NUREG-0024

POOR ORIGINAL

DRAFT ENVIRONMENTAL STATEMENT

related to construction of the

CLINCH RIVER BREEDER REACTOR PLANT

PROJECT MANAGEMENT CORPORATION
AND
TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-537

Published: FEBRUARY 1976

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D. C.

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SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation.

1. This action is administrative.

2. The proposed action is the issuance of a construction permit to the Project Management Corporation (PMC) and the Tennessee Valley Authority (TVA)* for constructing the Clinch River Breeder Reactor Plant (CRBRP), Docket No. 50-537. The proposed location is in Roane County, Tennessee, about 25 miles west of Knoxville, on the north side of the Clinch River. The site is within the city limits of Oak Ridge but it is owned by the United States of America and is presently in the custody of TVA. The United States [represented by the Energy Research and Development Administration (ERDA)] would also own the plant. Some delay is anticipated in the original schedule for site preparation to begin in September 1975, completion of construction in 1981, and startup in 1982. Criticality is now scheduled by the applicants for October 1983.

   During the first five years of operation (1984-1988), TVA would operate the CRBRP and purchase its electrical output as a demonstration plant under ERDA's Liquid Metal Fast Breeder Reactor (LMFBR) Program. At the end of that period, TVA would have the option of purchasing the plant for its own use over the remaining operating life of approximately 25 years.

   The CRBRP is designed to use a liquid sodium cooled fuel breeder reactor to produce 975 megawatts of thermal energy (MWt) with the initial core loading of uranium and plutonium mixed oxide fuel. This heat would be transferred by heat exchangers to nonradioactive sodium in an intermediate loop, and then to a steam cycle. A steam turbine generator would use the steam to produce 380 megawatts of electrical capacity (MWe). Future core design may result in gross power ratings of 1121 MWt and 439 MWe; these higher ratings are considered in the assessments made in this statement. In-plant uses of electricity would result in a net plant output of approximately 350 MWe initially and 379 MWe in the future.

   Exhaust steam from the turbine-generator would be cooled in condensers utilizing a mechanical draft cooling tower for dissipating heat to the atmosphere. The Clinch River would supply all CRBRP water needs. For maximum power, the annual average water requirement would be 15.8 cfs (7095 gpm), of which 6.1 cfs (2741 gpm) would be returned as blowdown to the river and about 9.7 cfs (4350 gpm) would be consumed, mainly by evaporation.

3. Summary of environmental impacts and adverse effects:

   (a) Some timber would be harvested and other vegetation and animal life would be destroyed on the 170 acres disturbed for construction of the plant facilities and 58 acres of right-of-way for new transmission lines. All but 73 acres would be revegetated after completion of construction (Sections 4.2.1, 4.4.1).

   (b) Erosion of land and minor siltation of the river would result from construction and subsequent rainfall, but planned control practices and revegetation would minimize this effect (Section 4.3).

   (c) Approximately 40,000 m^3 of river bank and bottom would be excavated or dredged to permit installation of a cofferdam and barge-unloading facility; part of these areas would be lost temporarily as benthic habitat (Section 4.4.2).

   (d) Access to an Indian mound and Hensley Cemetery onsite would be allowed, subject to plant security restrictions. These historic and archeologic resources would not be affected by construction activities (Sections 5.1 and 4.2.1).

   (e) Construction noise would be a temporary annoyance to a few nearby residents (Section 4.5.4).

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*Legislation was enacted by the Congress in January 1976 which authorized ERDA to become a co-applicant and acquire custody of the site; however, the contracts among the parties have not yet been revised.

(f) Construction traffic would add to congestion on local roads, particularly State Road 58, during shift changes (Section 4.5.1).

(g) Tax receipts would not fully compensate for increased public services needed by the additional workforce, particularly during construction (Sections 4.5 and 5.6).

(h) Plant and transmission structures would be concealed by ridges and hills, except from Gallagher Bridge and several residences south of the river. The cooling tower plume would usually extend no more than 1.5 miles, but could sometimes extend six miles. Fog resulting from the tower operation could be a minor nuisance on nearby roads a few hours per year (Section 5.3.3).

(i) Deposition of dissolved solids carried with vapor from the cooling tower would have no important effect on vegetation and animals (Section 5.3.3).

(j) Water consumed by the project would be a maximum of 35 gpm during construction and an average of 4500 gpm (10 cfs) during plant operation. These quantities are about 0.0002% and 0.2%, respectively, of the annual average river flow (Sections 4.3 and 5.2).

(k) Copper, iron and suspended solids potentially could result in adverse effects on aquatic life in the discharge plume under worst-case conditions of no river flow and high ambient concentrations (Section 5.4.1).

(l) The average annual radiation dose to an individual living at the site boundary would be 1.6 mrem/yr, and the cumulative dose to the estimated year-2010 population within 50 miles would be 0.2 man-rem/yr. These doses are less than 2% and 0.002%, respectively, of those received from natural radiation (Section 5.7.3).

(m) Risks associated with accidental radiation exposure would be very low (Chapter 7).

4. Major alternatives considered:

- Sites
- Facility systems
- Transmission route.

5. The following Federal, State, and local agencies have been asked to comment on the draft statement:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Energy Research and Development Administration
Environmental Protection Agency
Federal Energy Administration
Federal Power Commission
State of Tennessee
Anderson County, TN
Knox County, TN
Loudon County, TN
Roane County, TN
City of Oak Ridge, TN
City of Knoxville, TN

6. The draft statement was made available to the public, to the Council on Environmental Quality, and to other specified agencies in February 1976.

On the basis of the analysis and evaluation set forth in this statement, after the environmental, economic, technical and other benefits of the Clinch River Breeder Reactor Plant have been weighed against environmental and other costs, and after available alternatives have been considered, the staff concludes that the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of a construction permit for the plant subject to the following limitations for the protection of the environment:

(a) The applicant shall take the necessary mitigating actions, including those summarized in Section 4.6, during construction of the plant and associated transmission lines to avoid unnecessary adverse environmental impacts from construction activities.

(b) In addition to the preoperational monitoring programs described in Section 6.1 of the Environmental Report, with amendments, the staff recommendations included in Section 6.1 of this document shall be followed.

(c) The applicant shall demonstrate to the satisfaction of the staff that the realistically analyzed radiological consequences of postulated plant accidents (Table 7.2) will not exceed 15 rem to the bone, 2.5 rem to the whole body and 30 rem to the thyroid.

(d) The applicant shall establish a control program that shall include written procedures and instructions to control all construction activities as prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of environmental conditions. The applicant shall maintain sufficient records to furnish evidence of compliance with all the environmental conditions herein.

(e) Before engaging in a construction activity not evaluated by the Commission, the applicant will prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in this draft statement, the applicant shall provide a written evaluation of such activities and obtain approval of the Director of the Office of Nuclear Reactor Regulation prior to undertaking the activities.

(f) If unexpected harmful effects or evidence of serious damage are detected during plant construction, the applicant shall provide to the staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

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FOREWORD

This environmental statement was prepared by the U.S. Nuclear Regulatory Commission (NRC) in accordance with the Commission's regulation 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

NEPA states, among other things, that the continuing responsibility of the Federal Government is 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 supporting diversity and variety of individual choice.
- Achieve a balance between population and resource use, permitting 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 NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR Part 51, the NRC's Office of Nuclear Reactor Regulation (the staff) prepares a detailed statement on the foregoing considerations with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or a full-power operating license, the applicant submits an environmental report to the NRC. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation, and visits and inspects the project site and surrounding vicinity. Members of the staff may meet 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 are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Section 102(2)(C) of NEPA and 10 CFR Part 51.

This evaluation leads to the publication of a draft environmental statement by the Office of Nuclear Reactor Regulation which is circulated to Federal, State, and local governmental agencies for comment. A summary notice is published in the Federal Register of the availability of the applicant's environmental report and the draft environmental statement and interested persons are invited to comment. Comments on the draft statement should be addressed to the Director, Office of Nuclear Reactor Regulation, at the address shown below.

After receipt and consideration of comments on the draft statement, the staff prepares a final environmental statement which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final benefit-cost analysis that considers and balances the environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether--after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered - the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values.

Copies of this statement are available for inspection at the Commission's Public Document Room, 1717 H Street N.W., Washington, D.C. Single copies may be obtained by writing the Director, Office of Nuclear Reactor Regulation, Nuclear Regulatory Commission, Washington, D.C. 20555. If there are any questions regarding the contents, the NRC Environmental Project Manager, Mr. Paul H. Leech, may be contacted at the above address or by telephone, (301) 443-6980.

1. INTRODUCTION

1.1 THE PROPOSED PROJECT

The Clinch River Breeder Reactor Plant (CRBRP) is the demonstration plant proposed by the U.S. Energy Research and Development Administration (ERDA) under its Liquid Metal Fast Breeder Reactor (LMFBR) Program. A discussion of the LMFBR Program and the role of the demonstration plant in that program is included in Chapter 8 of this statement. Briefly, the major objectives of the CRBRP are (1) to demonstrate the technical performance, reliability, maintainability, safety, environmental acceptability, and economic feasibility of an LMFBR central station electric power plant, and (2) to confirm the value of this concept for conserving natural resources.

The CRBRP is designed to be an integrated electric power plant with a liquid-sodium-cooled breeder reactor supplying the thermal energy to produce steam to drive a turbine-generator. With the initial reactor core of uranium and plutonium mixed-oxide fuel, the plant is expected to produce 975 megawatts of thermal energy (MWt) and a net output of 350 electrical megawatts (MWe). Future core designs may result in a gross power of 1121 MWt and a net output of 379 MWe; these higher ratings are considered in the environmental assessments made in this statement.

The proposed location of the plant is in Roane County, Tennessee, on undeveloped land owned by the U.S. Government in the rural southwestern section of the City of Oak Ridge. The 1364-acre site is on a peninsula formed by the Clinch River and bounded on the north by ERDA's Oak Ridge Reservation, which lies between the site and developed areas of the city. Within a two-mile radius of the site, the area consists primarily of woodland; however, small farms and residences are scattered south and west of the Clinch River. The northwest edge of the site is designated for development as an industrial park.

Water needed by the plant would be supplied by the Clinch River. For maximum power, the annual average water requirement would be 15.8 cfs (7095 gpm), of which 6.1 cfs (2741 gpm) would be returned to the river and about 9.7 cfs (4350) would be consumed, mainly by evaporation from the mechanical-draft wet cooling tower used to cool the spent steam from the turbine-generator.

Two 161-kV transmission lines approximately 2.8 miles long would be constructed from the plant to an existing transmission line owned by the Tennessee Valley Authority (TVA). Nearly all of the right-of-way required would be obtained by widening existing corridors.

Electricity generated by the CRBRP would be purchased by TVA and distributed to loads on its power system. The applicants' plans call for a five-year demonstration period after operational testing of the plant. At the conclusion of the demonstration period, TVA may offer to purchase the plant at a price based upon its value as a power production facility; otherwise, the plant would remain under ERDA ownership for continued operation or decommissioning. If the plant is operated for a total of 30 years, the average capacity factor is estimated to be 68.5% (ER, p. A1-73).

1.2 THE PROJECT PARTICIPANTS

The CRBRP is a cooperative effort of industry and government. The project began with the acceptance in 1972 of the joint Commonwealth Edison Company (CE)-TVA proposal to work with the AEC (now ERDA) to design, develop, construct and operate the demonstration plant. To implement this proposal, two non-profit organizations, the Breeder Reactor Corporation (BRC) and Project Management Corporation (PMC) were established. BRC serves as the principal liaison between the project and over 700 electric utility organizations throughout the country which are contributing manpower and approximately $250 million. PMC, which is staffed largely with CE and TVA personnel, has the overall management responsibility for design, development, construction, testing and operation of the plant during the 5-year demonstration period.* ERDA has the lead role for technical supervision and administration of the design and construction of the nuclear steam supply system, and TVA is responsible for the plant operation and maintenance.

*Legislation was enacted in January 1976 by the Congress which authorizes reassignment of the overall management responsibility to ERDA; however, the necessary contracts among the parties have not yet been revised. PMC would continue to administer the financial interests of the utility industry and arrange for participation of utility personnel.

Westinghouse Electric Corporation is the lead reactor designer and manufacturer, with responsibility for the overall nuclear island, reactor system and primary heat transport system. The General Electric Comapny is responsible for the intermediate heat transport system and the steam generator systems; Atomic International is responsible for the fuel handling system, maintenance and auxiliary systems. GE is also the turbine-generator supplier.

Burns and Roe, Inc. is the architect-engineer for the project and Stone & Webster Engineering Corporation will manage its construction.

1.3 STATUS OF THE PROJECT

On October 15, 1974, in accordance with the Atomic Energy Act of 1954, as amended, and the Commission's regulstions thereunder, the Project Management Corporation (PMC) and the Tennessee Valley Authority (TVA) tendered an application to the NRC for a construction permit and a Class 104(b) operating license for the CRBRP. A combined term of 40 years was requested, beginning with the date a construction permit is issued. The Environmental Report (ER) and Chapter 2 of the Preliminary Safety Evaluation Report (PSAR) were found deficient by the NRC in several major areas of information and the applicants were so notified November 19, 1974. These deficiencies were satisfied in a series of submittals by the applicants and the application was docketed for environmental review on April 11, 1975. The remaining sections of the PSAR were submitted for acceptance review on April 24, 1975, and the PSAR was docketed on June 13, 1975.

