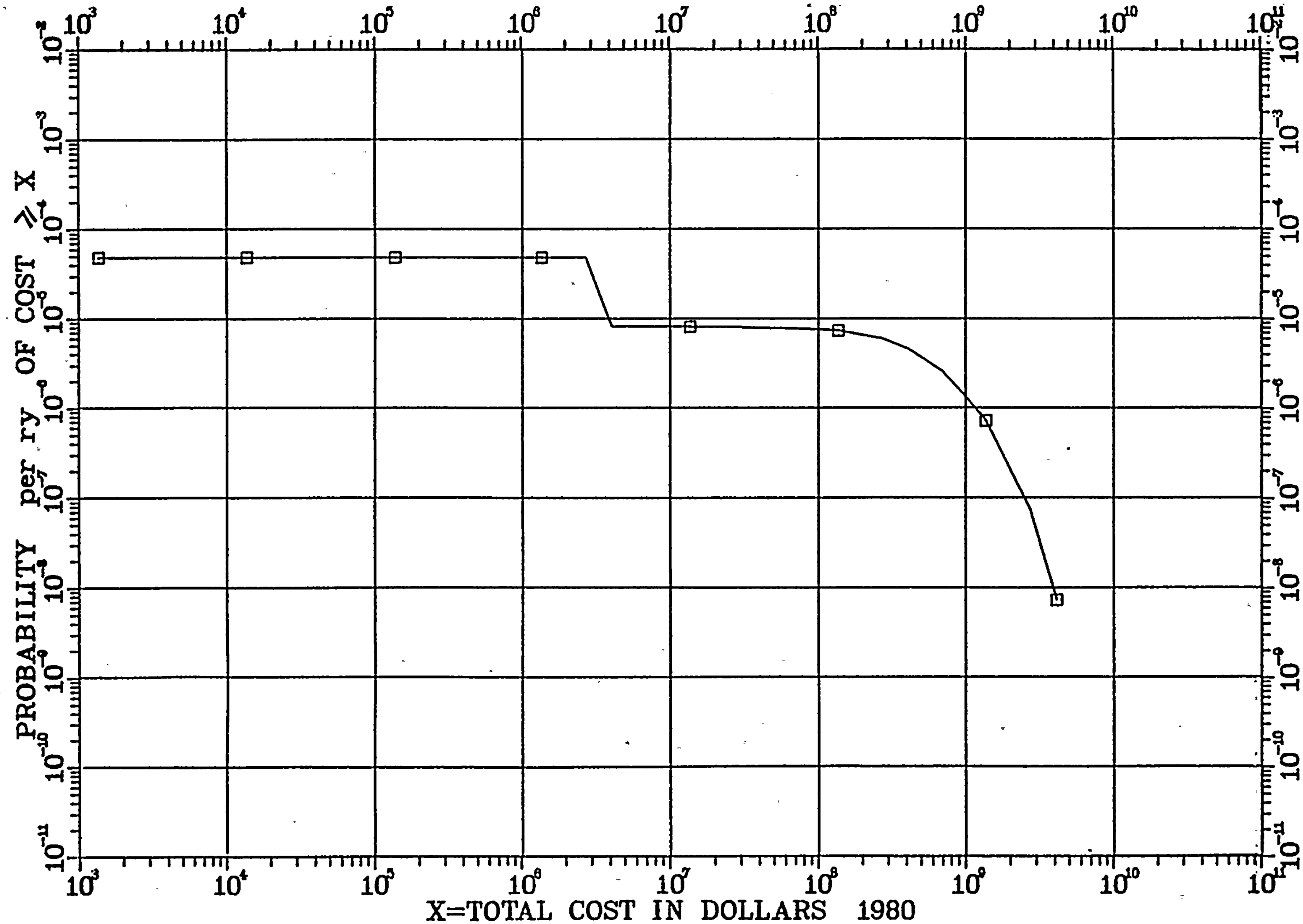


Figure 5.12 Probability distribution of mitigation measures cost (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates)

"typical," but they represented no real sites in particular. The discussion in this section is a summary of an analysis performed to determine whether or not the liquid pathway consequences of a postulated core-melt accident at the Shearon Harris site would be unique when compared to the generic land-based site adjacent to a small river considered in the LPGS.

The Shearon Harris site is located on the northwest shore of a 162-ha (400-acre) cooling tower makeup reservoir constructed by the applicant on Buckhorn Creek. The dam is about 4.0 km (2.5 miles) north of the confluence of Buckhorn Creek with the Cape Fear River, and the plant is about 7.2 km (4.5 miles) north of the dam.

Groundwater at the site exists primarily in the Triassic rocks. The thin layer of overburden overlying the Triassic rocks consists of clayey soils and saprolite that yield little or no usable groundwater. Because of compaction and cementation of individual rock layers, the Triassic rocks can be regarded only as a minor aquifer. The principal areas of groundwater storage are found near diabase dikes that have intruded the Triassic sediments.

The Triassic rocks exhibit very low permeability (3 m (10 ft) per day) for groundwater storage and movement. Another component of permeability, however, exists from fractures that have resulted from stress release. It is this permeability component (150 m (500 ft) per day) that was measured by the applicant during pumping tests at the site. The fractures are common to depths of about 30 m (100 ft).

In the event of a core-melt accident there could be a release of radioactivity to the water in the Triassic rocks underlying the plant. The radioactivity would then move downgradient toward the reservoir. From there it could eventually reach downstream water users on the Cape Fear River. There is no nearby groundwater usage that could be affected by groundwater contamination at the plant.

Contaminated groundwater from a core melt in Unit 1 would have to move about 550 m (1800 ft) downgradient toward the southeast to reach the Thomas Creek arm of the reservoir; contaminated groundwater from a core melt in Unit 2 would have to move about 730 m (2400 ft) before reaching the same arm of the reservoir. However, the groundwater gradient between Unit 1 and the reservoir is 0.022 and the gradient between Unit 2 and the reservoir is 0.036; thus the travel time from Unit 2 to the reservoir is shorter even though the pathway is longer.

Based on the fracture permeability and gradients described above and on a conservatively assumed effective porosity of 0.05, 8.2 years and 6.7 years, respectively, would be required for groundwater moving from Units 1 and 2 to reach the reservoir. This compares with 0.61 year for the generic site in the LPGS.

The LPGS demonstrated that for holdup times on the order of years virtually all the liquid pathway population dose results from Sr-90 and Cs-137. Therefore only these two radionuclides are considered in the remainder of this analysis.

The radionuclides Sr-90 and Cs-137 would move much more slowly than groundwater because of sorption on the geologic media. Based on the porosity and bulk density of the Triassic rocks and their distribution coefficients for the various radionuclides, retardation factors of 49 and 480 for Sr-90 and Cs-137 were determined. From these retardation factors, the radionuclide travel times from the two units are as shown in Table 5.9.

Table 5.9 Radionuclide travel times

Radionuclide	Unit	Travel time, years
Sr-90	1	400
Sr-90	2	330
Cs-137	1	3900
Cs-137	2	3200

These times compare with 5.7 years for Sr-90 and 51 years for Cs-137 for the generic site in the LPGS. These longer travel times would result in a significant reduction in the quantity of radionuclides entering the surface water compared to that of the LPGS. This reduction factor would be more than 1000 for Sr-90 and 10^{32} for Cs-137.

Without further analysis, the staff can conclude that the liquid pathway consequences of an assumed core-melt accident at Shearon Harris would be less than those calculated in the LPGS. The staff therefore concludes that Shearon Harris is not unique in its liquid pathway contribution to risk when compared to other land-based sites. Finally, there are measures that could be taken to further minimize the impact in the event of a major release to the groundwater. The staff estimated that the minimum travel time to the reservoir would be 6.7 years and that the holdup of much of the radioactivity would be much greater. This would allow ample time for engineering measures to be taken so that radioactive contamination may be isolated near the source.

(6) Risk Considerations

Environmental Risks

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 is also 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 5.10 shows average values of risk associated with population dose, early fatalities (with and without relocation of people between 16 and 40 km from the plant), latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by multiplying the probabilities by the consequences and summing these products over the entire range of the consequence distribution. Because the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

Table 5.10 Average values of environmental risks due to accidents per reactor-year

Environmental risk	Average value
Population exposure	
Person-rems within 80 km	42
Total person-rems	114
Early fatalities	
Evacuation to 16 km	1.8×10^{-4}
Evacuation to 16 km and relocation between 16-40 km	2.2×10^{-5}
Latent cancer, fatalities	
All organs excluding thyroid	6.7×10^{-3}
Thyroid only	2.1×10^{-3}
Cost of protective actions and decontamination, 1980 dollars	3770

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

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 plant personnel) shows that the accident risks are comparable to 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 0.00018 per reactor-year, however, the staff notes that a good approximation of the population at risk is that within about 16 km (10 miles) of the plant, which is about 30,000 persons in the year 2010. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 6.6 from motor vehicle accidents, 2.3 from falls, 0.9 from drowning, 0.9 from burns, and 0.4 from firearms. 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 5.13 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

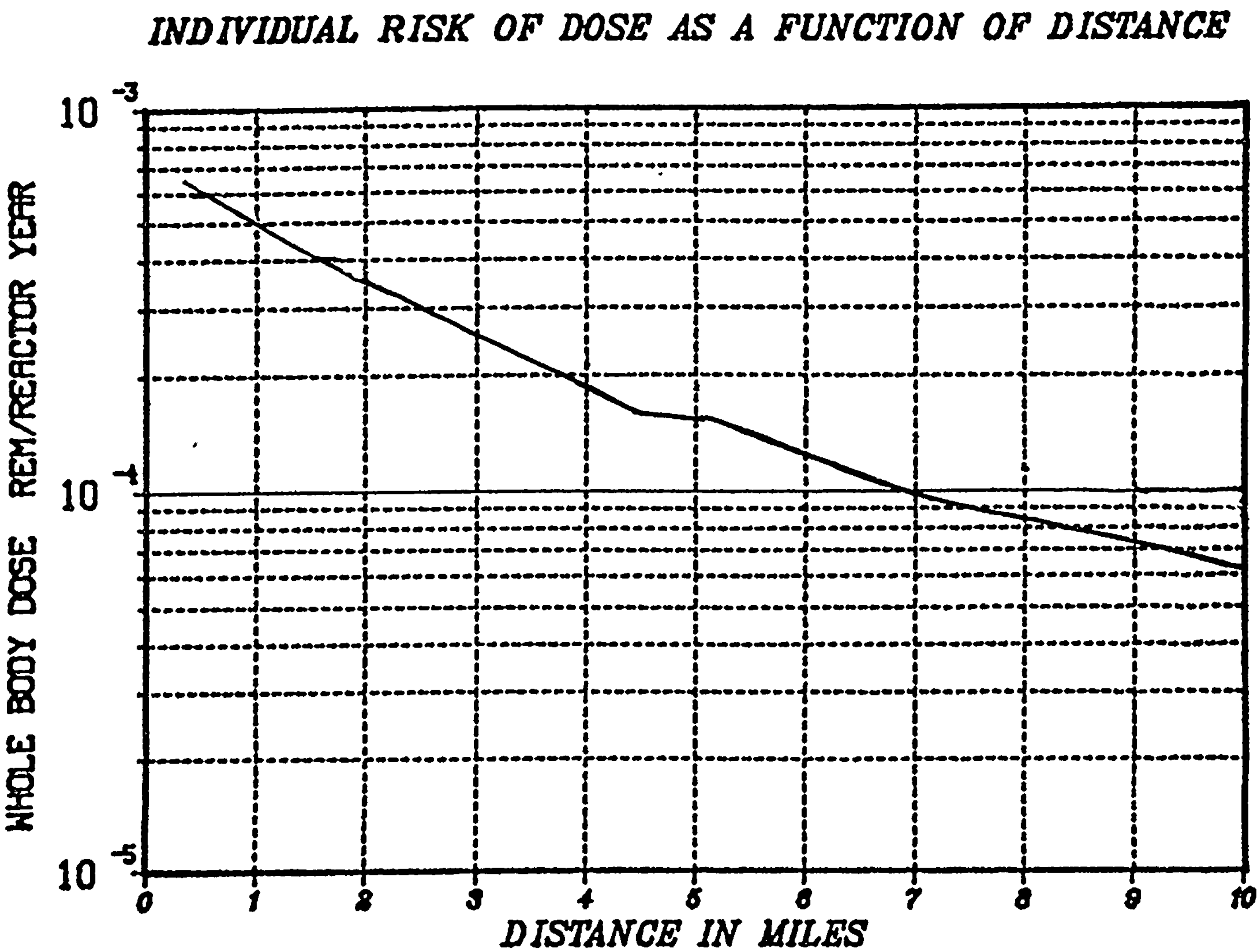


Figure 5.13 Individual risk of dose as function of distance (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates). (To convert mi to km, multiply by 1.6093.)

within the plume exposure pathway zone. The values are on a per-reactor-year basis, and all accident sequences and release categories in Table 5.7 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 5.14 shows the isopleths of constant risk per reactor-year to an individual living within the plume exposure pathway zone of the Shearon Harris site, of early fatality as functions of distance resulting from potential accidents in the reactor. Figure 5.15 shows the same type of isopleths for risk of latent cancer fatality. Directional variation of these plots reflects the variation in the average fraction of the year the wind would be blowing in different directions from the plant. For comparison, the following risks of fatality per year to an individual living in the United States may be noted (CONAES, page 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}.

In Section 5.9.4.2 it was recognized that fallout on open bodies of water of radioactivity released to the atmosphere from reactor accidents could lead to radiation exposure to humans. The staff evaluated the contribution of accident release fallout on adjacent water bodies in Addendum 1 to the Final Environmental Statement for Fermi Unit 2 (NUREG-0769) and the Final Environmental Statement for Perry Units 1 and 2 (NUREG-0884) and found that the likely fallout on adjacent open bodies of water constitutes insignificant risk compared to other pathways. For Shearon Harris, therefore, the radiation exposure from aquatic pathways resulting from fallout on the adjacent Buckhorn reservoirs would not significantly contribute to the risk from other pathways analyzed. Furthermore, the risk contribution attributable to fallout on the sea water (salt water) would be even smaller compared to exposures from previously considered pathways, mainly because of the distance from the site and the large dilution that would be provided by the sea and related edible fish harvest and, further, because of the absence of drinking water as a pathway of exposure and the reduced population in overwater directions.

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 cause substantial quantities of sulfur dioxide and nitrogen oxides to be emitted into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (CONAES, pages 559-560). This effect has not, however, been sufficiently quantified for a useful comparison to be drawn at this time.

Other Economic Risks

There are other impacts that can be monetized, but that are not included in the cost calculations discussed in Section 5.9.4.5(4). These impacts, which would result from an accident to the facility, produce added costs to the public (i.e., ratepayers, taxpayers, and share holders). These costs would accrue from decontamination and repair or replacement of the facility (recovery costs) and from increased use of fossil fuels to provide replacement power during restoration of the facility. Experience with such costs is being accumulated as a result of the accident at Three Mile Island Unit 2.

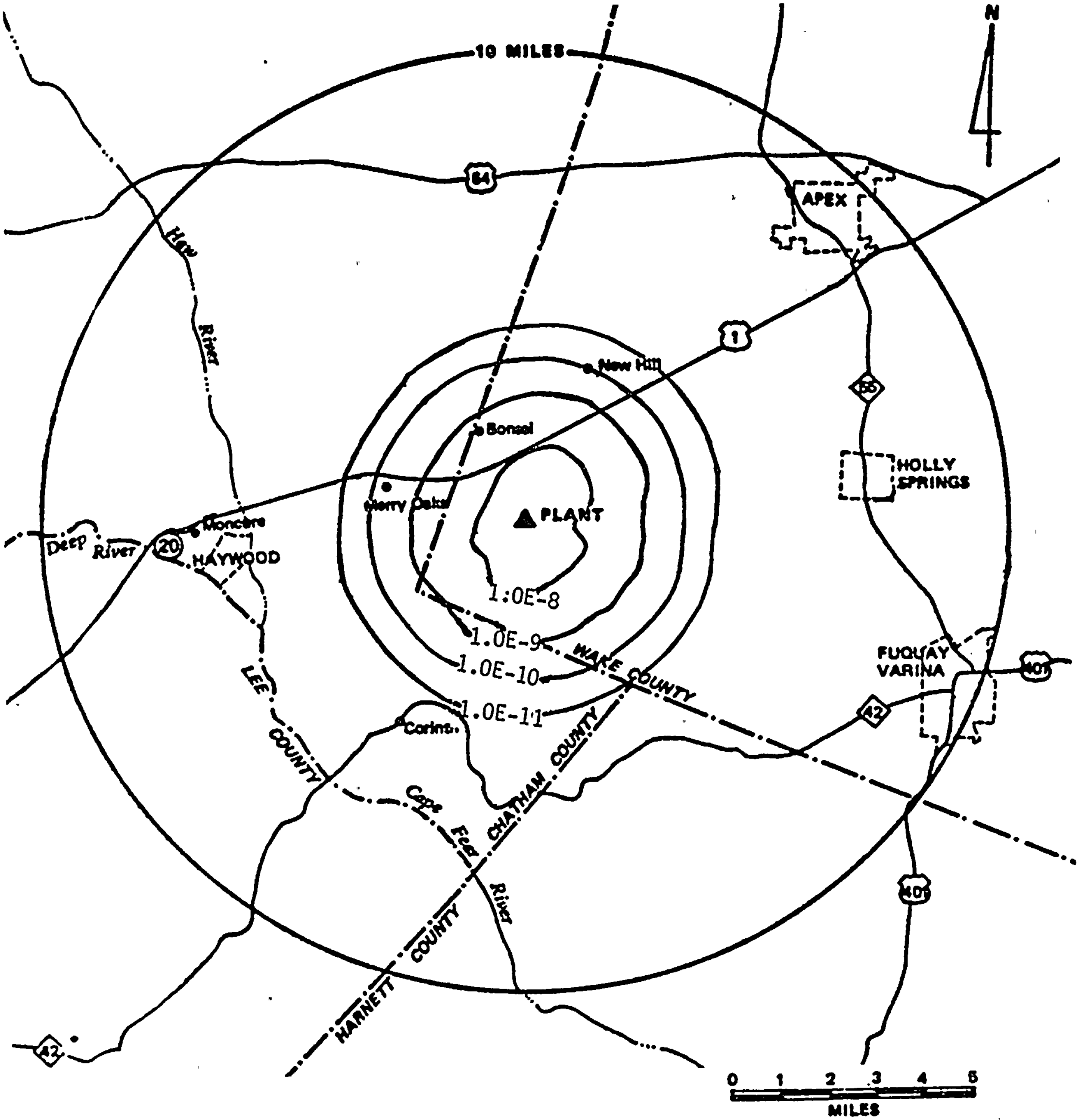


Figure 5.14 Isopleths of risk of early fatality per reactor-year to an individual. (To convert mi to km, multiply by 1.6093.) (Note: 1.0E-8 = 1 x 10^{-8}).

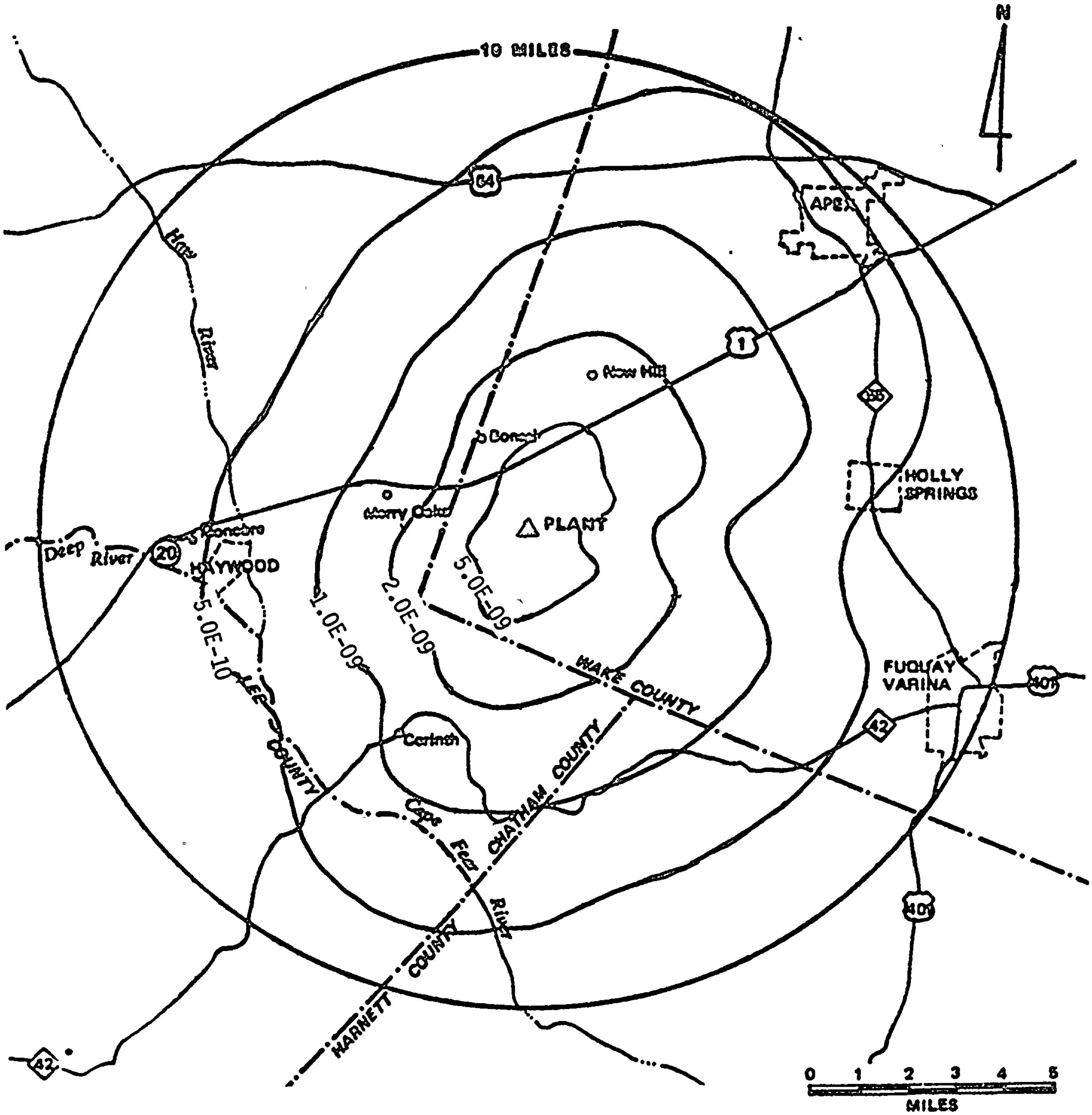


Figure 5.15 Isopleths of risk of latent cancer fatality per reactor-year to an individual. (To convert mi to km, multiply by 1.6093.) (Note: 5.0E-09 = 5 x 10^{-9}).

If an accident occurs during the first year of operation of Shearon Harris Unit 1 (1985), the economic penalty to which the public would be exposed would be approximately $1400 million (1985 dollars) for decontamination and restoration including replacement of the damaged nuclear fuel. This estimate is based on the escalation of the 1980 economic penalty determined for TMI-2 (Comptroller General). Although insurance would cover $300 million or more of the $1400 million accident cost, the insurance is not credited against this cost because the arithmetic product of the insurance payment and the risk probability would theoretically balance the insurance premium.

In addition, the staff estimates that system fuel costs would increase by approximately $57 million (1985 dollars) for replacement power during each year Shearon Harris Unit 1 is out of service. This estimate assumes that the unit will operate at an average 55% capacity factor and that replacement energy will be provided primarily from coal-fired generation. Assuming the unit does not operate for 8 years, the replacement power cost would amount to $456 million (in 1985 dollars).

The probability of a core melt or severe reactor damage is assumed as high as 10^{-4} per reactor year (this type of accident probability accounts for all severe core damage accidents leading to significant economic consequences for the owner). Multiplying the previously estimated costs of $1856 million (the sum of the replacement power and recovery costs) for an accident to Shearon Harris Unit 1 during the initial year of its operation by the above 10^{-4} probability results in an economic risk of approximately $185,600 (1985 dollars) applicable to Shearon Harris Unit 1 during its first year of operation. This is also the approximate economic risk (1985 dollars) anticipated for the second and each subsequent year of the unit's operation. Although the economic consequences of an accident tend to lessen as the unit ages (the unit depreciates in value and may operate at a reduced capacity factor), this tendency is offset by higher future costs of decontamination and restoration. The economic risk to Shearon Harris Unit 2 is also approximately $185,600 (1985 dollars) during the first year and each subsequent year of operation.

A severe accident that requires the interdiction and/or decontamination of land areas is likely to force numerous businesses to temporarily or permanently close. These closures would have additional economic effects beyond the contaminated areas through the disruption of regional markets and sources of supplies. This section provides estimates by bounding the range of these impacts; the estimates were made using: (1) the RSS consequence model discussed above and (2) the Regional Input-Output Modeling System (RIMS II), developed by the Bureau of Economic Analysis (BEA) (NUREG/CR-2591).

The industrial impact model developed by BEA is based on contamination levels of a physically affected area defined by the RSS consequence model. Contamination levels define an interdicted area immediately surrounding the plant, followed by an area of decontamination, an area of crop interdiction, and, finally, an area of milk interdiction.

Specific assumptions used in the analysis are

- In the interdicted area all industries would lose total production for more than a year.