With the expectation that the Commission would issue a Limited Work Authorization by September 1975, the applicants submitted with their application a schedule of site preparation activities to begin on that date. Completion of construction was scheduled for late 1981 and initial operation in 1982. However, approximately 15 months of delay are anticipated and reactor criticality is now scheduled for October 1983. On this basis, the 5-year demonstration period would cover the years 1984 through 1988.

1.4 STATUS OF REVIEWS AND APPROVALS

10 CFR Part 51 requires that the Director of Nuclear Reactor Regulation, or his designee, analyze the applicants' environmental report, which was submitted as part of the application, and prepare a detailed statement of environmental considerations. This environmental statement related to construction of the CRBRP has been prepared accordingly.

The major documents used in preparation of this statement were the applicants' Environmental Reports and amendments thereto, Chapter 2 of the PSAR, and both the Proposed Final Environmental Statement (WASH-1535) and the Final Environmental Statement on the LMFBR Program (ERDA-1535). Independent calculations and sources of information were also used as bases for assessments of environmental impact. Some of the information was gained by the staff during visits to the site and surrounding areas in January and November of 1975. Although data from all these sources were examined in making assessments, only brief summaries of the most pertinent data are included in this statement. As indicated above, references throughout the statement are indicated by name, agency, or document number in parenthesis; complete reference information is found alphabetically listed in the references section.

As part of its safety evaluation prior to the issuance of construction permits and operating licenses, the Commission makes a detailed evaluation of the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal conditions and potential accident conditions, including the effects of natural phenomena on the facility. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated environmental effects are repeated in this Environmental Statement.

Copies of this Environmental Statement and the applicants' documents referenced above are available for public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C., and at the public libraries in Oak Ridge and Knoxville, Tennessee.

In Section 12 of the ER, the applicants have provided an extensive listing of licenses and permits that might be applicable to the CRBRP. Since the plant would be titled in the United States and built on Federal land, the project is not required to obtain licenses and permits from State and local authorities. However, the applicants have stated in ER Section 12 that "close coordination and cooperation with these officials and agencies will be maintained to assure that the project is implemented in accordance with applicable regulations and recommended practices."

In addition to the construction permit and operating license required by the NRC, the applicants must obtain the following Federal authorizations:

Permits and Licenses	Issuing Agencies
1. Permit to construct water intake and discharge facilities.	U.S. Army Corps of Engineers
2. Permit to construct barge facilities	U.S. Army Corps of Engineers
3. Permit to discharge dredge or fill material into navigable waters.	U.S. Army Corps of Engineers
4. Permit for temporary work done in water way such as drilling, dredging or temporary pipes.	U.S. Army Corps of Engineers
5. Permit for lights used on structures near the navigation channel such as the barge facilities.	U.S. Coast Guard
6. Permit to discharge under the National Pollutant Discharge Elimination System (NPDES).	U.S. Environmental Protection Agency
7. Permit for tall structures-necessary for structures 200 ft or more above ground or any structures representing sudden elevation change (cooling tower, meteorological tower).	Federal Aviation Agency
8. Permit for radio transmitters and associated towers.	Federal Communications Commission
9. Licenses for radioactive source material and special nuclear material not covered by operating license.	NRC
10. License for radioactive by-product material.	NRC
11. Reactor Operator Licenses.	NRC
12. Permits for transportation of radioactive materials and metallic sodium.	U.S. Department of Transportation

The CRBRP is also subject to provisions of the following requirements relative to preservation of cultural, historical, archaeological and architectural resources: The National Historic Preservation Act of 1966 (16 USC §§ 470-70n); Executive Order No. 11593 (3 CFR 560 [1971]); and Public Law 93-291 (May 24, 1974).

2. THE SITE AND ENVIRONS

2.1 GENERAL DESCRIPTION

The proposed CRBRP site is located in Roane County, Tennessee, on the north side of the Clinch River (between CRM 16 and 18) and about 25 miles W of Knoxville (Figure 2.1). Nearby cities are Kingston, 7 miles W; Harriman, 9.5 miles NW, and Oak Ridge, 9 miles NE (Figure 2.2). The site, zoned Industrial 2, is in the remote southwestern corner of the City of Oak Ridge, on undeveloped land which is federally owned and under custody of the Tennessee Valley Authority (TVA). ERDA's Oak Ridge reservation meets the site's northern boundary.

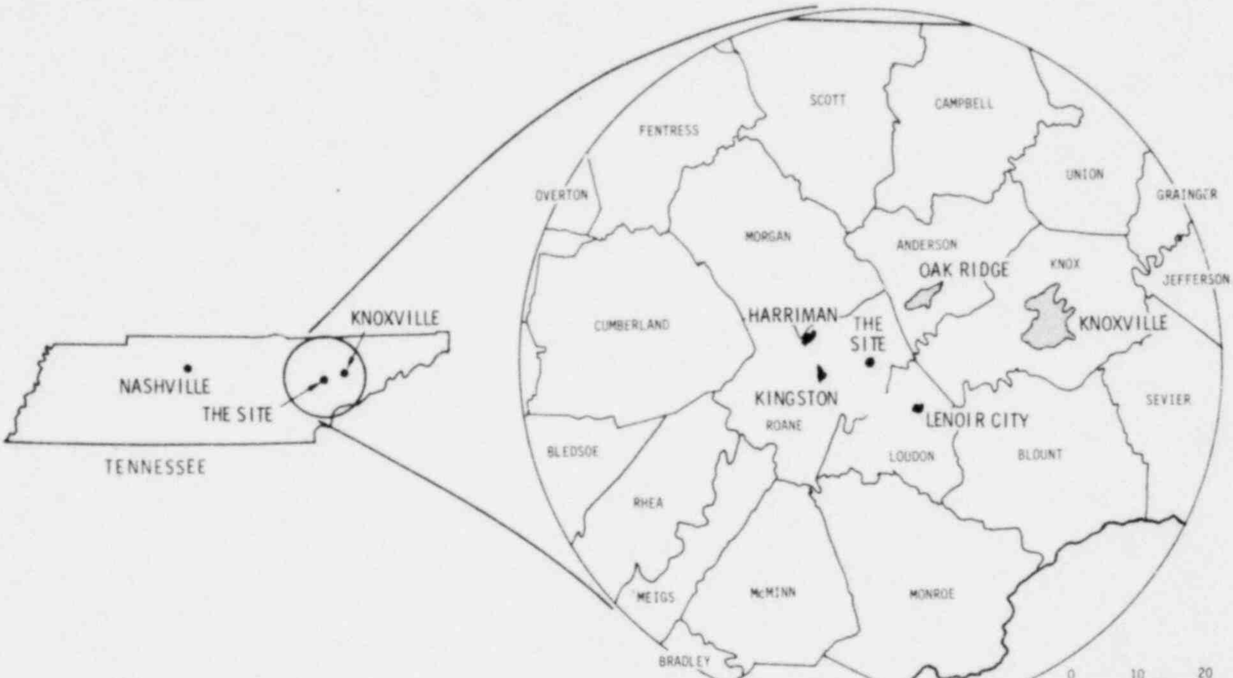


FIGURE 2.1 Site Location

The center of the reactor containment vessel would be located at 35°53'24" N latitude and 84°22'57" W longitude. Grade for principal plant structures would be 74 ft above the mean river water level of 741 ft above MSL. The site location is also shown by photographs in Figure 2.3 and 2.4 (ER, Sec 2.1; and Am I, Part II, G3). The site consists of 1364 acres of which about half of the acreage is taken up by the peninsula where the plant would be located, as shown in Figure 2.3. The site acreage extends northward, as shown partially in Figure 2.3 and completely in Figure 3.3 (on page 3-3).

Steep ridges, hills, and knobs are prevalent in the region. Chestnut Ridge, running through the north portion of the site, is the dominant topographic feature, reaching an elevation of 1100 ft above MSL at the crest (Figure 3.19). Figure 2.5 shows general land use near the site. Woodland dominates within a 2-mi radius of the plant location, although numerous residences and small farms lie immediately south and west of the river (ER, Fig 2.1-7).

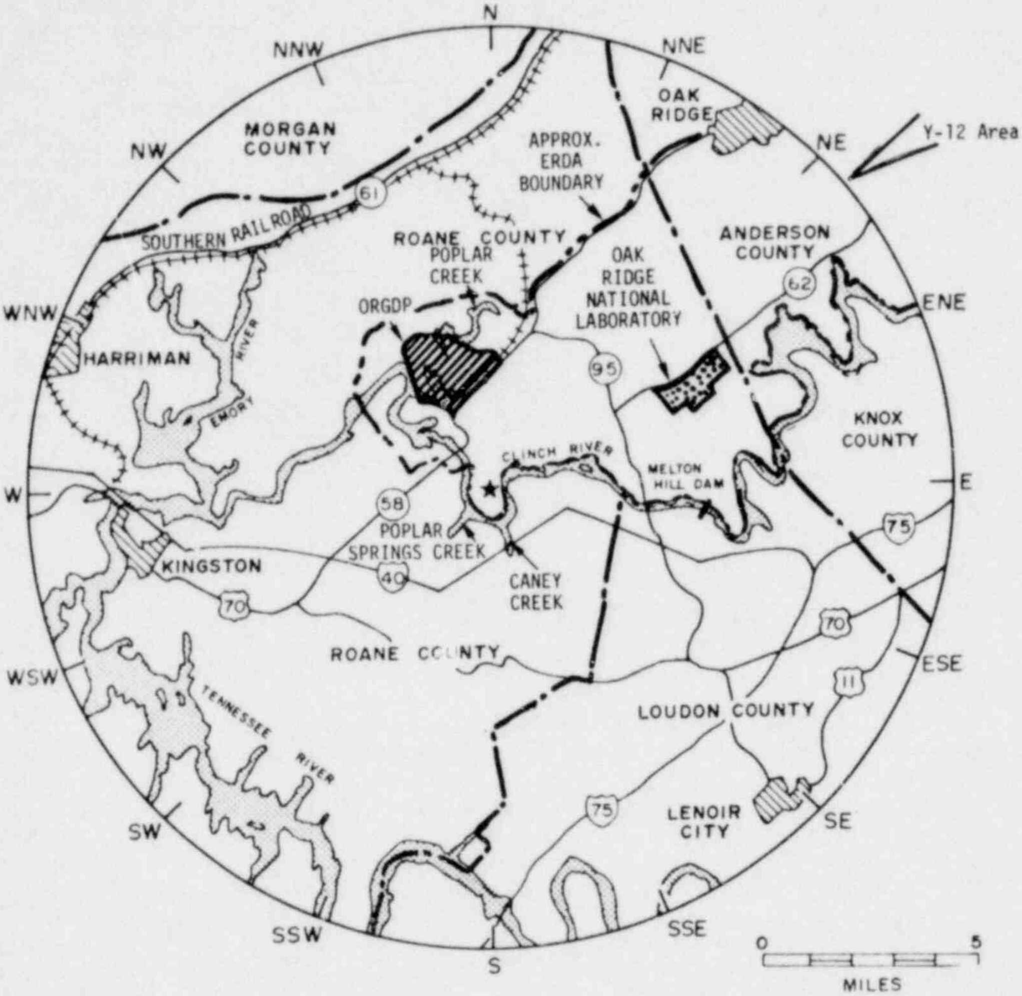


FIGURE 2.2 Local Transportation Routes

The general area within a 10-mi radius of the plant is taken up by residences, farms, recreation, industry, and woodland. Several commercial dairy farms are present in the area, although the trend over recent decades is toward beef production, with its lower labor requirement. Agricultural crops generally are grown in small plots for single family use. While the area has no major sports facility, over 60 recreational sites had, in all, about 3600 people present during the peak hour in 1970, and the staff anticipates 13,000 people during the peak hour in 2010 (ER, Tab 2.2-14). There are three bank fishing areas within 3 miles of the site. A 30-unit camping and day use area is located about 2-3/4 miles SE of the site. A 100-unit campsite, with plans for fishing, boating and swimming, is under development on Caney Creek, about 1 mile SE of the site boundary. No wildlife preserves or hunting areas are in the immediate vicinity, except for a waterfowl refuge 8 miles WSW, on the Tennessee River. Principal industrial activities are the Oak Ridge Gaseous Diffusion Plant (ORGDP), the Oak Ridge National Laboratory, the Y-12 Area, and TVA's Melton Hill Dam (Figure 2.2). At the northern end of the site, between Bear Creek Road and Grassy Creek, about 112 acres have been set aside for the Clinch River Consolidated Industrial Park (Figure 2.5). Twenty-two schools are located within the 10-mi radial area, with nearly 8000 students in 1973. Hospitals are located at Harriman and Oak Ridge. The Southern Railroad serves the ORGDP (shown in Figure 2.4) by way of a branch from the line about 4 miles N of the site. The area is served by several highways including I-40, less than 1 mile S of the site boundary, and State routes 58, 62, and 95. There are no airports or military installations in the 10-mi area (ER, Sec 2.2).

FIGURE 2.3 Aerial Vie. with Plant Location

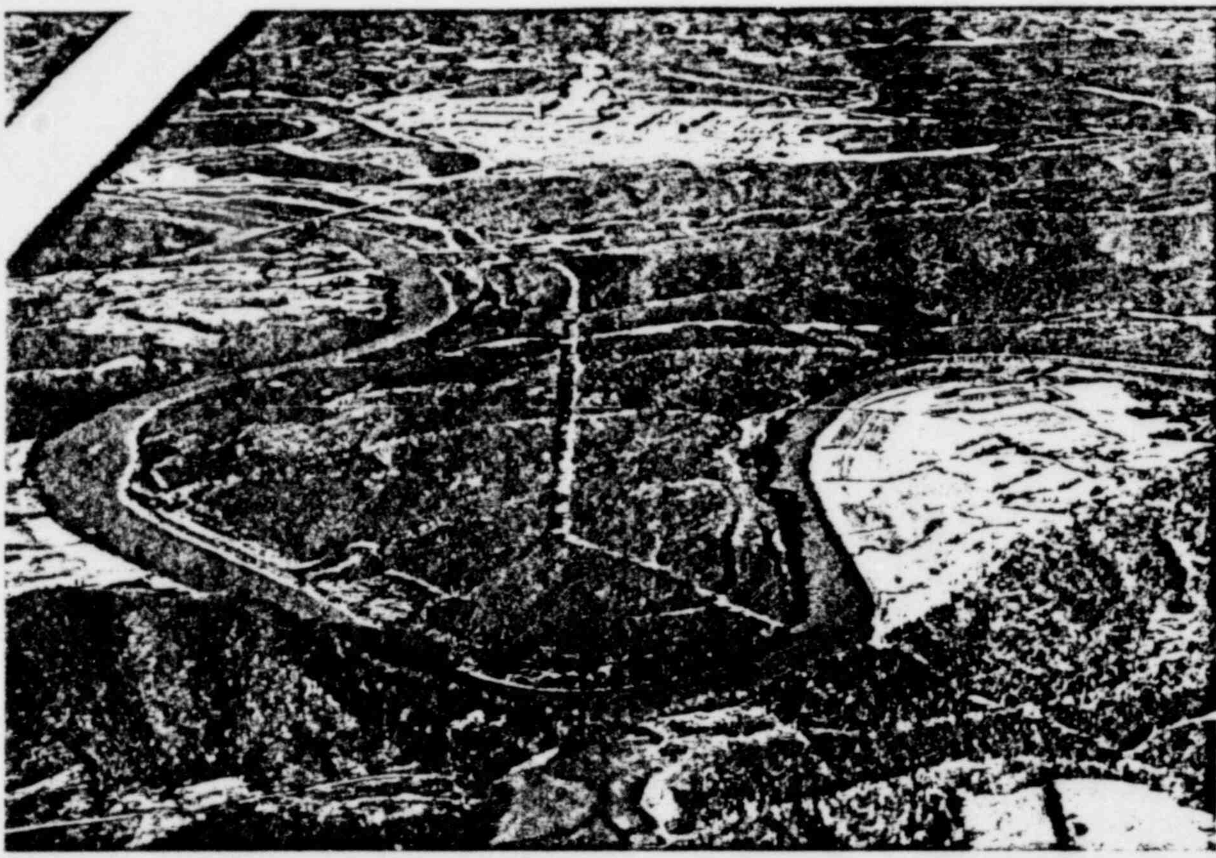


FIGURE 2.4 The Site with the Oak Ridge Gaseous Diffusion Plant in the Background

Within a 20-mi radius of the site, 8 public water systems and 16 industrial systems draw from surface water, including the Clinch River and the Emory River. The closest such withdrawal is by ERDA, 1.6 miles away. Groundwater supplies 17 public systems and many residences within the 20-mi radius. Over 100 such residences are within 2 miles, all located south of the Clinch River. The use of surface water for fishing is considered in Section 2.7. Commercial traffic through the Melton Hill Dam increased from 1000 tons in 1966 to 3600 tons in 1972. For the same years, the numbers of recreational craft dropped from 1198 to 761 (ER, Sec 2.2).

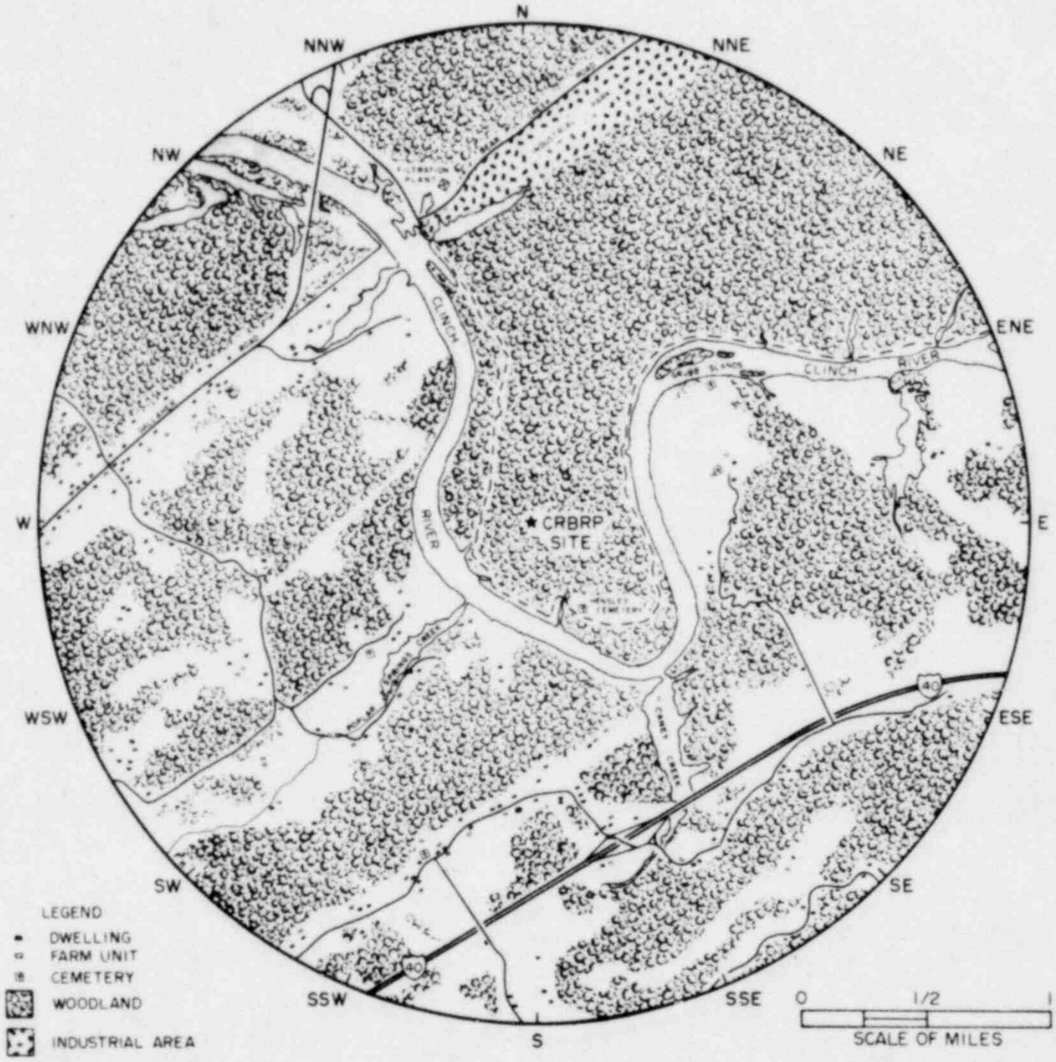
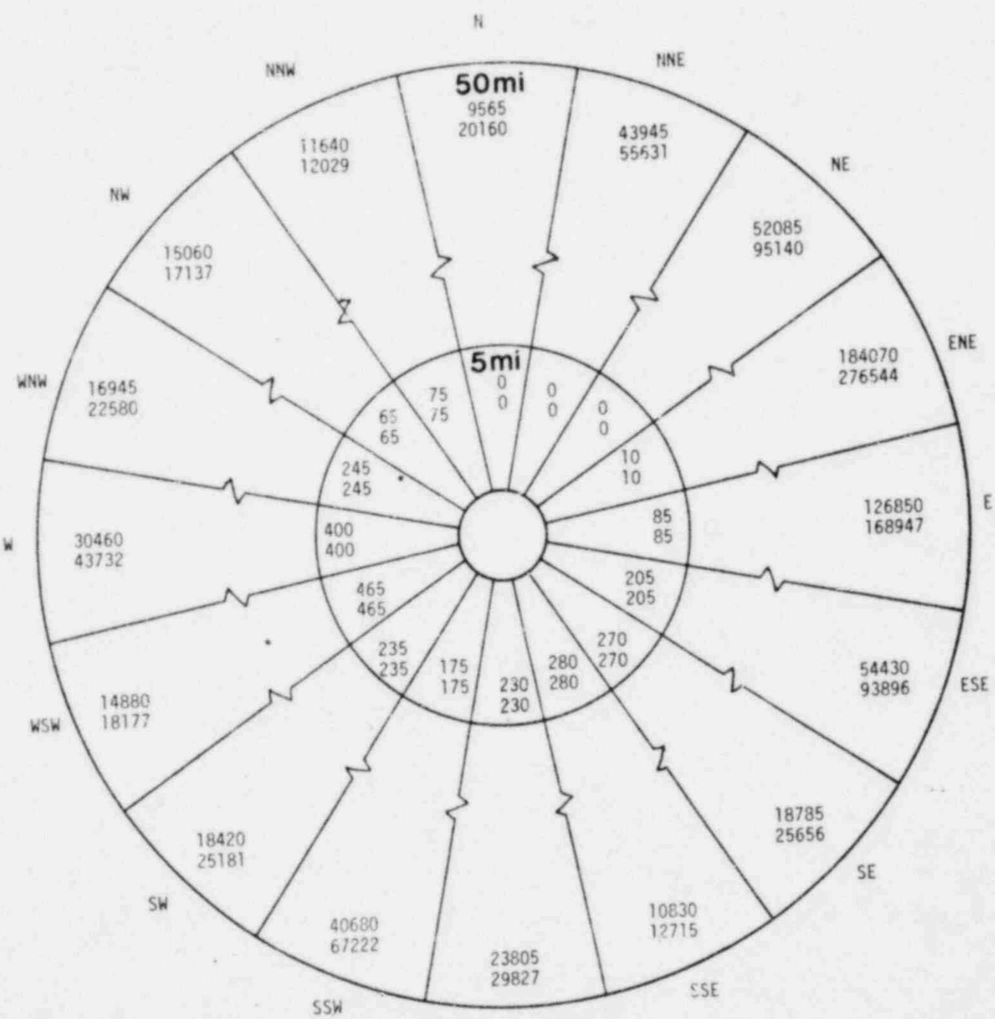


FIGURE 2.5 Land Use Near the Site

2.2 REGIONAL DEMOGRAPHY

Within a 50-mi radius from the plant, Knoxville and Oak Ridge are the largest urban centers, with 1970 populations of 174,587 and 28,319, respectively; 19 other centers had populations between 2500 and 15,000 (ER, Tab 2.2-1). In 1970 the 10-mi radial area had a population of 39,155, and the 50-mi area, 678,800. The corresponding population totals for 1980 are estimated to be 49,500 and 748,000; and for 2010, 65,000 and 987,000. Population distributions for the 1970 and 2010 estimates are shown in Figure 2.6 (ER, Sec 2.2). No growth is projected for the 5-mi radial area since it is remote from growing urban centers and no major development is planned that would increase agricultural intensity and, in turn, population.



Note: Top numbers are 1970 census figures. Bottom numbers are estimates for year 2010.

FIGURE 2.6 Population Distributions for 1970 and 2010 within 5 Miles and 50 Miles of the Site

2.3 HISTORIC AND ARCHAEOLOGICAL SITES AND NATURAL LANDMARKS

The National Register of Historic Places through January 1976 shows four sites within 10 miles of the CRBRP and the proposed transmission lines: tne Harriman City Hall, the County Court House at Kingston, the Southwest Point on the Tennessee River SW of Kingston, and the X-10 Reactor at ORNL. Within the site boundaries, four farmsteads of potential significance were located and recorded as 40RE120, -121, -122, and -123 (Figure 2.7) (ER, Fig 2.3-1). Only remains are present, except for -122 where the buildings stand in disrepair (Schroedl, 1972 and Thomas, 1973). The Hensley Cemetery, 40RE119 (Figure 2.7), with 5 marked graves is on the property, well beyond the plant construction area.

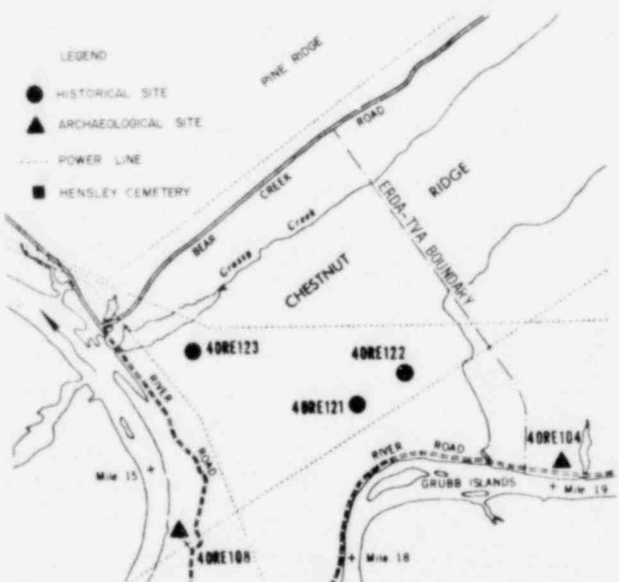


FIGURE 2.7 Archaeological and Historical Sites

Archaeological studies are completed or in process for 6 sites, 40RE104, -105, -106, -107, -108, and -124 (Schroedl, 1972 and 1973). Sites 40RE104, -105, and -106 yielded few cultural materials; further investigation is not planned. Finds at -107, -108, and particularly -124 indicate the need for further excavation, analysis, and reporting. Agreement to do the additional work, and complete it before construction, has been reached between TVA and the University of Tennessee (Schroedl, no date). Removal of nearly all sediments down to the premound surface of 40RE124 indicated interment of more than 36 individuals.