- In the decontamination zone there would be: a 3-month loss in nonagricultural output; a 1-year loss in all crop output, except there would be no loss in greenhouse, nursery, and forestry output; a 3-month loss in dairy output; and a 6-month loss in livestock and poultry output.

- In the crop interdicted area there would be: no loss in nonagricultural output; a 1-year loss in agricultural output, except there would be no loss in greenhouse, nursery, and forestry output; no loss in livestock and poultry output; and a 2-month loss of dairy output.

- In the milk interdiction zone there would be a 2-month loss in dairy output.

The industry-specific impacts are estimated for three levels of accident severity. The most severe accident sequences, the Event V and TMLB' accident sequences, resulted in very similar affected areas, as determined by the RSS consequence model, and were treated as having the same impacts. However, the probabilities of the Event V and TMLB' differ. The other accident sequences considered are the PWR 3 and PWR 7.

Because of the computational burden of using the BEA model for all wind vectors, the northeast and south-southwest vectors were chosen because they are likely to result in the widest range of industrial impacts. The northeast wind direction is into Wake County toward Raleigh, North Carolina. The south-southwest direction is toward Harnett County, North Carolina.

The estimates of industrial impacts are made for an economic study area that consists of a physically affected area and a physically unaffected area. An accident that causes an adverse impact in the physically affected area (for example, the loss of agricultural output) could also adversely affect output in the physically unaffected area (for example, food processing). In addition to the direct impacts in the physically affected area, the following additional impacts could occur in the physically unaffected area:

(1) decreased demand (in the physically affected area) for output produced in the physically unaffected area

(2) decreased tourism

(3) decreased availability of production inputs purchased from the physically affected area

Only the impacts occurring during the first year following an accident are considered. The longer term consequences are not considered because they will vary widely, depending on the level and nature of efforts to mitigate the accident consequences and decontaminate the physically affected areas.

Three estimates are provided for each of the levels of accident severity (Event V and TMLB', PWR 3, and PWR 7). The estimates vary according to assumptions made about the ways in which the regional economy will adjust (compensate) following an accident. The first estimate assumes no compensating effects. This assumption produces the largest estimates of industrial imapcts. The second estimate assumes there exists unused capacity in the physically unaffected area that can be utilized. This reduces the industrial impacts of the accident because losses in the affected area are mitigated by the increased production in the unaffected area. Finally, the third estimate assumes unused capacity exists in the physically unaffected area and that individuals displaced from their jobs maintain the same income and spending habits. This produces the smallest industrial impacts. The estimates, based on the compensating effects, assume the adjustments occur immediately following the accident. Realistically these effects would occur over a lengthy period. The estimates using no compensating effects are the best measures of first year economic impacts.

Table 5.11 shows employment losses for each wind direction and for the three accident sequences and are presented on an annual basis. For example, because agricultural output in the decontamination area is lost for 3 months, a job lost in this area is counted as one-fourth of a job. In the case of Event V and TMLB' sequences, total employment loss in all industries directly affected by the accident would contribute to the annual risk of from 0.23 to 0.86 employees, depending on wind direction (south-southwest and northeast, respectively). This is an insignificant fraction of a total employment in the economic area surrounding the site. The employment losses for the other accident sequences are considerably lower.

Table 5.11 also shows estimates of the value of lost output from the decreased industrial activity. The results are shown for each type of accident and wind direction and for direct losses, partially compensated losses, and fully compensated losses. For example, total output loss risk--excluding the loss of electric power generated by the Shearon Harris plant--is $5935 per reactor-year (1980 dollars) for the Event V and TMLB' sequences with wind direction toward the south-southwest. The risk of these losses would be reduced to $1235 per reactor-year if industrial output were able to increase in the physically unaffected area and households were able to resume normal consumption (fully compensated losses). These risks were calculated by multiplying the consequence values presented in Table 5.11 by the probabilities of the occurrence of the sequences listed in the table.

In addition to the direct effects in agriculture (primarily in fruits, vegetables, and tobacco) major impacts of an Event V or TMLB' would occur primarily in services, textile mill products, electrical and electronic machinery, and food and kindred products. Employment loss risks range from 0.17 employee per reactor-year (northeast wind direction) to 0.12 (south-southwest wind direction) when consequences of Event V and TMLB' are considered. Losses as a result of decreased exports to the physically affected area are small. Industries affected by a PWR 3 would be similar to those affected by an Event V or TMLB'. However, direct losses from a PWR 7, the least severe scenario considered, are limited to agriculture and indirect losses in tourist-related industries.

For each wind direction, the risk associated with industrial impacts is estimated by multiplying the probabilities of the accident sequences (TMLB', Event V, PWR 3, PWR 7) by the associated consequences. The overall risk associated with these four sequences is then estimated as the sum of the individual products. The risk calculations use consequences with none of the compensating effects discussed earlier because of the time required before the compensating effects could occur. Because the south-southwest and northeast wind directions are

Table 5.11 Private sector industrial impacts as a result of hypothetical reactor accident at the Shearon Harris Nuclear Power Plant[1]

Impact	Event V-TMLB' NE	Event V-TMLB' SSW	PWR 3 NE	PWR 3 SSW	PWR 7 NE	PWR 7 SSW
Employment losses (thousands of jobs annually)						
Direct losses in the physically affected area:						
Direct losses[2]	172	46	51	26	*	**
Partially compensated losses[3]	144	34	36	20	*	**
Fully compensated losses[4]	29	11	7	8	*	**
Indirect losses in the physically unaffected area as a result of:						
Decreased exports	4	2	0	1	0	0
Tourist avoidance	34	24	33	24	17	17
Supply constraints	7-50	12	6-16	11	None	None
Output losses in the physically affected area (millions of 1980 dollars)						
Direct losses[2]	4610	1187	1388	750	*	**
Partially compensated losses[3]	3476	798	872	483	---	---
Fully compensated losses[4]	820	247	197	221	---	---

[1]Methdology based on NUREG/CR-2591.

[2]Direct losses in the physically affected area.

[3]Partially compensated losses would occur if output increases up to the maximum desired capacity in the physically unaffected area, but households do not resume normal consumption.

[4]Fully compensated losses would occur if output increases up to maximum desired capacity in the physically unaffected area, and households resume normal consumption.

*Fewer than 50 jobs in dairy farm production are affected in this scenario. This translates into losses in agriculture of less than $295,000 in earnings and $385,00 in output.

**Fewer than 50 jobs in dairy farm production are affected in this scenario. This translates into losses in agriculture of less than $80,000 in earnings and $100,000 in output.

felt to result in minimum and maximum consequences, respectively, the estimated overall risk values expressed on a per-reactor-year basis, $8,000 for south-southwest and $27,000 for northeast, bound the range of risks from other wind directions.

(7) Uncertainties

The probabilistic and risk assessment discussion above has been based on the methodology presented in the RSS, which was published in 1975.

In the consequence calculations, uncertainties arise from an over-simplified 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 estmates of health effects, particularly the estimates 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 the 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 that exert considerable influence on the calculated results have uncertain values. The 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 release that determines the cross-wind spread of the plume is another parameter of considerable uncertainty. Warning time before evacuation also has considerable impact on the effectiveness of offsite emergency response; this parameter is not precisely calculated because of its dependence on other parameters (e.g., 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 judgment of the staff that the uncertainty bounds could be well over a factor of 10, but are not likely to be as large as a factor of 100.

5.9.4.6 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the Shearon Harris facility. 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) that, in order to obtain a license to operate the Shearon Harris facility, the applicant must comply with the applicable Commission regulations and requirements, and (3) a probabilistic assessment of the risk based upon the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is on the same order as 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 accidental deaths from other human activities in a comparably sized population.

The staff has concluded that there are no special or unique circumstances about the Shearon Harris site and environs that would warrant special mitigation features or operating procedures for the Shearon Harris plant.

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, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," 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 AEC report WASH-1248, "Environmental Survey of the Uranium Fuel Cycle." The NRC staff was also directed to develop an explanatory narrative that would convey in understandable terms the significance of releases in the table. The narrative was also to address such important fuel cycle impacts as environmental dose commitments and health effects, socioeconomic impacts, 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 those impacts of the LWR-supporting fuel cycle that reasonably appear to have significance for individual reactor licensing sufficient to warrant attention for NEPA purposes.

Table S-3 of the final rule is reproduced in its entirety as Table 5.12 of this report. Specific categories of natural resource use included in the table relate to land use, water consumption and 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 that found the S-3 rule invalid "due to their failure to allow for proper consideration of the uncertainties that underlie the assumption that solidified high-level and transuranic wastes will not affect the environment once they are sealed in a permanent repository" (Natural Resources Defense Council vs. NRC, No. 74-1586, D.C. Circuit). By its order of September 1, 1982, the D.C. Circuit delayed implementation of its earlier decision pending the filing of application for review of the decision by the U.S. Supreme Court. On November 1, 1982, the Commission issued a Statement of Policy concerning this decision (see 47 FR 50591, November 8, 1982). The Commission views the decision by the D.C. Circuit not as a finding of fault with the evidentiary record on waste management impacts and uncertainties, but rather as a rejection of the Commission's policy judgments regarding the weight and effect that those impacts and uncertainties should exert in reactor licensing. In summary, the Commission "directs its Licensing and Appeal Boards to proceed in continued reliance on the S-3 rule until further order from the Commission, provided that any license authorizations or other decisions issued in reliance on the rule are conditioned on the final outcome of the judicial proceedings."

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 Shearon Harris facility. The environmental impacts are based on the values given in Table S-3, and on an analysis of the radiological impact from radon-222 and technetium-99 releases. The NRC 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) due to 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 Measures and Controls To Limit Adverse Impacts

5.11.1 Atmospheric Monitoring

Onsite meteorological measurements began in March 1973, as discussed in the PSAR. However, no description of this onsite program was included in the RFES-CP issued in 1974. In January 1976, a meteorological measurement program was initiated in accordance with RG 1.23. The measurements include wind direction and speed at approximately the 10- and 60-m levels of the 76-m meteorological tower. Vertical temperature differences between these two levels are used as measures of atmospheric stability. Ambient and dew point temperature as well as precipitation, atmospheric pressure, and solar radiation are measured near ground level in the vicinity of the meteorology tower. Figure 5.16 illustrates a fairly uniform wind direction distribution of wind flow at the lower

Table 5.12 (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.
HCl	.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:
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	.4	NH_3—600 cfs. NO_3—20 cfs. Fluoride—70 cfs.
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 5.12 (Summary Table S-3) (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.

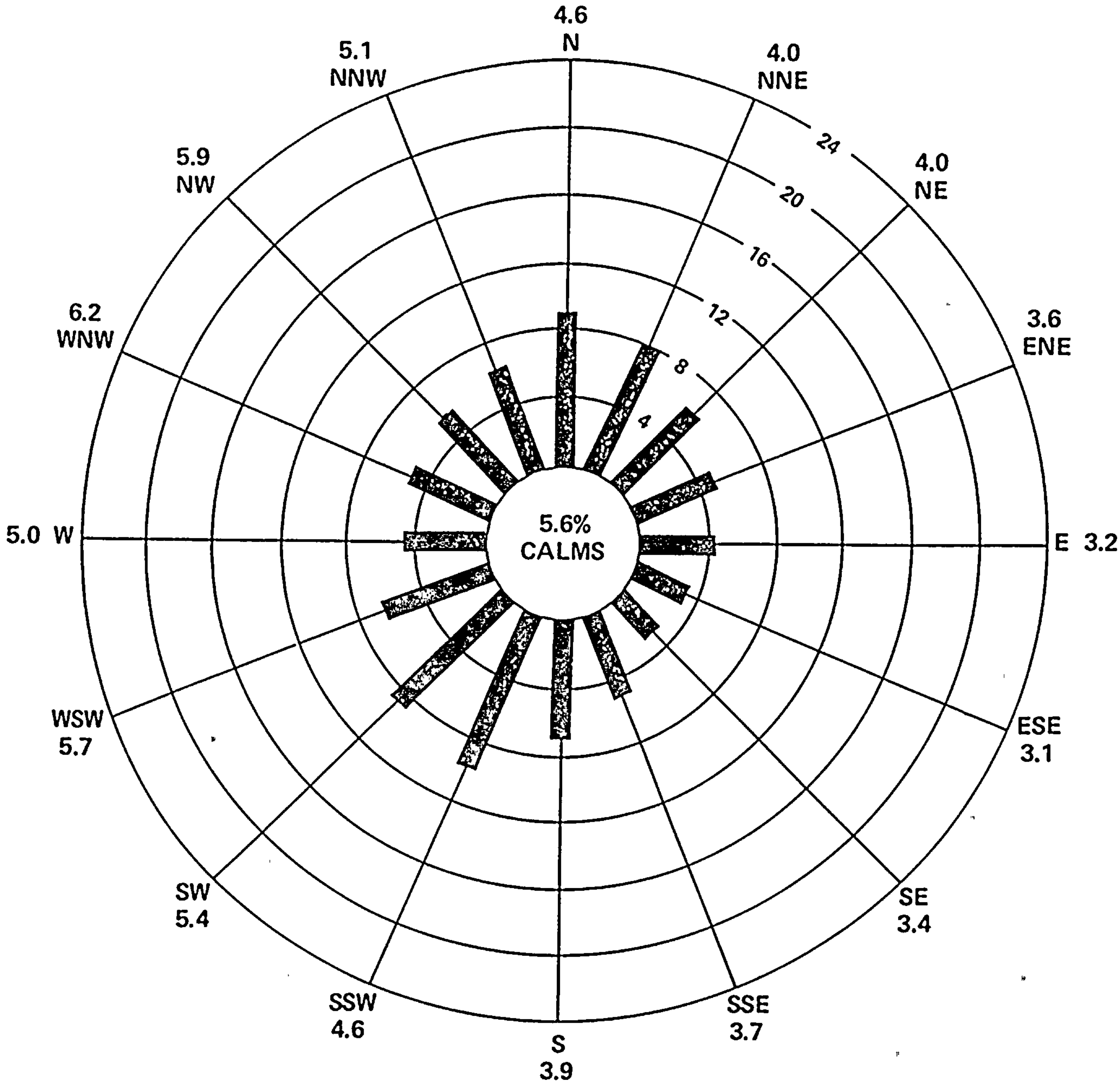
[8] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

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

[10] 1.2 percent from natural gas use and process.

level of the tower, with wind from the southwest and northeast quadrants having slightly greater frequencies than the other directions.

The preoperational monitoring program will be continued as the operational program. The capability of providing real time meteorological data displays in the control room will be added. These data will also be used in conjunction with the plant radiation monitoring system to assess doses from radioactive gaseous releases.



$\overline{U}$ = 4.6 MPH

$\overline{U}$ = ALL DIRECTION AVERAGE WIND SPEED

NOTE: DIRECTIONAL AVERAGE WIND SPEEDS (MPH) ARE DISPLAYED RADIALLY

WIND DIRECTION (%)

1/14/76 - 12/31/78

Figure 5.16 Site wind rose, 12.5-m level

5.11.2 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 North Carolina Department of Natural Resources and Community Development, Division of Environmental Management (DEM). The applicant received an NPDES permit effective from July 12, 1982 through June 30, 1987. A copy of the NPDES permit is included as Appendix G.

The NPDES permit sets limits and monitoring requirements on cooling tower blowdown and discharges from sanitary waste treatment, metal cleaning wastes, low volume wastes and point source runoff from construction. Also, the permit requires that each parameter identified in the various waste streams shall not result in violation of Class C water quality standards. The Class C designation defines a water body suitable for fishing and for propagation of fish and wildlife.

In accordance with Part III, condition J of the NPDES permit, the applicant has submitted information to the DEM to demonstrate (under Section 316(b) of the Clean Water Act) that the best technology available was used to minimize adverse environmental impact at the water intake structures (Zimmerman, 1982). The NRC will rely on the decisions made by the State of North 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 plans to conduct an operational phase of the nonradiological environmental monitoring program (CP&L, 1982) that was initiated in 1972. However, the NRC will rely on the State of North Carolina, under the authority of the Clean Water Act, for the protection of water quality and aquatic biota and for any associated nonradiological monitoring that may be required during plant operation.

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.

The EPP will be included as Appendix B to the Shearon Harris 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. Examples of reportable important events include fish kills, occurrence and/or mortality of species protected by the Endangered Species Act, occurrence of nuisance organisms or conditions, and unanticipated or emergency discharge of waste water or chemical substances.

5.12 Noise Impacts

Sound pressure levels expected to occur from operation of Shearon Harris have been calculated for seven receptor locations (See Figure 5.17). Receptor locations A to G represent the points at which ambient noise measurements were made by the applicant (ER-OL Section 2.7.1). Locations B, C, E, and G were chosen by the applicant because they represent nearby noise-sensitive areas. Ambient noise measurements representing the residual, intrusion, median, and equivalent noise levels (the L_{90} or noise level exceeded 90% of the time, L_{10}, L_{50} and L_{eq}, respectively) were taken by the applicant over a time period of at least a day to determine diurnal variation. The measurements were taken when Shearon Harris was under construction. The ambient noise levels varied over space and time so that the equivalent noise level range was 27 to 67 dBA (noise measured as A-weighted sound level in dBA).

A computer model (Dun, Policastro, and Wastag, 1982), based largely on the Edison Electric Institute (EEI) Environmental Noise Guide, was used to predict the effect of plant noise at the above seven receptors. Calculations were made using only the following significant noise sources:

(1) the two natural draft cooling towers. The noise arises from the falling water inside the tower, and this noise is emitted from both the stacks and rims of the cooling towers.

(2) the six 336 MVA transformers located in the switchyard. The transformers have tones at frequencies 120, 240, 360, and 480 Hz.

Other noise sources at the site lead to insignificant contributions to community noise levels because of their location inside buildings, the intermittent nature of some sources, or the low sound power level of other sources. The relatively large distances from these sources to the nearby sensitive areas further underscores the negligible contribution from those sources. The two natural draft cooling towers and six transformers 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. Source data on the cooling tower noise came from the EEI Noise Guide. However, data on the noise level of the 336 MVA transformers came from Ver and Anderson (1977). Data on transformers of similar MVA rating were examined, and the staff chose the data that represented the strongest source of noise. A conservative assumption was also made in neglecting the attenuation as a result of intervening trees between the sources and receptors.

Model predictions indicated that no adverse community reaction should be expected for any of the above receptors. A summary of the results for location C are illustrated in Table 5.13.

Receptor C represents the closest sensitive area to the noise sources being considered. The lowest measured ambient at that site was also used, 28 dBA, which is quite low. Because no measurements of octave band sound pressure levels were made by the applicant, the computer model assumed an octave band sound pressure level spectrum that matched 28 dBA and was typical of rural-type conditions. Model predictions in Table 5.13 show the contributions of the

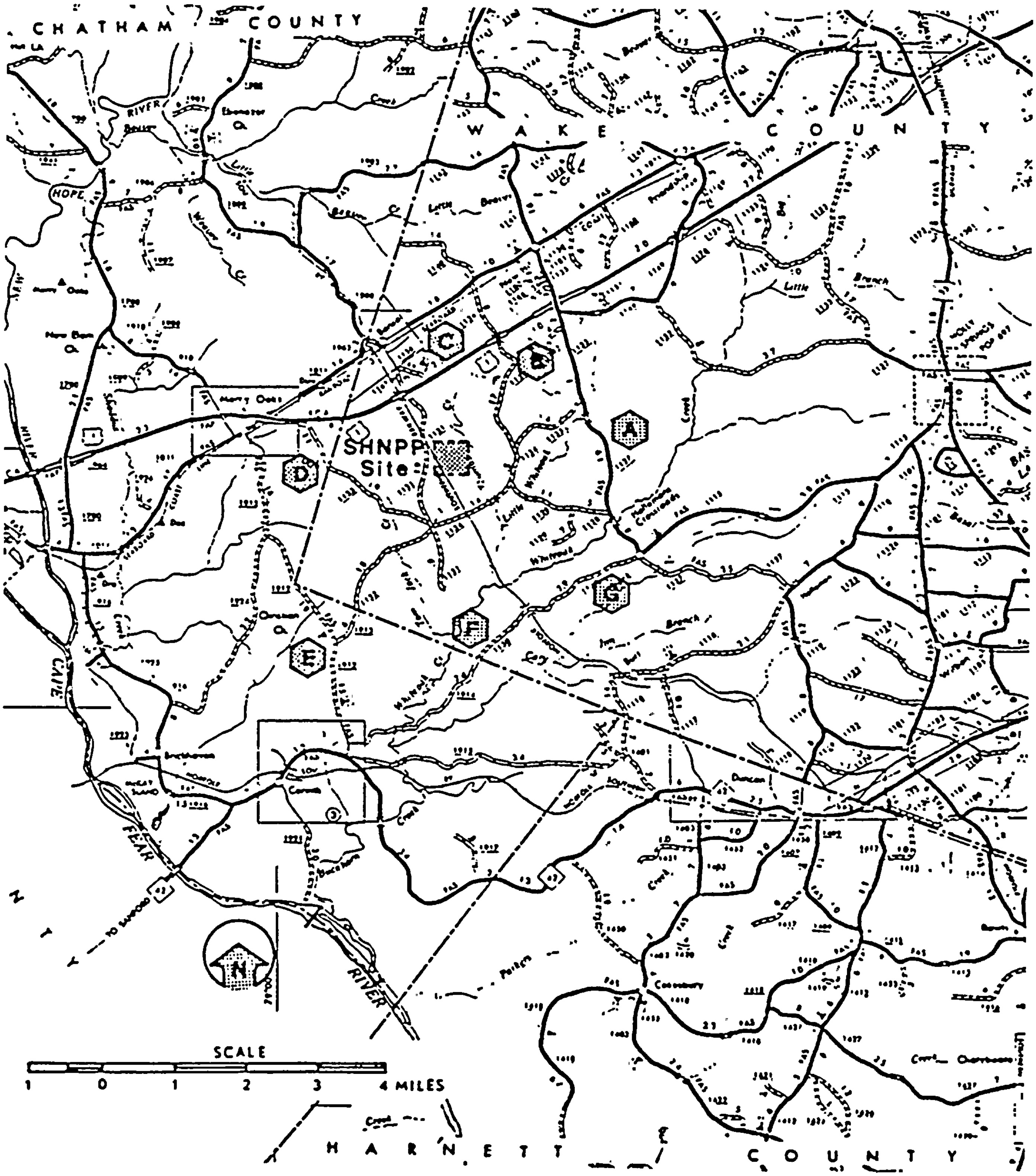


Figure 5.17 Ambient noise measurement locations in the Shearon Harris site vicinity (from ER-OL Figure 2.7.2-1)

Table 5.13 Contributions of the major noise sources to the noise level of community location C

Source	Sound Pressure Levels										
	Octave Band Levels (dB)									Totals	
	31	63	125	250	500	1000	2000	4000	8000	dBO	dbA
Two NDCTs (rim)	0	0	30	26	24	18	7	0	0	33	25
Two NDCTs (stack)	0	0	21	15	11	3	0	0	0	22	12
Six transformers	0	0	37	31	13	0	0	0	0	38	25
Total	0	0	38	33	25	19	7	0	0	39	28
Ambient	41	39	36	30	26	21	16	13	11	44	28
Grand total	41	39	40	35	28	23	17	13	11	45	31

individual sources to the sound pressure levels at receptor C along with the total, which includes ambient contributions. Note that for the broadband noise, the overall sound pressure level of the ambient is raised only 1 dB from 44 to 45 (an incremental increase indistinguishable to human ear) and the A-weighted sound pressure level is increased from 28 to 31 dBA.

Calculations of the audibility of transformer tones indicated that the 120 and 240 Hz frequencies add an amount 2 and 3 dB, respectively, above masking level. Anderson and Ver (1971) have found from community surveys that the probability of complaints is not significant unless the intruding tonal noise is 5 dB or more above masking level. Consequently, examination of the predicted broadband noise and the potential for annoyance because of the audibility of tones has revealed that no adverse community reaction would be expected from operation of the plant.

It should be recognized that because of trees between the noise sources and residences at location C attenuation may be significant. (This is specifically because of a thick conglomerate of trees to the north of the site.) Based on the computer model (Gordon, Piersol, and Wilby, 1978), 100 m of such trees (a conservative estimate for the Shearon Harris site) could lead to a noise reduction of at least an additional 5 dB between sources and receptor C, further reducing the already small impact of the broadband and tonal noise at community locations.

5.13 Decommissioning

The purposes of decommissioning are (1) to safely remove nuclear facilities from service and (2) 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 these purposes 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 to date no large commercial reactor has undergone decommissioning, 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; they 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 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.

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6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Impacts

The staff has reassessed the physical, social, biological, and economic impacts that can be attributed to the operation of the Shearon Harris station. These impacts are summarized in Table 6.1.

The applicant is required to adhere to the following conditions for the protection of the environment:

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

(2) The applicant will 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 license.

(3) If an adverse environmental effect or evidence of irreversible environmental damage is detected during the operating life of the plant, the applicant will 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 Short-Term Use and Long-Term Productivity

There have been no significant changes in the staff's evaluation for the Shearon Harris station since the construction permit stage environmental review.

6.4 Benefit-Cost Summary

6.4.1 Summary

Sections below describe the economic, environmental, and socioeconomic benefits and costs that are associated with the operation of the Shearon Harris station.