No natural landmarks are present on the site or in the immediate vicinity.

2.4 GEOLOGY

The CRBRP site lies near the western border of the Appalachian geosyncline, which was active during most of the Paleozoic Era (more than 230 million years ago). The site is underlain at shallow depths by sedimentary rocks (siltstone and limestone) of Ordovician age. They were deformed during the Paleozoic era and are now tilted to the SE at an angle of about 30°. Since then, weathering and erosion have been the dominant geologic processes at the site, with sediment accumulation being restricted to terrace and flood plain deposits of the Clinch River. The area is presently characterized by rugged terrain of subparallel ridges with intervening valleys. In the site vicinity, the major ridges (Chestnut Ridge to the northwest and Dug-Hood Ridge to the southeast) crest between 900 and 1,200 ft. The valley between these ridges, known locally as Poplar Springs Valley and Bethel Valley, consists of rolling hills which range between elevations of 750 and 800 ft. Within the site boundaries, Chestnut Ridge consists of two subordinate ridges, which crest at about 900 ft elevation. In the valley formed by these subridges, a topographic saddle rises to about 800 ft and the valley slopes from this saddle in both the northeasterly and southwesterly directions down to the Clinch River (normal summer pool 741 ft). There are no perennial streams on the site. Flow along valleys and gullies occurs only after heavy rainfall.

The site is situated between the traces of two tectonic structures, the Copper Creek and Whiteoak Mountain thrust faults. No reason has been found to suspect any post-Paleozoic activity associated with them. However, there have been 11 recorded earthquake epicenters within a 50-mi radius, 19 epicenters within a 100-mi radius and 44 within a 200-mi radius of the site. The largest earthquake known to have occurred within the tectonic province in which the site is located (Ridge and Valley Province) was on May 31, 1897 in Giles County, Virginia. The effects of such earthquakes on the proposed plant will be considered in the staff's Safety Evaluation Report, in accordance with 10 CFR Part 100, Appendix A.

2.5 HYDROLOGY

2.5.1 Surface Water

In the site vicinity, the Clinch River forms the north leg of the Watts Bar Reservoir, which is part of the TVA system. Its water elevation is controlled by Watts Bar Dam, 55 miles downstream of the proposed plant site, and generally maintained at 737 ft above MSL to 734 ft above MSL. The finished plant grade would be at an elevation 815 ft above MSL, well above the maximum recorded flood level of 764 ft above MSL. In the winter, the river is approximately 612 ft wide and has an average depth of 6.3 ft and average velocity of 1.4 fps. An average river width of 657 ft, depth of 11.6 ft and velocity of 0.6 fps are typical of summer conditions. Norris Dam, 55 miles upstream from the proposed site, regulates the Clinch River flow. However, the immediate influence on water flow at the site is Melton Hill Dam. It is small, but only 5 miles upstream from the proposed site. Since completion of TVA's Melton Hill Dam in 1963, the average year has included a total of 46 days when no water was released.

Based on 1963-1973 discharge records for Melton Hill Dam, the average flow of the river is about 4,800 cfs at the site. The maximum hourly average release was 43,400 cfs, and the maximum daily average release was 26,900 cfs (ER, Sec 2.5.1.2 and PSAR, Sec 2.4.1.2.4). River flow at the site can be upstream, downstream or quiescent, depending on the mode of operation of the Melton Hill Dam, Watts Bar Dam and Fort Loudon Dam (on the Tennessee River). Flow reversal would occur as a result of abrupt shutdown of Melton Hill and Watts Bar Dams and by release of water from Fort Loudon Dam. Zero flow conditions at Melton Hill Dam have been imposed for continuous periods of 29 days, 11 days, and shorter continuous periods for the purposes of controlling the growth of Eurasian water milfoil in the reservoir. However, no extended periods of zero flow are anticipated in the future. The applicant stated that operations of Melton Hill Dam would be regulated to meet the flow requirements at the CRBRP site. The 1963-1973 flow data for Melton Hill Dam show that nearly all monthly averages exceeded 1000 cfs, except for periods of no flow (ER, Sec 2.5.1.3). Assessments in Chapter 5 consider both no flow and 1000 cfs.

Water temperatures were measured at Clinch River Mile (CRM) 21.6 between May 1963 and December 1971. The maximum temperature observed during this period of record was 78°F and the minimum, 41°F. Table 2.1 gives the average daily maximum, minimum and mean temperature for each month (ER, Fig 2.5-7). Figure 2.8 illustrates the 1974 seasonal and spacial variation in water temperature of the Clinch River (ER, Am I, Part II, D1a). The water temperatures are vertically uniform except in the summer when stratification is naturally induced. Data on water quality appear in Table 2.2 (Gartrell, 1972). More detailed information is available in the ER, Sec 2.5, and the PSAR, Sec 2.4.

TABLE 2.1 Average Daily Maximum, Minimum and Mean River Temperatures for Each Month (1963-1971)[(a)]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	44	44	49	57	63	65	66	67	68	66	58	49
Minimum	41	41	45	54	60	62	63	65	66	63	56	47
Mean	43	42	47	55	61	64	64	66	67	64	57	48

(a) Clinch River Mile 21.6; temperatures in °F.

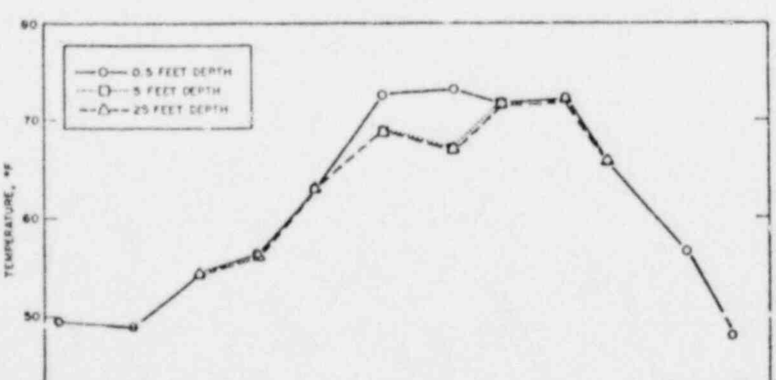


FIGURE 2.8 Water Temperature Survey, Clinch River Mile 14.4 (ER, Am I, Part II, D1a)

TABLE 2.2 Clinch River Water Quality Data[a]

Date	Time ET 24-hr Clock	Location in Stream[b]	Depth (ft)	Stream Discharge (cfs)	Coliforms Fecal (MPN/100 ml)	Coliforms Total (MPN/100 ml)	Water Temp (°F)	DO (mg/ℓ)	5-Day 20°C BOD (mg/ℓ)	Color (PCU)	Turb (JCU)	Nitrogen[c] Org (mg/ℓ)	Nitrogen NH_3 (mg/ℓ)	Nitrogen NO_2 (mg/ℓ)	Nitrogen NO_3 (mg/ℓ)	Phosphate Sol (mg/ℓ)	Phosphate Total (mg/ℓ)	pH	Alkalinity ($CaCO_3$) Phen (mg/ℓ)	Alkalinity ($CaCO_3$) Total (mg/ℓ)	Total Hardness ($CaCO_3$) (mg/ℓ)
Clinch River Mile 79.8																					
6/27/67	1055	Tailrace	0.5	6,400	2	62	50.2	7.8	0.5	5	5	0.37	0.00	0.01	0.43	0.01	0.01	7.8	0	89	115
7/27/67	0905	Tailrace	0.5	6,670	130	220	51.8	5.1	0.7	10	28	0.11	0.00	0.01	0.60	0.03	0.03	7.8	0	88	119
8/15/67	1050	Tailrace	0.5	8,500	6	130	57.2	2.9	1.2	15	6	0.08	0.13	0.01	0.48	0.01	0.01	7.6	0	10	129
9/26/67	1120	Tailrace	0.5	8,220	2	6	62.6	0.9	0.2	50	36	0.50	1.18	0.02	0.42	0.07	0.12	7.5	0	105	116
10/18/67	1820	Tailrace	0.5	7,220	11	11,000	64.4	2.3	0.3	30	43	0.27	0.09	0.01	0.23	0.06	0.11	7.7	0	105	128
11/8/67	1515	Tailrace	0.5	2,220	6	33	60.8	6.7	0.3	10	15	0.14	0.18	<0.01	0.19	0.05	0.09	7.6	0	85	101
2/15/68	0920	Tailrace	1.0	6,390	3	23	33.8	11.2	1.2	10	15	0.25	0.06	0.02	0.54	0.04	0.18	8.2	0	103	---
4/24/68	1700	Tailrace	1.0	0	160	620	42.8	10.5	1.0	10	2	0.04	0.05	0.01	0.80	0.05	0.05	7.8	0	92	96
Clinch River Mile 23.1																					
6/23/67	1415	Tailrace	0.5	16,500	94	940	64.6	8.6	0.0	5	14	0.40	0.01	0.02	0.40	0.01	0.11	7.8	0	96	128
7/28/67	1340	Tailrace	0.5	8,600	110	360	66.6	7.7	1.1	10	23	0.01	0.15	0.01	0.52	0.01	0.07	7.9	0	90	112
8/15/67	1535	Tailrace	0.5	15,260	3	230	63.5	7.9	0.9	15	31	0.09	0.09	0.01	0.47	0.05	0.25	7.5	0	32	124
9/26/67	1650	Tailrace	0.5	8,340	36	110	66.7	5.9	0.7	5	2	0.24	0.00	0.02	0.43	0.07	0.14	7.6	0	106	112
10/19/67	1305	Tailrace	0.5	8,340	16	3,400	62.6	6.2	1.6	10	8	0.34	0.17	0.03	0.31	0.06	0.16	7.9	0	100	125
11/8/67	1155	Tailrace	0.5	9,000	62	160	59.0	6.1	0.3	10	9	0.13	0.12	0.01	0.23	0.01	0.13	7.8	0	97	115
2/16/68	0900	Tailrace	1.0	7,500	3	36	41.0	11.7	<1.0	5	10	0.25	0.11	0.02	0.57	0.06	0.12	7.2	0	111	---
4/25/68	1815	Tailrace	1.0	0	<2	50	60.4	9.6	1.3	15	3	0.63	0.03	0.01	0.47	0.05	0.09	8.0	0	92	100

				Ca (mg/ℓ)	Mg (mg/ℓ)	Cl (mg/ℓ)	Na (mg/ℓ)	K (mg/ℓ)	Iron Fe (mg/ℓ)	Iron Total (mg/ℓ)	Mn Total (mg/ℓ)	SO_4 (mg/ℓ)	SiO_2 (mg/ℓ)	Specific Conductance at 25°C (µmhos/cm)	Solids Sus (mg/ℓ)	Solids Dis (mg/ℓ)	Solids Total (mg/ℓ)
Clinch River Mile 79.8																	
6/22/67	1055	Tailrace[d]	0.5	27.8	11.0	11	3.00	1.30	0.10	0.10	0.06	10	4.8	240	0	112	112
7/27/67	0905	Tailrace	0.5	28.8	11.4	3	2.50	1.40	0.01	0.12	0.06	12	3.9	241	13	131	144
8/15/67	1050	Tailrace	0.5	32.8	11.4	3	4.20	1.40	0.01	0.07	0.04	8	3.8	235	26	102	128
9/26/67	1120	Tailrace	0.5	31.0	9.4	7	2.50	1.30	0.01	0.10	0.21	18	3.4	284	4	140	134
10/18/67	1820	Tailrace	0.5	35.0	9.3	2	2.20	1.40	0.02	0.80	0.43	16	4.2	249	1	143	144
11/8/67	1515	Tailrace	0.5	26.0	8.8	3	2.40	1.50	0.02	0.73	0.09	14	---	222	0	129	129
2/15/68	0920	Tailrace	1.0	---	---	2	2.70	1.20	0.05	---	---	12	3.0	210	10	130	140
4/24/68	1700	Tailrace	1.0	23.0	9.5	3	1.70	3.80	0.05	0.06	0.02	10	2.7	240	---	---	---
Clinch River Mile 23.1																	
6/23/67	1415	Tailrace[e]	0.5	27.7	14.4	2	2.00	3.00	---	0.47	0.20	12	4.3	253	27	121	148
7/28/67	1340	Tailrace	0.5	28.8	9.6	5	2.30	1.50	0.01	0.40	0.07	16	4.6	201	2	120	122
8/15/67	1535	Tailrace	0.5	31.8	10.8	9	2.20	1.40	0.00	0.26	0.04	14	3.7	230	20	122	142
9/26/67	1650	Tailrace	0.5	29.5	9.2	18	1.70	1.40	0.01	9.21	0.07	18	3.5	284	63	90	153
10/19/67	1305	Tailrace	0.5	34.0	9.3	2	2.60	1.50	0.01	0.22	0.04	13	3.6	284	8	132	140
11/8/67	1155	Tailrace	0.5	31.0	9.1	3	2.80	1.60	0.02	0.17	0.45	14	---	266	15	98	113
2/16/68	0900	Tailrace	1.0	---	---	3	2.30	1.00	0.05	---	---	14	4.0	240	---	140	140
4/25/68	1815	Tailrace	1.0	26.0	9.0	3	3.00	4.00	0.05	0.19	0.04	12	1.1	230	10	100	110

(a) Gartrell, 1972)
(b) Location in Stream: Percent distance from left bank looking downstream.
(c) Nitrogen: Values shown are mg/ℓ nitrogen in the forms listed.
(d) Tailrace: Norris Dam.
(e) Tailrace: Melton Hill Dam.