Table 6.1 Benefit-cost summary

Primary impact and effect on population or resources	Quantity (Section)	Impacts
BENEFITS		
Direct		
Electrical energy	9000×10^6 kWh/yr (Units 1 and 2)	Large
Additional capacity	1800×10^3 kW	Large
COSTS		
Environmental		
Damage suffered by other water users		
Surface water consumption	1.2 m^3/sec (42 ft^3/sec)	Small
Surface water contamination	(Section 5.3.2)	Small
Groundwater consumption	(Section 5.3.2)	None
Groundwater contamination	(Section 4.3.2)	None
Groundwater contamination	(Section 4.3.2)	None
Damage to aquatic resources		
Impingement and entrainment	(Section 5.5.2)	Small
Thermal effects	(Section 5.3.2)	Small
Chemical discharge	(Section 5.3.2)	Small
Cooling lake drawdown	(Section 5.5.2)	Small
Damage to terrestrial resources		
Station operations		
Cooling tower emissions	(Section 5.5.1)	Small
Cooling lake drawdown	(Section 5.5.2)	Small
Transmission line maintenance	(Section 5.5.1)	Small

6.4.3.2 Socioeconomic Costs

No significant socioeconomic costs are expected from the normal operation of the Shearon Harris station or from the number of station personnel and their families living in the area. The socioeconomic impacts of a severe accident could be large; however, the probability of such an accident is small.

6.5 Conclusion

As a result of its analysis and review of potential environmental, technical, and social impacts, the staff has prepared an updated forecast of the effects of operation of the Shearon Harris station. The staff has determined that the Shearon Harris station can be operated with minimal environmental impact. No new information has been obtained that alters the overall favorable balancing of the benefits of station operation versus the environmental costs that resulted from evaluations made at the construction permit stage.

6.6 References

U.S. Nuclear Regulatory Commission, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning Nuclear Facilities," January 1981.

Table 6.1 (continued)

Primary impact and effect on population or resources	Quantity (Section)	Impacts
Adverse nonradiological health effects		
Water quality changes	(Section 5.3.2)	None
Air quality changes	(Section 5.4)	
Adverse radiological health effects		
Routine operation	(Section 5.9.3)	Small
Postulated accidents	(Section 5.9.4)	Small
Uranium Fuel Cycle	(Section 5.10)	Small
Adverse socioeconomic effects		
Loss of historic and archeological resources	(Section 5.7)	Small
Traffic	(Section 5.8)	Small
Demands on public facilities and services	(Section 5.8)	Small
Demands on private facilities and services	(Section 5.8)	Small
Noise	(Section 5.12)	Small

6.4.2 Benefits

The benefit from the operation of the Shearon Harris station is the approximately 9 billion kWh of baseload electrical energy that will be produced annually (assuming that both units will operate at annual average capacity factors of 55%). The addition of the plant will improve the applicant's ability to supply system load requirements by contributing 1800 MW of generating capacity to the Carolina Power and Light Company system.

6.4.3 Costs

6.4.3.1 Environmental Costs

The environmental costs were evaluated at the construction permit stage and have not adversely changed to any significant degree. No significant environmental costs are expected from the operation of the plant, including considerations of the uranium fuel cycle and plant accidents.

7 LIST OF CONTRIBUTORS

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8 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS TO WHOM COPIES OF THIS DRAFT ENVIRONMENTAL STATEMENT ARE BEING SENT

Advisory Council on Historic Preservation

Department of Agriculture

Department of Commerce

Department of Energy

Department of Health and Human Services

Department of Health and Urban Development

Department of the Army, Corps of Engineers

Department of the Interior

Department of Transportation

Environmental Protection Agency

Federal Emergency Management Administration

North Carolina Office of the Governor

North Carolina Office of Intergovernmental Relations

South Carolina Office of the Governor

South Carolina Department of Health and Environmental Control

Triangle J Council of Governments (North Carolina)

Chairman, Board of County Commissioners of Wake County (North Carolina)

Chairman, Board of County Commissioners of Chatham County (North Carolina)

9 SPACE 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

APPENDIX B
NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 miles) of the Shearon Harris facility, employing the same dose calculation models used for individual doses (see RG 1.109, Revision 1), for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR 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 of 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 RG 1.111, Revision 1, is used in conjunction with the dose models in RG 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. This assumption was tested and found to be reasonable for the Shearon Harris station.

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 RG 1.111, Revision 1, and the dose models described in RG 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 U.S. toward the northeastern corner of the U.S. 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 U.S. 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/s.

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 in the rivers and in atmospheric moisture. The concentration of tritium in the world's circulating water is estimated at the time after 20 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 RG 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, K. F. Eckerman, et al., "User's Guide to GASPAR Code," June 1980.

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---, RG 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

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the 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 (LWR) 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 Shearon Harris 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 x 10^6 m^3 (11.4 x 10^9 gal), about 42 x 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 x 10^6 m^3 (16 x 10^7 gal) per year and water discharged to the ground (for example, mine drainage) of about 0.5 x 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 x 10^6 m^3 per year is about 2% of that from the model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle

*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.

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 report (CEQ, 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 U.S.; 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 U.S. from plants associated with the fuel-cycle operations will be subject to requirements and limitations set forth in the NPDES permit.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient 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-ore 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 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.

*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 millirems and a stabilized U.S. population of 300 million.

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 <u>Perkins</u> record in a "lead case" approach, the 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 <u>Perkins</u> 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 <u>Perkins</u> record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to 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) permits intervenors a 60-day period to challenge the <u>Perkins</u> record on the potential health effects of radon-222 emissions.

**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

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.

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)		
Radon source	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

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.

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

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 range 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 (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 millirems. 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 gastro-intestinal 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 millirems. 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. Radioactive Wastes

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

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

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.

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

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

APPENDIX D

EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

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 Shearon Harris facility are estimated on the basis of the description of the radwaste systems in the applicant's FSAR and by using the calculational models and parameters described 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-mile) radius of the plant as a result of plant operations are discussed in detail in RG 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 20 years after the station begins operation (that is, the mid-point of station operation). For younger persons, changes in organ mass and metabolic parameters with age after the initial intake of radioactivity are accounted for.

2. Dose Commitments from Radioactive Effluent Releases

The NRC staff's estimates of the expected airborne releases (listed in Table D-1) along with the site meteorological considerations (discussed in Section 5.11 and summarized in Table D-2) were used to estimate radiation doses and dose commitments. Individual receptor locations and pathway locations considered for the maximally exposed individual in these calculations are listed in Table D-3.

The staff has performed an independent calculation of annual average relative concentration (χ/Q) and relative deposition (D/Q) values using the straight-line Gaussian atmospheric dispersion model described in RG 1.111, modified to reflect spatial and temporal variations in airflow. Ground-level releases using a 3-year period of record were evaluated.

Releases through the unit vent have been considered as ground level using the criteria described in RG 1.111. Other releases including those from the turbine and radwaste building also were considered as ground level with mixing in the turbulent wake of plant structures. Intermittent releases from the containment vent have been evaluated using the methodology described in NUREG-0324. A 3-year period of record (1976-1978) of onsite meteorological data was used for this evaluation. Wind speed and direction data were based on measurements made at the 12.5-m level, and atmospheric stability was defined by the vertical temperature gradient measured between the 11- and 60-m levels.

The NRC staff estimates of the expected liquid releases (listed in Table D-4), along with the site hydrological considerations (discussed in Section 2.3 and summarized in Table D-5), were used to estimate radiation doses and dose commitments from liquid releases).

(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 also 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 Table E-4 and E-5 of Revision 1 of RG 1.109.

(b) Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne and waterborne radioactive releases from the Shearon Harris facility are estimated for two populations in the year 2000: (1) all members of the general public within 80 km (50 miles) 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, F. P. Cardile and R. R. Bellamy (editors), "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.

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

---, RG 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.

Table D-1 Calculated releases of radioactive materials in gaseous effluents from Harris (Ci/yr per reactor)

Nuclides	Reactor building, Interm't*	Reactor building, Cont.	Auxiliary building, Cont.	Turbine building, Cont.	Air ejector exhaust, Cont.	Waste gas system and volume reduction system, Cont.
Ar-41	a	25	a	a	a	a
Kr-83m	a	1	a	a	a	a
Kr-85m	a	13	3	a	2	a
Kr-85	a	4	a	a	a	203
Kr-87	a	3	2	a	1	a
Kr-88	a	18	5	a	3	a
Kr-89	a	a	a	a	a	a
Xe-131m	a	9	a	a	a	4
Xe-133m	a	40	2	a	2	a
Xe-133	28	2200	120	a	73	3
Xe-135m	a	a	a	a	a	a
Xe-135	a	63	8	a	5	a
Xe-137	a	a	a	a	a	a
Xe-138	a	a	1	a	a	a
			Total Noble Gases			2841
Mn-54	0.0000008	0.00022	0.00018	b	b	0.0045
Fe-59	0.0000003	0.000074	0.00006	b	b	0.0015
Co-58	0.000003	0.00074	0.0006	b	b	0.015
Co-60	0.000001	0.00034	0.00027	b	b	0.007
Sr-89	0.00000006	0.000017	0.00013	b	b	0.00033
Sr-90	0.00000001	0.000003	0.0000024	b	b	0.00006
Cs-134	0.0000008	0.00022	0.00018	b	b	0.0057
Cs-137	0.000001	0.00038	0.0003	b	b	0.0085
I-131	a	0.012	0.0046	0.00056	0.029	0.033
I-133	a	0.011	0.0069	0.00079	0.043	0.031
H-3	a	156	624	a	a	
C-14	a	1	a	a	a	7

*Intermittent release, four 2-hr releases per year from reactor building ventilation.

[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.

Note: Interm't. = Intermittent; Cont. = Continuous

Table D-2 Summary of atmospheric dispersion factors (χ/Q) and relative deposition values for maximum site boundary and receptor locations near the Harris nuclear facility*

Location**	Source***	χ/Q (sec/m^3)	Relative deposition (m^{-2})
Nearest effluent-control boundary (2.1 km N of Units 1 and 2	A	7.4×10^{-6}	7.1×10^{-9}
	B	4.0×10^{-5}	3.8×10^{-8}
Nearest residence and garden (2.7 km NNE of Units 1 and 2)	A	4.0×10^{-6}	4.8×10^{-9}
	B	1.9×10^{-5}	2.3×10^{-8}
Nearest milk cow and meat animal (2.9 km N of Units 1 and 2)	A	3.8×10^{-6}	3.2×10^{-9}
	B	2.5×10^{-5}	2.1×10^{-8}
Nearest milk goat (7.4 km NNW of Units 1 and 2)	A	4.9×10^{-7}	2.5×10^{-10}
	B	6.0×10^{-6}	3.1×10^{-9}

*The values presented in this table are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with RG 1.111, Rev. 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

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

***Sources:

A - Reactor (containment), auxiliary and turbine buildings, waste gas processing system, and air ejector exhaust are all continuous ground level release sources.

B - Reactor building, intermittent ground level release, four releases per year, 2 hours each release.

Table D-3 Nearest pathway locations used for maximally exposed individual dose commitments for the Harris nuclear facility

Location	Sector	Distance (km)
Nearest effluent-control boundary*	N of Units 1 and 2	2.1
Residence and garden**	NNE	2.7
Milk cow	N	2.9
Milk goat	NNW	7.4
Meat animal	N	2.9

*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 Shearon Harris Units 1 and 2

Nuclide	Ci/yr per reactor*	Nuclide	Ci/yr per reactor
Corrosion and Activation Products		Fission products (cont'd)	
Cr-51	0.00017	Te-129	0.00008
Mn-54	0.00007	I-130	0.00007
Fe-55	0.00018	Te-131m	0.00004
Fe-59	0.0001	I-131	0.14
Co-58	0.0019	Te-132	0.00074
Co-60	0.00053	I-132	0.0014
Zr-95	0.00005	I-133	0.028
Nb-95	0.00007	Cs-134	0.013
Np-239	0.00002	I-135	0.0033
		Cs-136	0.0042
		Cs-137	0.010
Fission Products		Ba-137m	0.0084
Br-83	0.00001	Ba-140	0.00002
Rb-86	0.00002	La-140	0.00002
Sr-89	0.00004	Ce-144	0.00018
Mo-99	0.0021		
Tc-99m	0.0020		
Ru-106	0.00008	All Others	0.00006
Ag-110m	0.00002	Total (except H-3)	0.2
Te-127m	0.00003	H-3	370
Te-127	0.00003		
Te-129m	0.00013		

*Nuclides whose release rates are less than 10^{-5} Ci/yr per 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 Harris nuclear facility*

Location	Transit time (hours)	Dilution factor
ALARA Dose Calculations		
Nearest drinking-water intake Lillington, North Carolina	24	96
Nearest sport-fishing location (discharge area)**	24	1
Nearest shoreline (bank of Harris Main Reservoir near discharge area)	0.1	1
Population Dose Calculations		
Discharge point in Harris Main Reservoir		
Sport Fish	168	1
Commercial Fish	240	1
80-km Cape Fear River segment downstream from Harris Main Reservoir		
Commercial Fish	480	96

*See RG 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

**Assumed for purposes of an upper limit estimate; detailed information not available.

Table D-6 Annual dose commitments to a maximally exposed individual near the Harris plant