2.5.2 Groundwater

Groundwater occurs at the proposed site primarily in weathered joints and fractures in the subsurface rocks (ER, Sec 2.5.2.4). This zone extends from the ground surface to the top of the continuous rock. Borings made at the proposed site and in the river show that the elevation of the top of continuous rock lies at 700 MSL. All groundwater at the site flows towards the river, generally parallel with the ridges that characterize the region and from topographic highs to topographic lows. Groundwater recharge is primarily derived from precipitation.

2.6 METEOROLOGY

The regional climate, with relatively warm summers and cool winters, is characteristic of continental climatic regions in the southeastern United States. In the winter, cold dry air masses from Canada predominate. They usually are modified and warmed somewhat as the air crosses the ridges of the Cumberlands and moves down the eastern slopes. During the remainder of the year, the anticyclonic circulation of the atmosphere about the Burmuda-Azores high pressure system results in predominance of warm, moist air from the Gulf (Landsberg, 1974; USDC 1; USDC 2). On about 33 days annually, temperatures may be expected to reach 90°F or higher, and temperatures of 0°F or lower may be expected on one day each year. Temperatures of 32°F or lower may be expected to occur on 82 days annually (USDC 1 and USDC 3). Precipitation amounts are greatest during winter and early spring, and are lowest in early autumn. A secondary precipitation maximum, associated with thundershower activity, occurs in July (USDC 1). Relative humidity, on an annual basis, averages 70%. Additional information is presented in Sec 2.6.1 of the ER.

Locally, long-term records show that extreme maximum and minimum Knoxville temperatures are 104°F and -16°F, respectively (USDC 2). At Oak Ridge the extreme maximum and minimum air temperatures, recorded over a shorter period of record, are 105°F and -9°F, respectively (USDC 1). A maximum 24-hr precipitation total of 7.5 in. was recorded at Oak Ridge, and a 24-hr total of 7.75 in. at the X-10 station site (Landsberg, 1974). A 24-hr snowfall total of 12 in. was recorded at Oak Ridge and data indicate that heavy fog (visibility 0.25 mile or less) occurs on about 3 days annually at the weather office location (USDC 1). Such occurrences may be more frequent at the plant site,which is nearer the river. Wind speed and direction distributions (wind roses), based on July 1973 to July 1974 data collected onsite at the 75- and 200-ft above ground levels, are presented in Figure 2.9 (ER, Fig 2.6-4 and -9). Onsite data used in determining the dispersion factors for radiological dose assessments (Section 5.7) were collected during the period from June 1, 1974 through May 1, 1975 (Section 6.1.3). Temperature and precipitation data for the X-10 station site are presented in Table 2.3 (ER, Tab 2.6-4 and -8). Additional local meteorological information is available in Sec 2.6.2 of the ER.

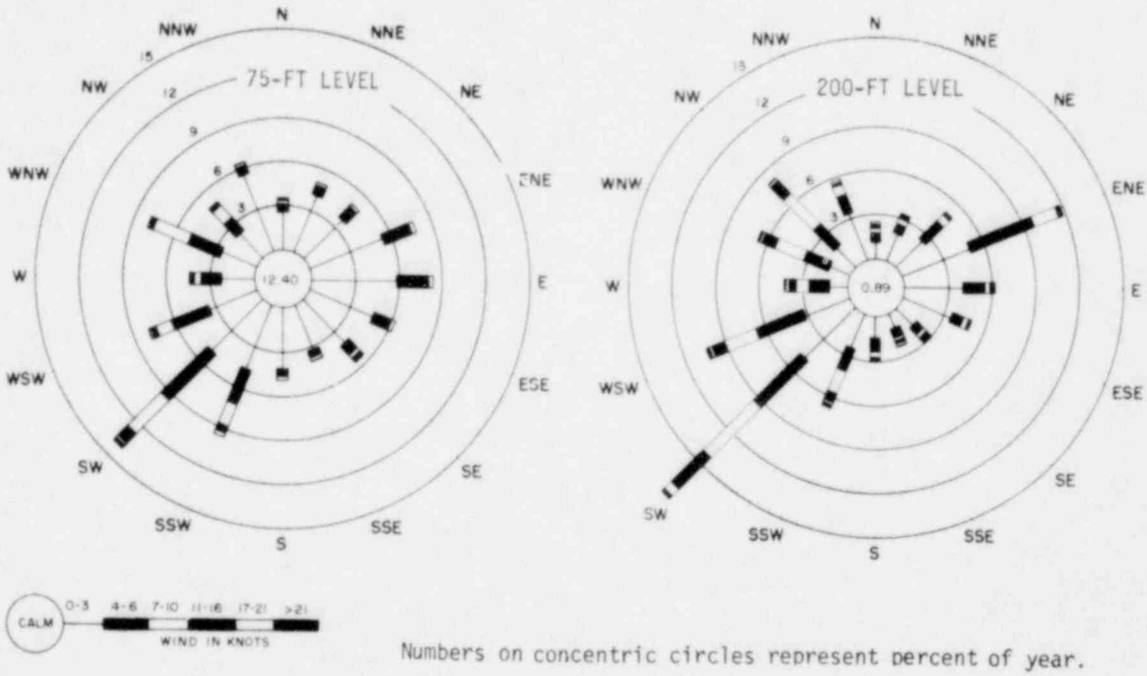


FIGURE 2.9 Annual Onsite Wind Roses (ER, Fig 2.6-4 and -9)

Local severe weather occurrences may be associated with intense, large-scale winter storms or with severe thunderstorms, mainly in the warmer seasons. Remnants of hurricanes or tropical storms occasionally affect the area. Six tornadoes were reported within the one degree latitude-longitude square containing the site during the period 1955-1967, giving a mean annual tornado frequency of 0.5 and a recurrence interval for a tornado at the plant site of 3000 years (Sels, 1969; Thom, 1973). For the same square and time period, there were 15 reports of hail 0.75 in. diameter or greater, and 46 windstorms reported with speeds of 50 knots (58 mph) or greater (Sels, 1969). During the period 1871-1973, 4 tropical storms or hurricanes passed within 50 miles (Cry, 1965; USDC 4). Freezing precipitation may be expected to occur about 5 times each year and a severe ice storm (accumulation of 1 in. or more) once every 5 years (Tattleman and Gringorton, 1973). High air pollution potential (air stagnation) can be expected to occur on 7 days annually (Gross, 1970; Holzworth, 1972).

Table 2.3 Climatological Temperature and Precipitation - Oak Ridge Area Station X-10[(a)]

		Temperature, 1945-1964					Precipitation, 1944-1964			
		Climatological Standard Normals 1931-1960			Extremes 1945-1964					
Month		Mean Monthly (°F)	Daily Maximum (°F)	Daily Minimum (°F)	Highest Temp (°F)	Lowest Temp (°F)	Monthly Average[(b)] (in.)	Monthly Maximum (in.)	Monthly Minimum (in.)	Maximum in 24 Hr (in.)
December		40.4	49.4	31.3	76	-5	5.22	10.28	1.98	4.38
January		40.1	48.9	31.2	77	-8	5.24	12.37	1.11	3.96
February		41.7	51.6	31.8	77	0	5.39	10.01	1.89	3.23
	Winter	40.7	50.0	31.4	77	-8	15.85			
March		48.0	58.9	37.0	87	4	5.44	9.69	2.05	3.84
April		58.2	70.0	46.3	89	24	4.14	8.54	1.25	2.39
May		66.9	79.0	54.8	94	32	3.48	7.01	0.90	2.09
	Spring	57.7	69.3	46.0	94	4	13.06			
June		74.7	86.1	63.3	99	41	3.38	7.55	1.18	3.08
July		77.4	88.0	66.7	103	49	5.31	10.19	2.14	3.74
August		76.5	87.4	65.6	99	44	4.02	10.31	0.50	3.31
	Summer	76.2	87.2	65.2	103	41	12.71			
September		71.1	83.0	59.2	103	33	3.59	12.84	0.21	7.75
October		60.0	72.2	47.7	91	21	2.82	6.43	0.00	2.32
November		47.6	58.6	36.5	83	4	3.49	12.00	1.01	3.20
	Fall	59.6	71.3	47.6	103	4	9.90			
	Annual	58.5	69.4	47.6	103	-8	51.52	12.84	0.00	7.75
		Oak Ridge City Office Climatological Standard Normals 1941-1970								
	Annual	57.8	68.6	47.0	105[(c)]	-9[(c)]				
		Knoxville Vicinity Climatological Standard Normals 1941-1970								
	Annual	59.7	69.8	49.5	104[(d)]	-16[(d)]				

(a) Source: ER, Tab 2.6-4 and 2.6-8.
(b) Standard climatological normals - 1931-1960.
(c) May 1947 - October 1974.
(d) 1874 - October 1974

2.7 ECOLOGY

2.7.1 Terrestrial Ecology

The site supports moderately diverse plant and animal populations. A mosaic of forest types covers nearly all of the 1364 acres, with 37% in hardwoods, 47% in conifers, 11% in mixed forest, and 5% in nonforested land (ER, Sec 2.7.1.3.1). The mosaic reflects previous land use and present forest management practices on the site. Extensive farming prior to 1942 resulted in erosion and loss of soil fertility on steep slopes. Most of the existing deciduous forests were present as early as 1924, but acreages of conifers doubled from 1940 to 1972 because of natural old field succession and because of recent plantings of pine (McConathy, 1975). Two of the plant communities, so-called "natural areas", on the site are of ecological interest because of their stages of succession and relatively undisturbed condition (ER, Sec 2.7.1.3.3 and Fig 2.7-6). These are 1) less than 28 acres on the east boundary of the site dominated by northern red oak, tulip poplar, and white oak, and 2) about 15 acres of mixed deciduous (oak-beech-cedar) forest in the northern part of the site. Plant and animal populations on the site are similar to those of much of the surrounding land (ER, Sec 2.7.1.4). For example, the Oak Ridge Reservation contains 29,443 acres in the various woodland types shown in Table 2.4.

2.7.1.1 Flora

Plant species on the site are largely those expected for land undergoing secondary succession in Eastern Tennessee which has a relatively rich flora (Braun, 1972). Rare plant species (ER, Sec 2.7.1.3.4 and ER Am I, Part II, B7) include Panax quinquefolium (ginseng), Citticifuga rubifolia (black snakeroot) and Saxifiaga carayana (carey's saxifrage). Also occurring are Cypripedium acaule (Pink lady's slipper), Dicentra canadensis (squirrel corn) and Liparis lilifolia (large twayblade) which are listed as uncommon in southern National Forests (Duncan, 1970). Six species were collected which had not been collected previously in Roane County according to the University of Tennessee Herbarium (ER Am I, Part II, B7). None of the endemic species of the Tennessee cedar glades (Baskin, et al., 1968) was found in cedar glades on the site. Except for those species listed above, no rare or endangered plant species on the Smithsonian Institute list (USDI, 1975) or on the list given by Goff et al. (1975) or by Sharp (1974) have been reported on the site.

TABLE 2.4 Forested Acres of the Oak Ridge Reservation[(a)]

Community Type	Acres	% of Total
Hardwood	10,876	37
Pine Plantation	5,002	17
Natural Pine	4,888	16
Cedar and Pine	478	2
Hardwood-Cedar	1,660	5
Hardwood-Pine	5,959	20
Hardwood-Cedar-Pine	589	3
	29,443	100

(a) Appendix B.

2.7.1.2 Fauna

2.7.1.2.1 Mammals. The two most common small mammals on the site are the white-footed mouse (Peromyscus leucopus) and the golden mouse (Peromyscus nuttali). Mammals providing sport and recreation, those with economic value as furbearers, and those considered rare or threatened are identified below with special reference being made to species found on the site.

1) Mammals Providing Sport and Recreation

- The white-tailed deer population in Roane County is about one deer per 2000 acres although populations at the site may be higher (ER Am I, Part II, B5). Roane, Loudon and Knox Counties are closed to deer hunting and the site itself is closed to all hunting (ER, Sec 2.7).
- Eastern cottontail rabbits are common in the open areas of the site, but uncommon in pine areas (ER Am I, Part II, B5). For the four counties near the site (Roane, Loudon, Knox, and Anderson), rabbits are at about one per 3 to 7.5 acres and hunter success is about 0.65 rabbit per hunter trip in east Tennessee as a whole.
- The gray squirrel is common only in mature mixed hardwood areas on site. The four counties near the site have about one squirrel per 1.5 acres and hunter success in east Tennessee is about 1.55 squirrels per hunter trip.