Location	Pathway	Doses (mrems/yr per unit, except as noted)			
		Noble Gases in Gaseous Effluents			
		Total Body	Skin	Gamma Air Dose (mrads/yr/unit)	Beta Air Dose (mrads/yr/unit)
Nearest site boundary* (2.1 km, N)	Direct radiation from plume	0.20	0.57	0.33	0.81
		Iodine and Particulates in Gaseous Effluents**			
		Total Body		Organ	
Nearest*** site boundary (2.1 km, N)	Ground deposition	0.44 (T)		0.44 (C) (thyroid)	
	Inhalation	0.24 (T)		0.56 (C) (thyroid)	
Nearest residence and garden (2.3 km, NNW)	Ground deposition	0.26 (C)		0.26 (C) (bone)	
	Inhalation	0.13 (C)		0.003 (C) (bone)	
	Vegetable consumption	0.49 (C)		1.13 (C) (bone)	
Nearest milk cow and meat animal (2.9 km, N)	Ground deposition	0.20 (C)		0.20 (I) (thyroid)	
	Inhalation	0.11 (C)		0.22 (I) (thyroid)	
	Vegetable consumption	0.41 (C)		N/A	
	Cow milk consumption	0.18 (C)		4.19 (I) (thyroid)	
	Meat consumption	0.04 (C)		N/A	
Nearest milk goat (7.4 km, NNW)	Ground deposition	0.016 (C)		0.016 (I) (thyroid)	
	Inhalation	0.014 (C)		0.027 (I) (thyroid)	
	Vegetable consumption	0.052 (C)		- (I) (thyroid)	
	Goat milk consumption	0.035 (C)		0.43 (I) (thyroid)	
		Liquid Effluents**			
		Total Body		Organ	
Nearest drinking water at Lillington	Water ingestion	0.007 (A)		0.01 (C) (liver)	
Nearest fish at plant discharge area	Fish consumption	1.7 (A)		2.3 (A) (liver)	
Nearest shore access near plant discharge area	Shoreline recreation	0.002 (A)		0.002 (A) (liver)	

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

**Doses are for age group and organ that result in the highest cumulative dose for the location: A=adult, T=teen, C=child, I=infant. Calculations were made for these age groups and for the following organs: gastrointestinal tract, bone, liver, kidney, thyroid, lung, and skin.

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

Table D-7 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of the Harris nuclear plant

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives*	Calculated Doses**
Liquid effluents		
Dose to total body from all pathways	3 mrems	1.6 mrems
Dose to any organ from all pathways	10 mrems	2.1 mrems (liver)
Noble gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.3 mrads
Beta dose in air	20 mrads	0.8 mrads
Dose to total body of an individual	5 mrems	0.2 mrems
Dose to skin of an individual	15 mrems	0.6 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	4.6 mrems (thyroid)
	Population Within 80 km	
	Total Body (person-rems)	Thyroid (person-rems)
Natural background radiation†	180,000	
Liquid effluents	1.7	0.04
Noble gas effluents	1.7	1.7
Radioiodine and particulates	12	22

*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 North Carolina of 100 mrems/yr, and year 2000 projected population of 1,750,000.

Table D-8 Calculated RM-50-2 dose commitments to a maximally exposed individual from operation of the Harris plant*

	Annual Dose per Site	
	RM-50-2 Design Objectives**	Calculated Doses
Liquid effluents		
Dose to total body or any organ from all pathways	5 mrems	3.8 mrems
Activity release estimate, excluding tritium (Ci)	10	0.4
Noble gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.6 mrads
Beta dose in air	20 mrads	1.6 mrads
Dose to total body of an individual	5 mrems	0.4 mrems
Dose to skin of an individual	15 mrems	1.2 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	9.2 mrems (thyroid)
I-131 activity release (Ci)	2	0.16

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

**Annex to Appendix I to 10 CFR Part 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-rems/yr
Natural background radiation*	26,000,000*
Radiation from Harris Units 1 and 2 (combined) operation	
Plant workers	880
General public:	
Liquid effluents**	0.9
Gaseous effluents	48
Transportation of fuel and waste	6

*Using the average U.S. background dose (100 mrem/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-mile) population dose

APPENDIX E

REBASELING OF THE RSS RESULTS FOR PWRs

APPENDIX E

REBASELINING OF THE RSS RESULTS FOR PWRs

The results of the Reactor Safety Study (RSS) (NUREG-75/014) 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 light water reactors (LWRs) could be consistently compared.

Primarily, the rebaselined RSS (NUREG/CR-1659) results reflect use of advanced modeling of the processes involved in meltdown accidents, i.e., the MARCH computer code modeling for transient- and loss-of-coolant-accident (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 RSS was completed. The advanced accident process models (MARCH and CORRAL) produced some changes in staff estimates of the release magnitudes from various accident sequences in WASH-1400 (NUREG-75/014). 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, although some increases in the release magnitudes for the cesium and tellurium isotopes were predicted.

Entailed in this rebaselining effort 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 (pressurized water reactor and boiling water reactor, 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 was done to reflect both experimental and calculative indications that such explosions are unlikely to occur in those sequences involving small 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 postulated in WASH-1400.

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

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 that 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 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.*

Event V (Interfacing System LOCA)

During the Reactor Safety Study, a potentially large risk contributor was identified as a result 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 emergency core cooling system (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 expose the LPIS to high overpressures and dynamic loadings, the RSS judged that a high probability of LPIS rupture would exist. Because 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 ensure 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 Shearon Harris PWR units.

*For additional information detail see Reactor Safety Study (WASH-1400, NUREG-75/014) Appendix V.

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 power 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 power was 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 LOCA occurring in a specific region of the plant; 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 due either to 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. Because 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 involve a containment base mat melt-through as the containment failure mode. With exception of TML-ε and TKQ-ε, all involve the potential failure of the ECCS following a LOCA with the containment engineered safety features continuing to operate as designed until the base mat is 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 base mat. 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, NUREG-75/014, "Reactor Safety Study" (formerly issued as WASH-14400), October 1975.

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

---, NUREG/CR-1659, Vol. 1, "Reactor Safety Study Methodology Applications Program," April 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 hours following an initiating transient that 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

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 post-accident response to reduce exposure from long-term ground contamination. The Reactor Safety Study (RSS) (NUREG-75/014, 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 that 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 that has been used herein is a modified version of the RSS model (Sandia, 1978) and is, to a certain extent, site emergency planning oriented. The modified version is briefly outlined below.

The model utilizes a circular area with a specified radius (the 16-km (10-mile) 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 radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity 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 release of radioactivity 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 center line--that is, those people who would potentially be under the radioactive cloud that would develop following the release--would leave their residences after lapse of a specified amount of delay time* and then evacuate. The delay time is reckoned from the beginning of the warning time and is recognized as the sums of: the time required by the reactor operators to notify the responsible authorities; the time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and the time required for the people to mobilize and get under way.

*Assumed to be of a time constant value that 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 24 km (15 miles) (which is 8 km (5 miles) more than the 16-km (10-mile) 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 that 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; that is, 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 already overhead when an evacuee starts to leave, or (3) an evacuee would be initially 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/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 that is calculated to exist after complete passage of the cloud, after they are completely passed by the cloud; (2) exposed to one-half the calculated concentration when 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 of the main body of this environmental statement for accidents involving significant release of radioactivity to the atmosphere were based upon the assumption that all people within the 16-km (10-mile) plume exposure pathway EPZ would evacuate according to the evacuation scenario des-

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

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

cribed above. Because sheltering can be a mitigative feature, it is not expected that detailed inclusion of any facility (see Section 5.9.4.5(2)) near a specific plant site, where not all persons would be 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. Although the applicant has not yet provided estimates of the time required to clear the 16-km (10-mile) zone, he has indicated that there are no unusual hindrances that would affect the evacuation. The staff has therefore conservatively estimated the effective evacuation speed to be 1 meter per second (2.2 mph). It is realistic to expect that the authorities would evacuate persons at distances from the site where exposures above the threshold for causing early fatalities could be reached regardless of the EPZ distance. The sensitivity of the early fatalities to evacuation distance was calculated by assuming the longer evacuation distance of 24 km (15 miles) from Shearon Harris. As an additional emergency measure for the Shearon Harris site, it was also assumed that all people beyond the evacuation distance who would be exposed to the contaminated ground would be relocated after passage of the plume. For these people outside of the evacuation zone and within 40 km (25 miles), 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 40-km (25-mile) 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, 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 the early fatalities for (1) evacuation distances of 24 km (15 miles), (2) 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, (3) a case of evacuation to 16 km (10 miles) followed by relocation from between 16 and 40 km, and (4) the base case of evacuation of the 16-km (10-mile) zone around the site.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as the original 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 8-km (5-mile) 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 dollars) per person, which includes cost of food and temporary sheltering for a period of 1 week.

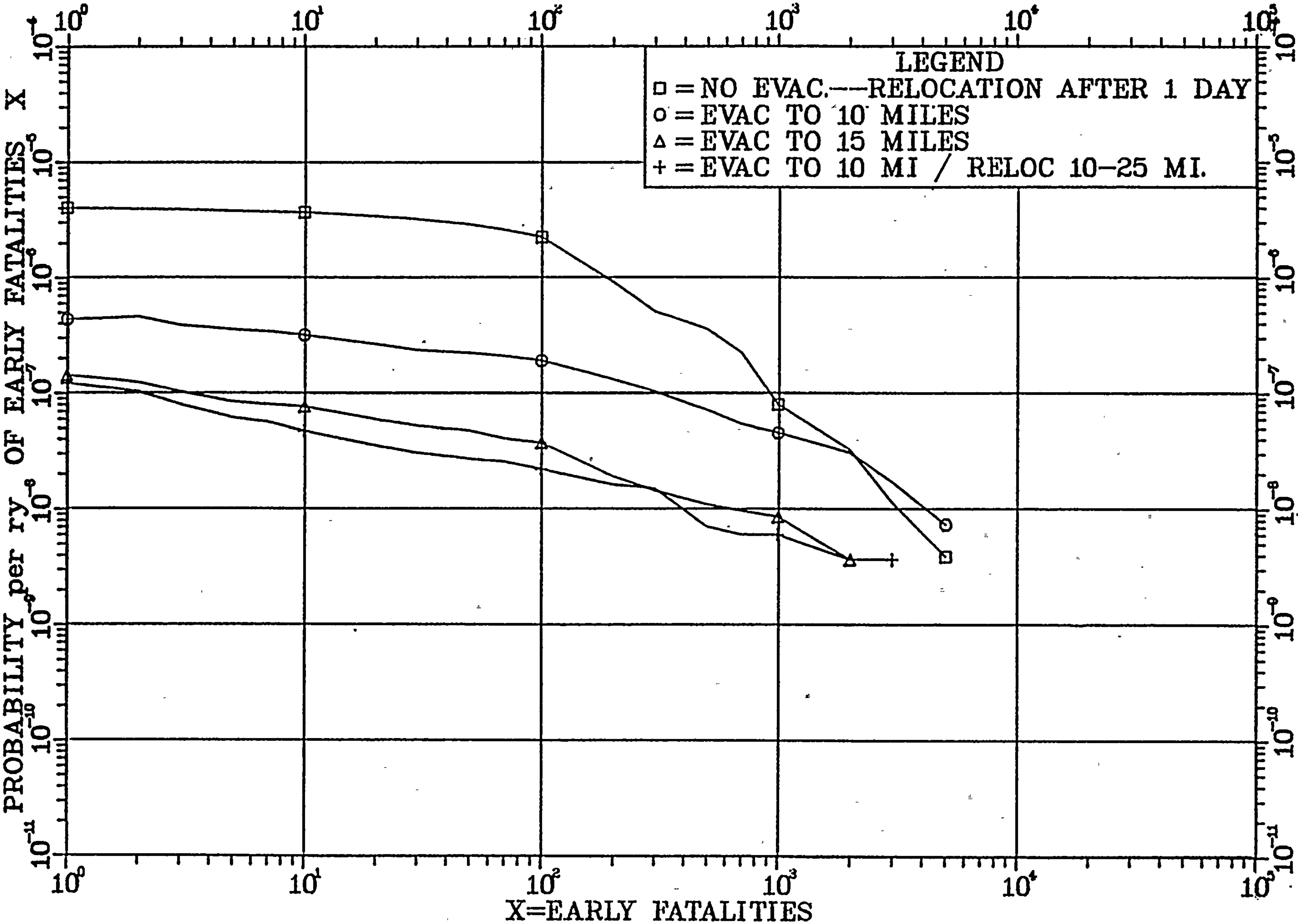

Figure F.1 Sensitivity of early fatalities to evacuation characteristics. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.) (To convert miles to km, multiply by 1.6093.)

F.2 Early Health Effects Model

The medical advisors to the Reactor Safety Study 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 post-exposure medical treatment from "minimal," to "supportive," to "heroic"; they are more fully described in NUREG-0340.

The calculative estimates of the early fatality risks presented in the text of Section 5.9.4.5(3) of the main body of this report and in 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 one chance in three 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 and early relocation as made in Section 5.9.4.5(3). This shows an overall four-fold increase in annual risk of early fatalities (see Table 5.8). The major fraction of the increased risk of early fatality in the absence of supportive medical treatment would occur within 24 km (15 miles) and virtually all would be contained within 56 km (35 miles) of the Shearon Harris site.

F.3 References

Sandia Laboratories, "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND 78-0092, June 1978.

U.S. Nuclear Regulatory Commission, NUREG-75/014 (WASH-1400), "Reactor Safety Study," October 1975.

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

APPENDIX G

FINAL NPDES PERMIT

North Carolina Department of Natural Resources & Community Development

James B. Hunt, Jr., Governor — Joseph W. Grimsley, Secretary

DIVISION OF ENVIRONMENTAL MANAGEMENT

July 12, 1982

Mr. P. W. Howe
CP&L - Shearon Harris
411 Fayetteville Street Mall
Raleigh, North Carolina 27602

Subject: Permit No. NC0039586
CP&L Shearon Harris
Wake County

Dear Mr. Howe:

In accordance with your application for discharge Permit received August 1, 1977, we are forwarding herewith the subject State - NPDES Permit. This permit is issued pursuant to the requirements of North Carolina General Statutes 143-215.1 and the Memorandum of Agreement between North Carolina and the U. S. Environmental Protection Agency dated October 19, 1975.

If any parts, requirements, or limitations contained in this Permit are unacceptable to you, you have the right to an adjudicatory hearing before a hearing officer upon written demand to the Director within 30 days following receipt of this Permit, identifying the specific issues to be contended. Unless such demand is made, this Permit shall be final and binding.

Please take notice that this Permit is not transferable. Part II, B.2. addresses the requirements to be followed in case of change in ownership or control of this discharge.

This Permit does not affect the legal requirement to obtain other Permits which may be required by the Division of Environmental Management. If you have any questions concerning this Permit, please contact Mr. Bill Mills, telephone (919)733-5181.

Sincerely yours,

W. Lee Fleming
for Robert F. Helms
Director

cc: Mr. Jim Patrick, EPA
Raleigh Regional Office
Raleigh Regional Office Manager

Permit No. NC 0039586

STATE OF NORTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES & COMMUNITY DEVELOPMENT
DIVISION OF ENVIRONMENTAL MANAGEMENT

PERMIT

To Discharge Wastewater Under the NATIONAL
POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of North Carolina General Statute 143-215.1, other lawful standards and regulations promulgated and adopted by the North Carolina Environmental Management Commission, and the Federal Water Pollution Control Act, as amended,

Carolina Power and Light Company

is hereby authorized to discharge wastewater from a facility located at

Shearon Harris Nuclear Power Plant
Wake County

to receiving waters of Harris Reservoir on Buckhorn Creek .

in accordance with effluent limitations, monitoring requirements, and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective July 12, 1982.

This permit and the authorization to discharge shall expire at midnight on June 30, 1987.

Signed this day of July 12, 1982.

W. L. [signature]
for Robert F. Helms, Director
Division of Environmental Management
By Authority of the Environmental Management Commission

M1 & I1

SUPPLEMENT TO PERMIT COVER SHEET

Carolina Power and Light Company

is hereby authorized to: (include only appropriate items)

1. Enter into a contract for construction of wastewater treatment facilities

2. Make an outlet into Harris Reservoir on Buckhorn Creek

3. Construct and operate a facilities to control pollutants from cooling tower blowdown, sanitary sewage treatment plant, metal cleaning and low volume wastes in accordance with applicable effluent limits located at Shearon Harris Nuclear Power Plant

   subject to Part III, condition No. C. of this Permit, and

4. Discharge from said treatment works into the Harris Reservoir Buckhorn Cr which is classified Class "C".

A. ( ). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning at first discharge and lasting until expiration permittee is authorized to discharge from outfall(s) serial number(s). 001-Cooling tower blowdown to Harris Reservoir
Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)				
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type	Sample Location
Flow			1/	30 mgd	Continuous or Pump Log	Recorder	E
Temperature			1/		1/	1/	1/
Zinc**			1.0 mg/l	1.0 mg/l	1/Week	Grab	E*
Total Chromium**			0.2 mg/l	0.2 mg/l	1/Week	Grab	E*
Phosphours**			5 mg/l	5 mg/l	1/Week	Grab	E*
			Average	Instantaneous Maximum			
Free available Chlorine 2/			0.2 mg/l	0.5 mg/l	1/Week	Multiple Grab	At each tower
Total Residual Chlorine 2/					1/Week	Multiple Grab	At each tower

1/ Discharge of blowdown from the cooling system shall be limited to the minimum discharge of recirculating water necessary for the purpose of discharging materials contained in the process, the further build-up of which would cause concentrations or amounts exceeding limits of established engineering practice. The discharge shall not result in th violation of Class "C" water quality standards outside of a mixing zone of 200 acres around the point of discharge. This mixing zone is for temperature and chlorine. The temperature within the mixing zone shall not :(1) prevent free passage of fish around or cause fish mortality within the mixing zone;(2) result in offensive conditions;(3) produce undesirable aquatic life or result in a dominance of nuisance species outside of the zone(4)endanger the public healt or welfare. Monitoring adequate to demonstrate compliance with the blowdown minimization, water quality standards fo temperature outside of the mixing zone, and prohibitions within the mixing zone shall be proposed by the permittee si months prior to start-up and, upon approval of the proposal, the results submitted with the monthly monitoring report The permittee may discharge cooling water to the auxillary reservoir in compliance with Part III-E of this Permit.

2/ Neither free available chlorine nor total residual may be discharged from any unit for more than two hours in any one day and not more than one unit in any plant discharge free available or total residual chlorine at any one time unless the permittee can demonstrate to the Director Division of Environmental Management that the unit in question cannot operate at or below this level of chlorination. The permittee shall record and report the times of release as a part of the monthly monitoring report.

3/ No later than three years after promulgation or July 1, 1987, whichever is earlier, Total Residual Chlorine shall not exceed a maximum concentration of 0.14 mg/l in the combined cooling tower blowdown discharge. Note: In the event th

(Continued on next page)

( ) EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

3/ (continued) BAT regulations for control are promulgated in a manner inconsistent with the October 14, 1980, proposed guidelines, requirements of this paragraph shall be modified consistent with the promulgated regulations (40 CFR 423). There shall be no discharge of detectable amounts of materials added for corrosion inhibitition or any chemical added which contain the 129 priority pollutants.

* Effluent prior to mixing with any other waste stream.

** Effective after July, 1983. These limitations and monitoring requirements apply only if these materials are added by the permittee.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored weekly on a grab sample of the effluent.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

A. ( ). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on initiation of discharge and lasting until expiration permittee is authorized to discharge from outfall(s) serial number(s). 002 Sanitary waste treatment plant discharge to Harris reservoir on Buckhorn Creek. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample	Sample *
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type	Location
low			0.05 MGD	0.075 MGD	Continuous or pump log	Recorder	I or E
OD			30 mg/l	45 mg/l	Monthly	Composite	E
SS			30 mg/l	45 mg/l	Quarterly	Composite	E

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I-Influent, E-Effluent

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly on a grab sample of the effluent.

There shall be no discharge of floating solids or visible foam in other than trace amounts outside of an area 5 mete

Part I
Page of
Permit No.
NC [illegible]

A. ( ). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning upon initiation of discharge and lasting until expiration permittee is authorized to discharge from outfall(s) serial number(s). 003 metal cleaning wastes Such discharges shall be limited and monitored by the permittee as specified below: discharged to Harris Reservoir on Buckhorn Cree

Effluent Characteristics	Discharge Limitations: Kg/day (lbs/day) Daily Avg.	Kg/day (lbs/day) Daily Max.	Other Units (Specify) Daily Avg.	Other Units (Specify) Daily Max.	Monitoring Requirements: Measurement Frequency	Sample Type	Sample Locatio
Flow			0.8		During discharge	1/	E*
TSS	(Quantities of pollutants discharged shall not exceed the quantity obtained by multiplying the flow of metal cleaning wastes generated times the concentrations listed to the right.)		30 mg/l	100 mg/l	Daily during discharge	Grab	E*
Oil & Grease			15 mg/l	20 mg/l	Daily during discharge	Grab	E*
Copper, Total			1.0 mg/l	1.0 mg/l	Daily during discharge	Grab	E*
Iron, Total			1.0 mg/l	1.0 mg/l	Daily during discharge	Grab	E*

*Effluent prior to mixing with any other waste stream

1/ Commensurate with treatment system installed

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored daily during discharge on a grab sample of the effluent. *

There shall be no discharge of floating solids or visible foam in other than trace amounts outside of an area 5 ...

A. ( ). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning upon initiation of discharge and lasting until expiration permittee is authorized to discharge from outfall(s) serial number(s). 004 low volume wastes discharged Such discharges shall be limited and monitored by the permittee as specified below: to Harris Reservoir on Buckhorn Creek

Effluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)				
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Measurement Frequency	Sample Type	Sample Location
Flow			1.5 MGD		1/	1/	1/
TSS	170(375)	568(1251)			Weekly	Grab	Effluent*
Oil & Grease	85(187)	113(250)			Weekly	Grab	E*

G-8

1/ Commensurate with treatment system installed

*Effluent prior to mixing with any other waste stream

Low volume wastes shall mean but not all inclusive, taken collectively as if from one source, wastewater from wet scrubber air pollution control system, ion exchange, water treater systems, water treatment evaporator blowdown, laboratory and sampling streams, floor drainage, cooling tower basin cleaning wastes, blowdown from recirculating house service water systems, and steam generator blowdown.

Prior to Start-up of Unit #2, quantity limitations shall be one-half of the limitations shown.

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The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored weekly on a grab sample of the effluent.

There shall be no discharge of floating solids or visible foam in other th

A. ( ). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning upon initiation of discharge and lasting until expiration permittee is authorized to discharge from outfall(s) serial number(s). 005 Point Source run-off from construction
Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type	Location

·int source run-off from construction is permitted in compliance with a sedimentation and erosion control plan approved b
e Land Quality Section of the Division of Land Resources.

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   Not Applicable.

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.

Act used herein means the Federal Water Pollution Control Act, As amended. DEM used herein means the Division of Environmental Management of the Department of Natural Resources and Community Development
"EMC" used herein means the North Carolina Environmental Management Commission.

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 month(s) shall be summarized for each month and reported on a Monthly Monitoring Report Form (DEM No. MR 1.0, 1.1, and 1.4) postmarked no later than the 45th day following the completed reporting period. The first report is due on The DEM may require reporting of additional monitoring results by written notification. Signed copies of these, and all other reports required herein, shall be submitted to the following address:

Division of Environmental Management
Water Quality Section
Post Office Box 27687
Raleigh, North Carolina 27611

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 sampled 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 The EMC regulations published pursuant to N. C. G. S. 143-215.63 et seq.. The Water and Air Quality Reporting Act, Section 304(g), 13 USC 1314, of the Federal Water Pollution Control Act, As Amended, and Regulation 40 CFR 136.

5. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, 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 as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Monthly Monitoring Report Form (DEM MR 1.0, 1.1, 1.4) Such increased monitoring frequency shall also be indicated. The DEM may require more frequent monitoring or the monitoring of other pollutants not required in this permit by written notification.

7. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained by the permittee for a minimum of three (3) years, or longer if requested by the State Division of Environmental Management or the Regional Administrator of the Environmental Protection Agency.

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 DEM of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Non compliance Notification

   If, for any reason, the permittee does not comply with or will be unable to comply with any effluent limitation specified in this permit, the permittee shall provide the Division of Environmental Management 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 to achieve compliance with the terms and conditions of this permit.

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 Water Quality Section of DEM 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 waters of the State or navigable waters of the United States.

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 from wastewater control facilities upon the reduction, loss, or failure of the primary source of power to said wastewater control facilities.

8. Onshore or Offshore Construction

This permit does not authorize or approve the construction of any onshore or offshore physical structures or facilities or the undertaking of any work in any navigable waters.

B. RESPONSIBILITIES

1. Right of Entry

The permittee shall allow the Director of the Division of Environmental Management, the Regional Administrator, and/or their authorized representatives, upon the presentations of credentials:

a. The 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

This permit is not transferable. In the event of any change in control or ownership of facilities from which the authorized discharge emanates or is contemplated, the permittee shall notify the prospective owner or controller by letter of the existence of this permit and of the need to obtain a permit in the name of the prospective owner. A copy of the letter shall be forwarded to the Division of Environmental Management.

3. Availability of Reports

Except for data determined to be confidential under N. C. G. S. 143-215. 3(a)(2) or Section 308 of the Federal Act, 33 USC 1318, all reports prepared in accordance with the terms shall be available for public inspection at the offices of the Division of Environmental Management. 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 N. C. G. S. 143-215.6(b)(2) or in Section 309 of the Federal Act.