2) Mammals of Economic Value

A number of furbearing mammals occur onsite. Ranked on the basis of price per pelt in descending order, these are red and gray fox, mink, raccoon, skunk, muskrat and opossum. In addition, raccoon, opossum and muskrat are eaten by some people. Red and gray foxes, raccoons, and opossum are popular game mammals in Tennessee.

- Red and gray foxes are the most common predators on the site, with probably more red than gray foxes occurring throughout the site.

- Mink occur along the Clinch River where they prey upon both aquatic and shoreline mammals.
- Raccoons are found near water but move around throughout the site.
- Striped skunk are present, especially near aquatic areas, but spotted skunk have not been found.
- Muskrats are found along the Clinch River.
- Opossum are common on the site.

3) Threatened Species

Trapping at 12 different areas on the site, over all four seasons of the year, revealed no small mammal species classified federally as endangered or threatened (ER Am I, Part II, B3). The only mammal listed as endangered (US Dept of Int, 1973 and App A) which might occur on the site is the Indiana Bat (Myotis sodalis) although it has not been found on the site nor on the Oak Ridge Reservation (Howell and Dunaway, 1959).

2.7.1.2.2 Birds. Birds were censused using transects on representative habitats in late May and in mid-December, with seven counts at each sampling time (ER Am I, Part II, B4). Additional qualitative surveys were conducted in March, May, August, and mid-November (ER, Section 2.7.1.4.2). Of the 125 species observed on the site, the Southern bald eagle (Haliaeetus leucocephalus leucocephalus) is on the Federal list of threatened species (U.S. Dept of Int, 1973) and considered endangered by the State of Tennessee (App A). The American osprey (Pandion haliaetus), considered by the State to be endangered ("status undetermined" on Federal list), also is present. In addition, these three species of hawk, considered by the State to be threatened, have been observed: the sharp-shinned hawk (Accipiter striatus), Cooper's hawk (Accipiter cooperii), and marsh hawk (Cirus cyaneus). All five rare species are present on the Oak Ridge Reservation (ER, Tab 2.7-15).

Four species of upland game birds occur on the site. Bobwhite quail is the most abundant with six covies (4 to 6 individuals per covey) observed in the spring survey (ER, Am I, Part II, B5). For the four counties near the site (Knox, Loudon, Anderson, and Roane), populations of quail are one covey (about 12 birds) per 50 to 75 acres. The quail populations on the site are less because of the small amount of preferred habitat (open brushy areas) on the site. Quail harvest for east Tennessee is about 1.3 quail per hunter trip. Mourning doves are present; nine individuals were observed in the spring and summer surveys. The surrounding four-county area does not generally have large dove populations because there is not much small grain. Current harvest figures for east Tennessee as a whole indicate 4.2 birds per hunter trip. The ruffed grouse was also observed; five individuals were reported from the spring and summer survey periods. The American woodcock was found in wet fields and border areas; five individuals were identified during the survey (ER, Am I, Part II, B5).

2.7.1.2.3 Reptiles and Amphibians. Herptofaunal species are relatively abundant on the site because of the variety of habitats available, especially in mixed oak forests and in wet places. None of the species listed in Table 2.7-20 of the ER and on the State list is federally classified as threatened. The bull frog is classified as a game animal in the State.

2.7.2 Aquatic Ecology

Physical and chemical characteristics of the Clinch River near the site are discussed in Section 2.5. Water quality seems similar to that of southeastern U.S. rivers (Geraghty, 1973). Total and fecal coliform counts (Section 2.5) are well below the maximum allowable limit of 5000/100 mℓ (total fecal) for any one water sample required by the State of Tennessee (TWQCB, 1973) for the protection of fish and aquatic life. The higher counts in March can be attributed to pollution by agricultural run-off, especially from fecal contamination by farm animals (ER, Sec 2.7.2.4.1).

The phytoplankton community sampled from March through September 1974 is represented by 132 species. The diatoms (Chrysophyta) were the most numerous division from March through May; they decreased in June and July, and increased during August and September. The blue-green algae (Cyanophyta) were present in May, increased in June and July to become the most numerous division, and decreased in August and September. The green algae (Chlorophyta) comprised a small percentage of the total population from May through July and increased significantly in August and September. Two other divisions of phytoplankton, euglenoids (Euglenophyta) and dinoflagellates (Pyrrophyta) were present but in relatively low numbers. Phytoplankton densities ranged from 3.1×10^5 to 2.9×10^6 cells/ℓ typical of TVA water bodies (Taylor, 1971). Diversity indices (Shannon-Wiener) were not significantly different among stations and sampling periods. Mean chlorophyll a concentrations for June through September were 3.8 mg/m^3 and ranged from 2.2-6.0 mg/m^3, typical of TVA water bodies (Taylor, 1971). A mean ratio of 1.3 was determined for the pheophytin a content of the phytoplankton. Pheophytin a is the natural degradation product of chlorophyll a. The ratio of pheophytin a to chlorophyll a is the ratio of optical densities before and after acidifying pigment extract. A ratio of 1.0 indicates the presence of only pheophytin a, whereas a ratio of 1.7 indicates that the samples are free of pheophytin a (EPA, 1973).

A total of 56 zooplankton species were identified from March through September 1974, of which 40 species were rotifers and 16 arthropods. The arthropods consisted mainly of cladocerans and copepods. The number of zooplankters ranged from 1/ℓ to 206/ℓ, with biomass estimates ranging from 13 to 639 μg/ℓ, typical of the nation's rivers (Pennak, 1963). Highest densities were recorded in May with lowest densities occurring in March. Predicted seasonal variations in the Clinch River zooplankton are as follows: rotifers dominate numerically during early spring and summer, but decrease during the colder months; cladocerans are abundant from March through October; copepods are present throughout most of the year, even though not abundant, except possibly during the warmer months (ER, Sec 2.7.2.4.3). Diversity indices were not significantly different between stations but June-September mean diversity indices were higher than those for March or May. Some vertical stratification does occur among the rotifer species, but little among the arthropod species. Rotifers were two to four times more abundant in the surface samples than in the bottom samples.

Periphyton (attached algae) samples were collected from March through October 1974 with 123 species present representing 5 Phyla. Diatoms were the most numerous periphyton organisms with green algae, blue-green algae, euglenoids and dinoflagellates in decreasing order of abundance. The mean number of algal cells (no./cm^2) ranged from 1.1×10^5 to 3.9×10^6. Diversity indices showed no apparent differences between stations or seasons. The seasonal pattern of abundance is quite typical for these organisms. Diatoms had high densities in spring and lower densities during the summer. The blue-greens increased during the summer and reached highest densities in October. During the fall and winter, green and blue-green algae are expected to decrease with blue-greens being nearly absent in winter. Diatoms should be the numerically dominant form in the winter months with green algae being present in small amounts. Abundance and seasonal patterns are typical for Tennessee over the past seven years (ER, Sec 2.7.2.4.4). Mean values of chlorophyll a ranged from 8.4 to 55.8 mg/m^2 for the period between May and October 1974. The mean value for pheophytin a for all samples analyzed was 1.6, indicating a nondecaying photosynthetically active community.

The distribution and abundance of macrophytes in the site area were sparse. A few strands of Eurasian water milfoil were collected, but their origin could not be identified. The sparse growth of macrophytes is attributed to limited light penetration in the water, steep shorelines, hard substrate, and a fluctuating river water level (ER, Sec 2.7.2.4.6).

The benthic macroinvertebrates (benthos) collected by dredging were numerically dominated by insect larvae (chiromonids), representing over 50% of all species collected. Other important groups included mollusks, annelids, flatworms and coelenterates. A total of 50 species was collected from March through September. Densities of the benthos ranged from 75 to 467 organisms/m^2 and diversity indices were low. Substrate type is a significant factor affecting benthos distribution (EPA, 1973). Three types of substrates, fine sand, sand, and gravels, were identified for the Clinch River near the site. Annelids, mainly Limnodrilus, were the dominant form in the fine sediments with the mollusk Corbicula and the coelenerate Hydra dominant in the coarse sand and gravel, respectively. Biomass, expressed as composite blotted and ash-free dry weight, were estimated for Corbicula alone and for all other organisms combined. Corbicula biomass estimates ranged from 2 to 11,400 mg/m^2 and for the other organisms, 0 to 92 mg/m^2.

Artificial substrates were also used to assess the macroinvertebrates. Chironomid larvae represented over 50% of the 44 species identified. Biomass values ranged from 152 to 874 mg/m^2. Chironomids have been classified as biological indicators of water quality (EPA, 1973). Ten species of chironomids collected in the dredge samples and 8 species collected on artificial substrates are listed by EPA as being intolerant to decomposable organic waste. The presence of those species implies that the study area around the site is not widely contaminated with decomposable organic waste. The Asiatic clam, Corbicula, was the dominant macroinvertebrate collected in terms of biomass. (For more detailed biomass values, lengths, and life history of this clam, refer to the ER, Sec 2.7.2.4.5.)

A total of 30 fish species representing 10 families were collected by electroshocking and gill netting from March through September 1974 (Table 2.5). The species collected have been divided into general categories of game, rough, and forage fishes. In terms of numbers, the forage fishes represented 54% of the total catch with the threadfin shad being the most numerous. The rough fish (so-called "commercial" fish) comprised about 34% of the total catch of which skipjack herring were most numerous. The game fishes include centrachids (sunfishes), perichthyids (temperate basses) and percids (perches). They comprised about 12% of the total catch. Bluegills were the most numerous game fish. Largemouth bass and white crappie are the most desired game fish in the area, and if introduced striped bass become plentiful, they will be prized highly by sport fishermen (Hatcher, 1975). In terms of weight, rough fish were most abundant, representing about 70% of the total fish weight with forage and game fish comprising 17 and 12%, respectively.

TABLE 2.5 Fish Species - Relative Abundance Clinch River[a] Collected March 28, 1974-September 26, 1974

	Common Name	Total No.	% of Total No.	Total Weight (g)	% of Total Weight
Game					
Centrarchidae					
Amblopites ruspestris	Rock bass	4	0.6	338	0.2
Lepomis auritus	Redbreast sunfish	3	0.5	328	0.2
L. macrochirus	Bluegill	26	4.2	2468	1.8
L. megalotis	Longear sunfish	2	0.3	168	0.1
L. microlophus	Redear sunfish	2	0.3	240	0.2
Micropterus punctulatus	Spotted bass	1	0.2	3	<0.1
M. salmoides	Largemouth bass	6	1.0	1713	1.3
Pomoxis annularis	White crappie	1	0.2	37	<0.1
Percidae					
Perca flavescens	Yellow perch	2	0.3	320	0.2
Stizostedion canadense	Sauger	12	2.0	5955	4.4
Percichthyidae					
Morone chrysops	White bass	16	2.6	4636	3.4
M. saxatilis	Striped bass	1	0.2	128	0.1
Forage					
Clupeidae					
Dorosoma cepedianum	Gizzard shad	74	12.1	13391	10.0
D. petenense	Threadfin shad	234	38.3	9629	7.2
Cottidae					
Cottus carolinae	Banded sculpin	1	0.2	5	<0.1
Cyprinidae					
Hybopsis storeriana	Silver chub	3	0.5	181	0.1
Notropis ardens	Rosefin shiner	1	0.2	8	<0.1
N. atherinoides	Emerald shiner	15	2.4	85	<0.1
Percidae					
Percina caprodes	Logperch	2	0.3	62	<0.1
Rough					
Catostomidae					
Carpiodes cyprinus	Quillback carpsucker	12	2.0	8645	6.4
Hypentelium nigricans	Northern hogsucker	2	0.3	270	0.2
Ictiobus bubalus	Smallmouth buffalo	9	1.5	11830	8.8
Moxostoma carinatum	River redhorse	5	0.8	6380	4.8
M. duquesnei	Black redhorse	1	0.2	1085	0.8
M. erythrurum	Golden redhorse	41	6.7	17793	13.3
Clupeidae					
Alosa chrysachloris	Skipjack herring	66	10.8	24238	18.1
Cyprinidae					
Cyprinus carpio	Carp	30	4.9	18220	13.6
Hiodontidae					
Hiodon tergisus	Mooneye	13	2.1	2355	1.8
Ictaluridae					
Ictalurus punctatus	Channel catfish	0	1.5	1940	1.4
Sciaenidae					
Aplodinatus grunniens	Freshwater drum	17	2.8	1510	1.1

(a) Classification is based on Bailey, R.M., et al., A List of Common and Scientific Names of Fishes From the United States and Canada, third edition, American Fisheries Society Special Publication No. 6, Washington, 1970. Not included are 17 "minnows" (fishes under 4 in. in length) yet to be identified.

The 1972 commercial fish catch in Watts Bar Reservoir contained the following species: catfish, buffalo, carp, drum and paddlefish with a total weight of approximately 100,000 lb, and a commercial value of about $15,000. About 1000 lb or 1% of the total catch for Watts Bar Reservoir was harvested within a 10-mi radius of the site (ER, Am I, Part II C2).

Information on the sport fishing around the site is very limited. During the baseline monitoring program, approximately 280 hours were spent on the water collecting samples and less than 10 fishing parties were observed. According to TVA biologists, the best fishing in the area is in the tailwaters of Melton Hill Dam, approximately 6 miles upstream of the site (ER, Am I, Part II, C3).