4. Permit Modification

After notice and opportunity for a hearing pursuant to N. C. G. S. 143-215.1(b)(2) and G. S. 143-215.1(e) respectively, 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 requires 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 pollutant 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), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance pursuant to N. C. G. S. 143-215.6 or Section 309 of the Federal Act, 33 USC 1319.

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 N. C. G. S. 143-215.75 et seq. or Section 311 of the Federal / 33 USC 1321.

8. 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.

9. 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.

10. Expiration of Permit

Permittee is not authorized to discharge after the expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit such information, forms, and fees as are required by the agency authorized to issue permits no later than 180 days prior to the expiration date. Except as provided in N.C.G.S. 150A, any discharge without a permit after the expiration will subject the permittee to enforcement procedures as provided in N.C.G.S. 143-215.6 and 33 USC 1251 et seq..

B. Previous Permits

All previous State water quality permits issued to this facility, whether for construction or operation or discharge, are hereby revoked by issuance of this permit. The conditions, requirements, terms, and provisions of this permit authorizing discharge under the National Pollutant Discharge Elimination System governs discharges from this facility.

C. Construction

No construction of wastewater treatment facilities or additions thereto shall be begun until Final Plans and Specifications have been submitted to the Division of Environmental Management and written approval and Authorization to Construct has been issued. If no objections to Final Plans and Specifications has been made by the DEM after 30 days following receipt of the plans or issuance of this permit, whichever is latter, the plans may be considered approved and construction authorized.

D. Certified Operator

Pursuant to Chapter 90A of North Carolina General Statutes, the permittee shall employ a certified wastewater treatment plant operator in responsible charge of the wastewater treatment facilities. Such operator must hold a certification of the grade equivalent to the classification assigned to the wastewater treatment facilities.

E. Heated Water Discharge to Auxillary Reservoir

In order to insure that the auxillary reservoir is available for its' designed use at all times, the permittee may circulate heated water through the auxillary reservoir to prevent ice formation at any time that the surface water temperature is below $35^{O}F$ provided that the surface water temperature in the auxillary reservoir is not raised more $5^{O}F$ above ambient temperature and in no case is raised to more than $40^{O}F$.

F. There shall be no discharge of polychlorinated biphenyls (PCB's) from this facility to the extent that this compound is not present in the facility's intake waters.

G. Withdrawal from the Cape Fear River

Withdrawals from the Cape Fear River, shall be limited to 25% of the flow in the river except that no withdrawals shall be made from the river when the flow is 600 cfs or less nor which will reduce the flow in the river to less than 600 cfs as measured at the USGS Lillington Gauge. The withdrawals shall be monitored and reported monthly on the monthly monitoring report.

H. Nothing contained in this Permit shall be construed as a waiver by the Permittee of any right to a nearing it may have pursuant to State or Federal law or regulations.

I. Water discharged as backwash from intake screens is permitted without limitations or monitoring requirements.

J. The Permittee shall submit information relative to the design, location, construction and capacity of the cooling water intake structures to demonstrate application of best technology available for minimizing adverse environmental impact in accordance with the adopt guidelines for cooling water intake structures. This information must be submitted on or before December 31, 1982.

K. If any applicable standard or limitation is promulgated under sections 301(b)(2)(C) and (D), 304(b)(2), and 307(a)(2) and that effluent standard is more stringent than any effluent limitation in this permit or controls a pollutant not limited in this permit, this permit shall be promptly modified, or revoked and reissued, to conform to that effluent standard or limitation.

L. Within one year after start-up of the first unit the permittee shall analyze the discharges serial no.s 001,003, and 004 for the priority pollutants as required by 40 CFR 122.53(d)(7) to the extent that data is still required by regulation in effect at that times.

M. Should the guidelines and/or water quality standards upon which the limitations of this permit are based be revised to be less stringent, the permittee may request relaxation of the permit limits in keeping with the revised guidelines and/or standards.

APPENDIX H

LETTER FROM DEPUTY STATE HISTORIC PRESERVATION OFFICER

AND

MEMORANDUM FROM STATE HISTORIAN

NORTH CAROLINA DEPARTMENT OF CULTURAL RESOURCES

Raleigh, North Carolina 27611

Division of Archives and History
William S. Price, Jr., Director

Sara W. Hodgkins, Secretary
James B. Hunt, Jr., Governor

June 28, 1982

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Preparation of Environmental Impact Statement,
Shearon Harris Nuclear Station Operating License,
Multi-county, ER 82-7493

Dear Mr. Miraglia:

Thank you for your letter of June 14, 1982 concerning the above project.

While there are several known archaeological sites that are either listed in or eligible for listing in the National Register of Historic Places within the fifty-mile radial area surrounding the Shearon Harris Nuclear Power Plant, there are no such archaeological sites within the plant area itself. As you are aware, Carolina Power and Light Company had several archaeological studies conducted of the reservoir and dam sites and other facilities. No significant sites were located as a result of these investigations.

At present, we have no evidence to indicate that the operation of the Shearon Harris Plant will have any effect upon the significant archaeological resources within the fifty-mile radial area indicated on your map.

As for structures of architectural or historical significance, we are unaware of any properties, other than those mentioned in Dr. Jones's 1973 letter, within the immediate area.

For our own records, we would appreciate receiving information on the current status of the Burke and Ragan houses mentioned in the 1973 report.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act of 1966, the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106, codified at 36 CFR Part 800, and to Executive Order 11593, "Protection and Enhancement of the Cultural Environment."

Thank you for your cooperation and consideration. If you have questions concerning the above comments, please contact Ms. Renee Gledhill-Earley, Environmental Review Coordinator, at 919/733-4763.

Sincerely,

John J. Little

John J. Little, Deputy State
Historic Preservation Officer

JJL:slw

STATE OF NORTH CAROLINA
Department of Art, Culture and History
Raleigh 27611

Grace J. Rohrer
~~Sam Ragan~~
Secretary

Office of Archives and History
H.G. Jones, Administrator

11 January 1973

MEMORANDUM

To: Mr. Randolph Hendricks
Clearinghouse and Information Center

From: Dr. H. G. Jones
State Historian/Administrator

Subject: Draft Environmental Statement, Shearon Harris Nuclear Power Plant, Units 1, 2, 3, and 4. U.S. Atomic Energy Commission, File No. 127-72

Following an on-site inspection of the project area, Mrs. Catherine Cockshutt and Mr. C. Greer Suttlemyre of our staff report that apparently no structures or sites of outstanding architectural or historical significance will be disturbed by the proposed construction. The old Dupree house is of considerable architectural value as a ca. 1780 dwelling nearly intact; however, we understand it has been sold to Mr. Allen Brock of Raleigh, who plans to move and preserve it, an action we were quite pleased to learn of. Two other houses were noted as pre-Civil War structures, the Burke House and the Ragan House; these are of some local historical value and their preservation should be considered. We have consulted the most recent listing of the National Register of Historic Places and would like to report that no properties on the National Register or properties currently under consideration for the National Register will be affected by the project.

We appreciate very much the courtesy and cooperation shown by Carolina Power and Light Company and especially Mr. Aaron Padgett, who guided our staff in their inspection.

APPENDIX I

FISHERY ESTIMATES OF HARRIS RESERVOIR AND CAPE FEAR RIVER IN THE VICINITY OF THE SHEARON HARRIS NUCLEAR PLANT

PREPARED FOR THE NRC STAFF BY
RICHARD B. MCLEAN, PH.D.
OAK RIDGE NATIONAL LABORATORY

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INTRODUCTION

Shearon Harris Nuclear Plant is located in Wake and Chatham Counties, North Carolina on a 1620-ha (4000-acre) reservoir made by impounding Buckhorn Creek, a tributary of the Cape Fear River. Water release from the reservoir is controlled at a dam, which provides some protection to the Cape Fear River biota in case of an accidental release of contaminants to Harris reservoir.

The public will be allowed to fish the reservoir, but access will be limited and could be controlled if the need arose. The Cape Fear River is a turbid river. It is relatively unaccessible for 80.5 km (50 miles) downstream of the Shearon Harris plant because there are few access points and there is a series of rapids that make boat passage extremely difficult.

METHODS

Fishery yields of Shearon Harris Reservoir and the Cape Fear River 80.5 km (50 miles) downstream of the plant are estimated. These estimates are made with a minimum of data because the reservoir is too young for standing stock data and the Cape Fear River is not a well-studied system, characteristic of most rivers in the U.S. Fishery estimates are made using the following assumptions:

(1) Fish species in Harris reservoir will be similar to those in North Carolina and Tennessee Valley reservoirs.

(2) The amount of sport and commercial fish harvest will range between the estimate given for three North Carolina reservoirs (Badin, High Rock, and Tillery) and that found in the Tennessee Valley reservoirs (Leidy and Jenkins, 1977).

(3) The Cape Fear River sport fish harvest will range between the estimate found in the Liquid Pathway Generic Study (NRC, 1978) and the Tennessee Valley Reservoirs.

(4) Only 25% of the Cape Fear River is accessible to fishermen.

The Cape Fear River has been sampled by electrofishing and hoop and gill netting (CP&L, 1977). These data are used to established species composition. The Liquid Pathway Generic Study uses a value of 5 kg/ha to represent recreational harvest in streams. No data are offered to support the number, but the number is the opinion of the Sport Fishing Institute. The 5 kg/ha estimate is probably a reasonable low range value and will be used to contrast with the 11.5 kg/ha value for Tennessee reservoirs.

RESULTS AND CONCLUSIONS

Shearon Harris Reservoir

Sport fish harvest

Mean of three North Carolina reservoirs = 5.4 kg/ha/yr
5.4 kg/ha/yr x 1620 ha = 8748 kg/yr

Mean of Tennessee Valley reservoirs = 11.5 kg/ha/yr
11.5 kg/ha/yr x 1620 ha = 18,630 kg/yr

Therefore, the Shearon Harris Reservoir sport fish harvest = 8,748 - 18,630 kg/yr

Commercial fish harvest

Mean of Tennessee Valley reservoirs = 16.3 kg/ha/yr
16.3 kg/ha/yr x 1620 ha = 26,406 kg/yr

Cape Fear River

Liquid Pathway Generic Study = 5 kg/ha/yr
5 kg/ha/yr x 541 ha = 2,705 kg/yr
2,705 kg/yr x 25% accessible = 676 kg/yr

Mean of Tennessee Valley reservoirs = 11.5 kg/ha/yr
11.5 kg/ha/yr x 541 ha = 6,621 kg/yr
6,621 kg/yr x 25% accessible = 1,555 kg/yr

Therefore, the Cape Fear River sport fish harvest is between 676 and 1555 kg/yr

No commercial harvest is known to occur for this stretch of the Cape Fear River.

Sport fish in Harris Reservoir will probaby consist of carp, catfish, smallmouth bass, largemouth bass, spotted bass, sunfish, crappie, and walleye.

Sport fish in the Cape Fear River consist of black crappie, sunfish, catfish (brown bullhead, flathead, yellow bullhead, white and channel catfish) yellow perch, and largemount bass.

The catfishes and carp will constitute the majority of any commercial fish in the reservoir. No commercial fishery is expected in the Cape Fear River.

In conclusion, the Shearon Harris Reservoir is estimated to produce between 35,154 kg/yr and 45,036 kg/yr of recreational and commercial fish.

The Cape Fear River fish harvest will be between 676 kg/yr and 1555 kg/yr.

Thus, the maximum total fish harvest for both systems is estimated to be 46,591 kg/yr.

REFERENCES

Carolina Power and Light Company, "Cape Fear Steam Electric Generating Plant 316(b) Demonstration," 77 pp, 1977.

Leidy, G. R., and R. M. Jenkins, "The Development of Fishery Compartments and Population Rate Coefficients for Use in Reservoir Ecosystem Modeling," USDI Fish and Wildlife Service, National Reservoir Research Program, Fayetteville, Arkansas, 1979.

U.S. Nuclear Regulatory Commission, NUREG-0440, "Liquid Pathway Generic Study," 1978.

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*
NUREG-0972

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*
Draft Environmental Statement Related to Operation of the Shearon Harris Nuclear Power Plant, Units 1 and 2

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)

5. DATE REPORT COMPLETED

MONTH	YEAR
April	1983

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	YEAR
April	1983

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
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10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES
Docket Nos. 50-400 and 50-401

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

The information in this statement is the second assessment of the environmental impact associated with the construction and operation of the Shearon Harris Nuclear Power Plant, Units 1 and 2, located in Wake and Chatham Counties, North Carolina. The first assessment was the Final Environmental Statement related to construction, issued in March 1974 (as revised) prior to issuance of construction permits for Shearon Harris. The Shearon Harris Unit 1 plant construction is now 76% complete and startup is scheduled for June 1985. The present assessment is the result of the NRC staff review of the activities associated with the proposed operation of the plant.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
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