Ichthyoplankton (fish eggs and larvae) were sampled from late March through August 1974. Approximately 300 unidentified fish eggs and 14 larvae were collected; 93% of the fish eggs were collected on May 16 and June 23, 1974. The 14 larvae were identified as sauger (1) and redhorse (13). Spawning habits of the 7 most abundant species are described in Appendix 2.7 of the ER.

Stomach content analysis was performed on the 7 most abundant fish species present from March through September 1974. ER Tables 2.74-140-146 show the percent occurrence of each food item of the individual fish species whose stomachs contained food. The major food items varied with fish species but included fish, zooplankton, benthic invertebrates, aquatic insects, detritus and bottom material.

No species designated as rare or endangered by any governmental agency were collected or observed in the baseline ecological survey performed from March through October 1974. A more complete description of the physical, chemical and biological parameters including complete taxonomic lists, data analysis and life histories is in the ER, Sec 2.7.2.

2.8 SOCIAL AND COMMUNITY CHARACTERISTICS

TVA activity in the thirties brought a significant change in the region's life style. From a setting of farms, coal mines, and small towns, land was transferred to the Federal domain for constructing Norris Dam. Later, Norris Lake was formed, inundating much of the appropriated acreage.

Since that time, the Oak Ridge reservation has been a center for construction and operation of manufacturing and scientific/engineering facilities supporting the nation's nuclear energy activity. Most of the manufacturing consists of increasing the ^{235}U content of uranium to values ranging from slightly above the 0.7% naturally occurring to contents exceeding 90%. Early in the period, the enrichment was done electromagnetically as well as by gaseous diffusion. Today only the latter process is used, employing about 2800 people at the Oak Ridge Gaseous Diffusion Plant. The Oak Ridge National Laboratory (ORNL) employs about 4500 people. The Y-12 area employing about 4700 people, provides engineering/fabrication support to the nuclear weapons effort, ORNL, and Federal agencies. ERDA's Oak Ridge Operations Office, with a complement of several hundred employees, is concentrated on the southern edge of the Oak Ridge residential area.

Construction employees usually have resided outside of Oak Ridge since low cost housing is scarce in the city and an ordinance forbids mobile homes. The incoming CRBRP force probably would follow that pattern, settling in nearby areas south and west of the site (Section 4.5.1). Local services in Anderson County and surrounding counties are strained by the influx of workers, particularly during construction peaks. Since the industrial facilities are located on federally owned land, the customary property tax revenues have not come to local communities. To meet needs for schools, highways, and other services, as well as to compensate for the dedication of land to usage for industrial facilities, Anderson and Roane Counties have sought and obtained federal payments in lieu of property taxes. In the opinion of many county residents, the payments are considerably below tax revenues that would accrue from the same facilities on private land. For convenience, school enrollment data are placed in Section 4.4, along with the assessment of construction impacts.

The City of Oak Ridge, representing about half of Anderson County's population, is characterized by relatively high incomes. Schools are uncrowded (ER, Sec 8.1). Outside Oak Ridge, the area is mostly rural, with the exception of the Knoxville region and schools generally are at capacity or somewhat in excess of it (ER, Sec 8.1). Because of the relatively low value of taxable property, Anderson County levies a personal property tax about double that of East Tennessee counties having a similar amount of industry and in the same population range (Tax Study, 1971). Based upon 1970 data, 15% of the Anderson County households had poverty level incomes, increasing to 18% in Loudon County and Roane County (ER, Tab 8.1-11).

3. FACILITY DESCRIPTION

3.1 EXTERNAL APPEARANCE

The most prominent CRBRP feature would be the dome-capped reactor containment building, rising 169 ft above the grade set for principal plant structures. Metal curtain walls, finished to blend with the environment, would enclose the turbine building, the steam generator maintenance bay, the reaction products equipment bay, the shop and warehouse, and the radwaste building. Textured masonry would cover the one-story plant service building. Concrete construction, having exposed design patterns coordinated with other buildings, would be used for the control building, the reactor service building, the diesel generator building, the steam generator and auxiliary bay building, and the intermediate bay. The mechanical draft wet cooling tower would be 400 ft long, 60 ft wide, and 55 ft high. The emergency cooling tower structure would consist of a concrete basin having two 32 ft diameter mechanical draft wet cooling towers, each about 40 ft high. The training center building would provide eight rooms for visitors.

Two switchyards are planned, a generation yard and a startup reserve yard, each occupying less than one acre. High steel structures would be painted in dark neutral colors and low-lying equipment would be painted in bright colors for contrast.

The plant buildings and the switchyards would be located within an area of about 34 acres. A conceptual architectural rendering of the plant as viewed from the west is shown in Figure 3.1; the plant layout, in Figure 3.2; and the plant with access to it, in Figure 3.3 (ER, Sec 3.1; Am I, Part II, G5 and G10; PSAR, Fig 2.1-5). Forest and natural terrain would limit views of the plant, although part of the containment building would be visible from Gallaher Bridge and about 10 homes south of the river would have a view of some of the plant. The security fence would enclose less than 7 acres (Figure 3.2). The exclusion area would include the full width of the river touching the site property and the full 1364-acre site except for the 112 acres in the Clinch River Consolidated Industrial Park (Figure 3.3).

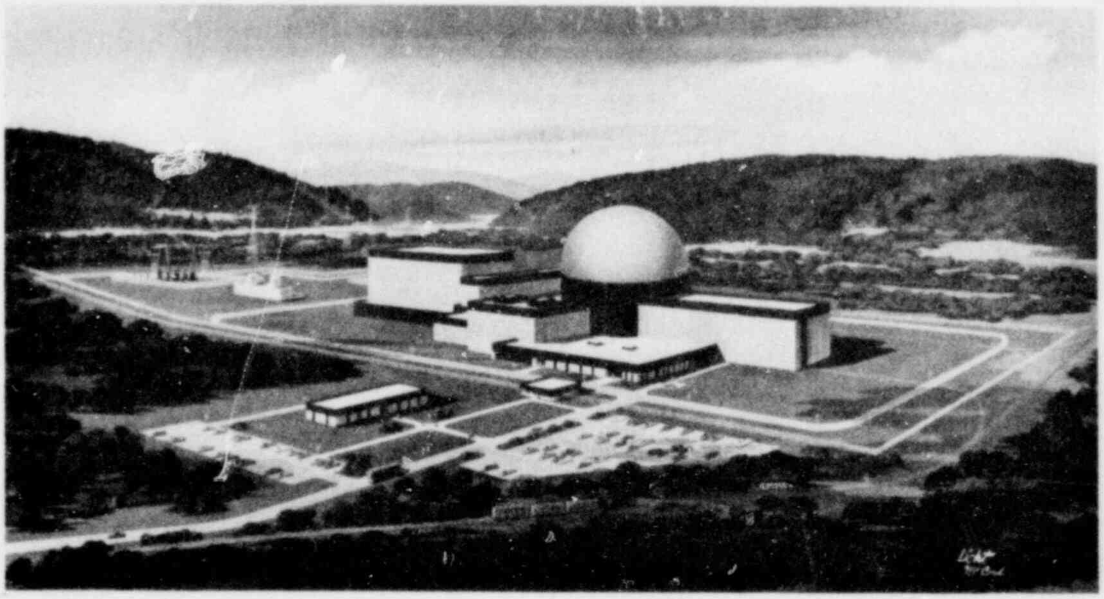


FIGURE 3.1 A Conceptual Architectural Rendering of the CRBRP

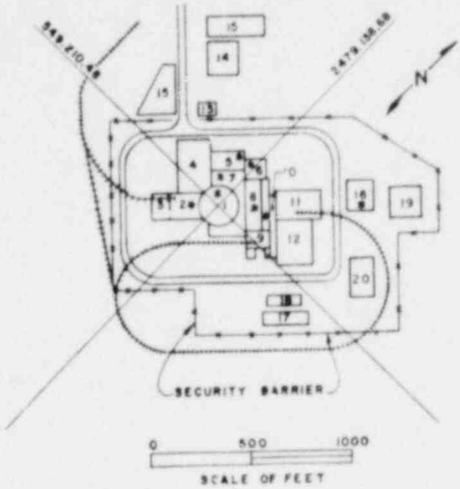


FIGURE 3.2 Layout of CRBRP Structures

3.2 REACTOR AND STEAM-ELECTRIC SYSTEM

The CRBRP would be a single-unit electric power plant with a liquid sodium-cooled breeder reactor utilizing mixed uranium-plutonium dioxide fuel (UO_2-PuO_2). With the initial reactor core, the gross power rating would be 975 megawatts thermal (MWt) and 380 megawatts electrical (MWe). Future core designs may achieve a maximum rating of 1121 MWt and 439 MWe. In-plant uses of power would result in a net plant output of approximately 350 MWe initially and a maximum of 379 MWe with future cores. The anticipated gross thermal efficiency is 39% and the net plant efficiency is estimated to be 36%.

The mixed-oxide fuel would be in the form of sintered ceramic pellets encapsulated in stainless steel rods. Plutonium enrichments would range from 18.7 to 32% in the active 36-in. middle section of each rod, whereas the 14-in. upper and lower axial blanket sections would contain depleted UO_2 pellets with 99.8% fertile ^{238}U and 0.2% ^{235}U. Each of the 198 fuel assemblies (Fig. 3.4) in the reactor core would have 217 of these fuel rods. Surrounding the core would be a radial blanket consisting of 150 fuel assemblies, each with 61 rods containing depleted UO_2 pellets. Figure 3.4 shows a partial cross section of the reactor indicating how the fuel assemblies are positioned (WASH-1535, Fig 4.2-3; ER, Fig 3.8-1). During the 5-year pre-equilibrium demonstration period of operation, an average of 102 core fuel assemblies and 13 radial blanket assemblies would be replaced annually. In the succeeding equilibrium cycle over the remaining plant life of approximately 25 years, about 66 core assemblies and 30 blanket assemblies would be replaced annually.

During operation of the reactor, a portion of the fertile ^{238}U in the axial and radial blankets would be converted to ^{239}Pu. That action, exceeding the consumption of fissile material in the core by approximately 20%, is the breeding objective of the LMFBR concept.

Heat would be removed from the reactor core and the radial blanket by the primary sodium coolant, as shown in Figure 3.5 (ER, Fig 3.2-1). The heat would then be transferred by means of heat exchangers to nonradioactive sodium in the intermediate loops circulating through evaporators in the steam generation system. The feedwater passing through the evaporators would be converted to steam, which would then be superheated to 900°F at 1450 psig. The 436.8 MWe turbine-generator driven by this steam would generate electricity at 22 to 24 kV. The voltage would be stepped up by transformers in the switchyard to 161 kV for delivery to the TVA system.

Waste heat released by condensation of exhaust steam from the turbine would be rejected to the atmosphere through a cooling tower and to the Clinch River in the cooling tower blowdown, as described in Section 3.4.

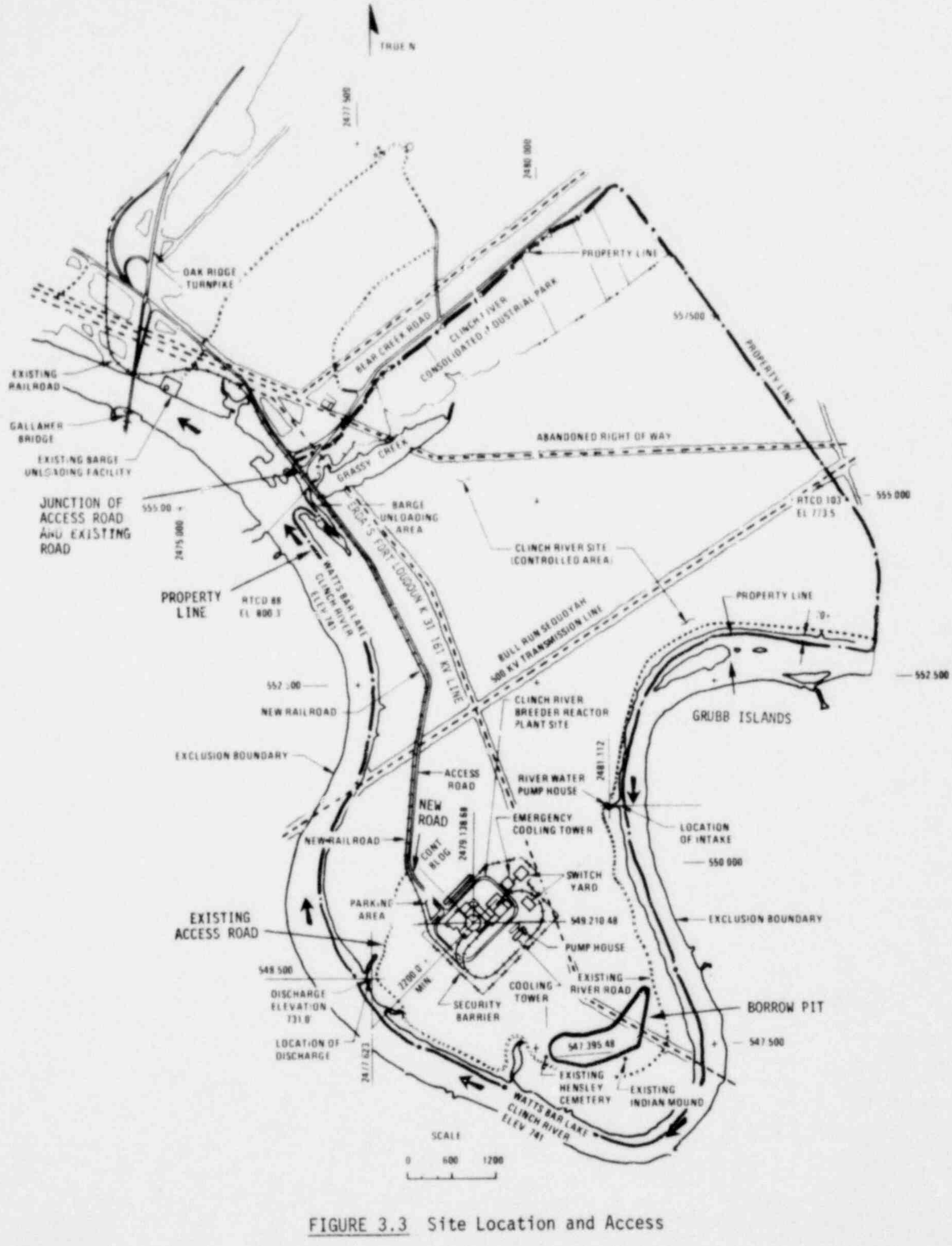


FIGURE 3.3 Site Location and Access

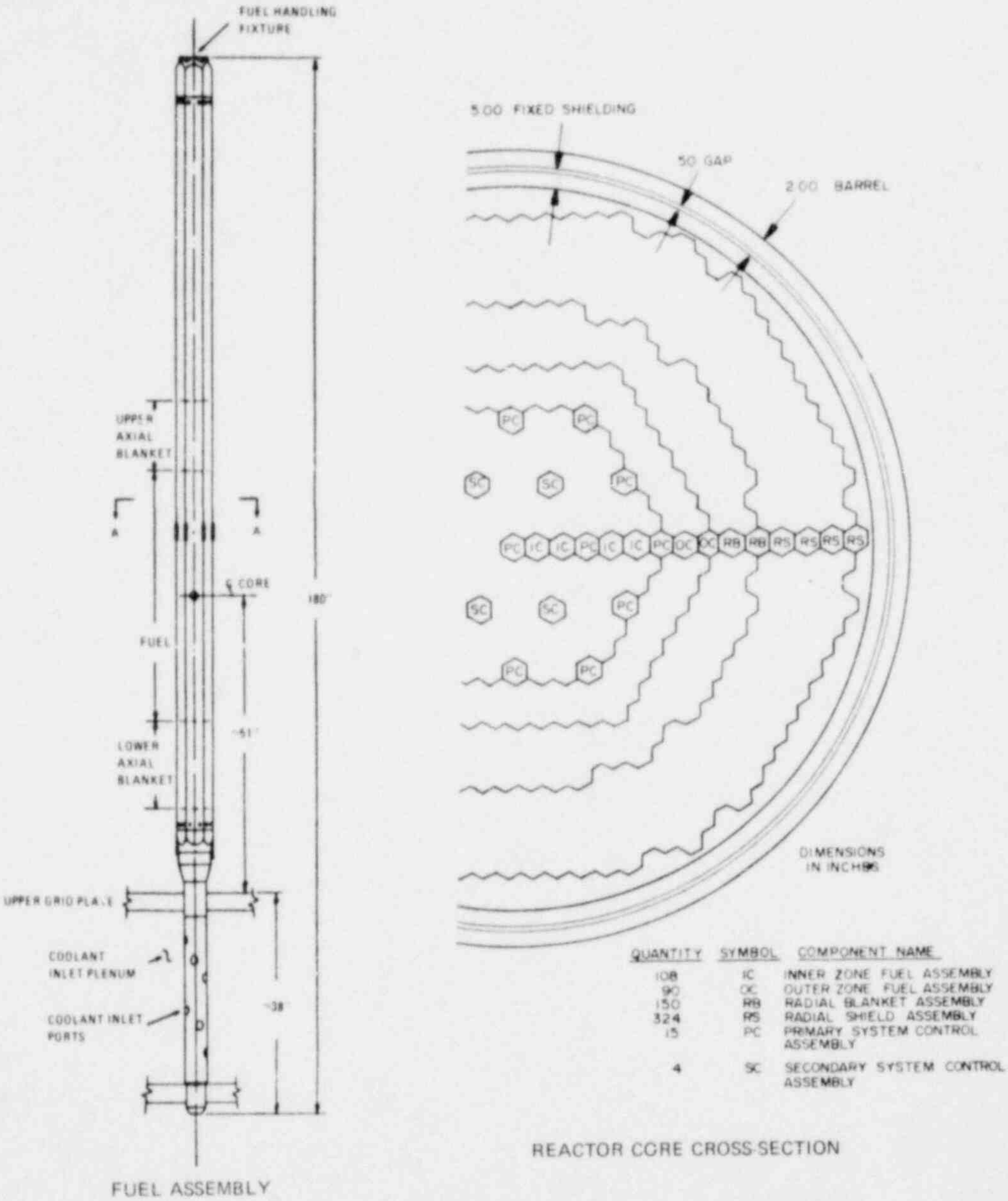


FIGURE 3.4 Fuel Assembly and Reactor Core

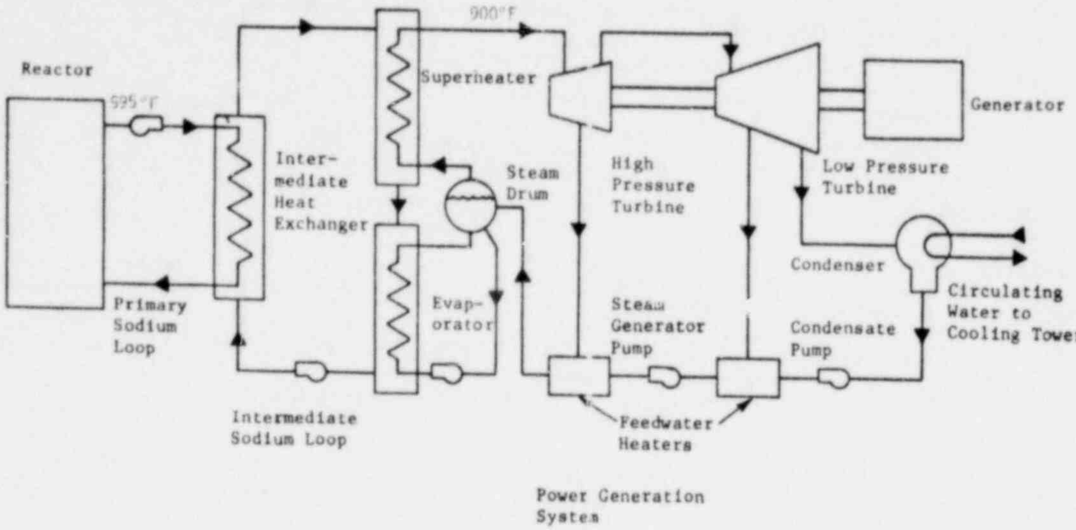
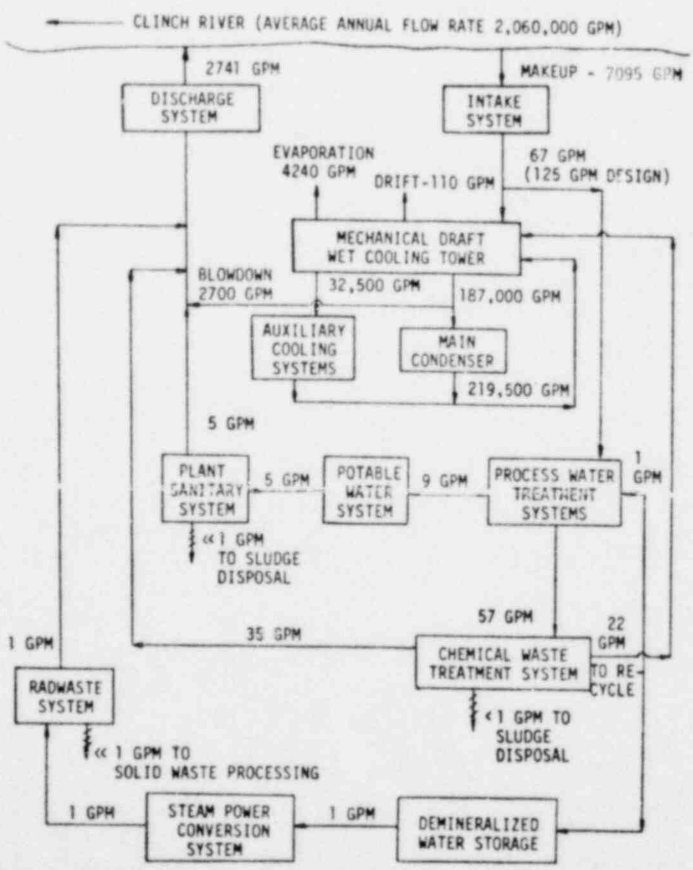


FIGURE 3.5 The CRBRP Cycle

3.3 WATER REQUIREMENTS

All water for operation would be supplied by the Clinch River. For maximum power, the anticipated annual average water makeup requirement would be 15.8 cfs (7095 gpm). An average of 6.1 cfs (2741 gpm) would be returned to the river as blowdown, and approximately 9.7 cfs (4354 gpm) would be consumed through evaporation, drift, and plant water usage. Figure 3.6 is a water usage flow diagram for the plant (ER, Fig. 3.3-1). The greatest consumptive water use, representing about 0.2% of the river's annual average flow rate, would take place in the heat dissipation system.



NOTE: COOLING TOWER FLOWRATES ARE ANNUAL AVERAGES AT MAX. POWER OPERATION

FIGURE 3.6 Average Annual Water Use

3.4 HEAT DISSIPATION SYSTEM

3.4.1 Cooling System

The proposed power output rating for the initial core is 3.34×10^9 Btu/hr. Subsequent cores would have design capability for a power output rating of 3.83×10^9 Btu/hr. At the higher output the full load heat rejection rate over the main condenser would be 2.34×10^9 Btu/hr. To dissipate that amount of heat, 187,000 gpm of cooling water would be circulated between the steam condensers and the cooling tower during maximum power operation.

The plant would employ a mechanical draft wet cooling tower with 10 cells. The tower would be 55 ft x 60 ft x 400 ft long and have a rated heat dissipation capacity of 2.73×10^9 Btu/hr. Cooling water would be pumped from the tower basins to the turbine steam condensers. Temperature rise of the water passing through the condenser would be about 25°F after which the heated water would be pumped back to the tower and evenly distributed at its top. The water would cascade down over the tower's fill as the air induced by the cooling tower fans flows across the fill. Evaporation cooling accounts for 60-70% of the heat dissipation, and convective cooling for the remainder. The system is designed for a drift rate of 0.05%. Table 3.1 lists expected monthly operating conditions and tower performance (ER, Table 3.4-4). The maximum outfall flow temperature of 94.5°F is expected during July. During the winter a 69°F minimum temperature is expected. Cooling tower blowdown is a function of evaporation which is dependent upon the wet bulb temperature. Figure 3.7 illustrates the relationship between wet bulb temperature and the blowdown rate (ER, Fig. 3.4-4).

TABLE 3.1 Water Temperatures of the Clinch River and the Cooling Tower Blowdown[a] (ER, Table 3.4-4)

	River Water[b]			Mechanical Wet Cooling Tower Blowdown		
	Average	Average Maximum	Average Minimum	Average	Daily Maximum	Daily Minimum
Jan	42.7	48.0	37.9	73.6	75.5	69
Feb	42.1	48.0	37.6	74.4	76	69
Mar	47.0	54.9	40.9	76.8	78	71
Apr	55.1	62.3	48.1	80.7	83	74
May	60.9	66.4	56.0	84.6	87.5	77.5
Jun	63.5	69.9	58.5	89.5	92.5	81
Jul	64.4	69.4	60.3	90.7	94.5	83
Aug	65.7	70.1	61.9	90.1	94	82.5
Sep	66.9	70.4	63.4	87.2	91.5	79.5
Oct	64.6	68.7	60.2	81.7	85.5	75.5
Nov	57.0	63.4	50.4	76.8	70	71
Dec	47.7	53.8	43	74	75.5	69

(a) All temperatures are in °F.
(b) June 1963 to October 1972, Whitewing Bridge temperature data from TVA.

The auxiliary cooling water systems would be designed to provide 32,500 gpm of cooling water at 95°F or less. The systems would cool auxiliary plant equipment during normal operating conditions, and would function in parallel with the main circulating water system discussed above.

3.4.2 The Intake

All plant water requirements would be met by water supplied from the river through two submerged perforated pipes located approximately 70 ft from shore (Figure 3.8). Figure 3.9 shows the location of the intake structure (ER, Am I, Part II, D18). The pipes would be positioned parallel to the river flow and supported off the river bottom as shown in Figure 3.10 and Figure 3.11 (ER, Fig. 3.4-7 and 3.4-6). Note that the top of the perforated pipe is 4.5 ft above river bottom (Figure 3.11). The overall length of each intake assembly would be about 18 ft. Because of the low inlet velocity of 0.3 to 0.5 fps, the applicant anticipates no substantial accumulation of trash on the perforated pipe; therefore trash racks and screens would not be necessary. However, removal of debris from the inlet pipe can be accomplished by flow reversal in the intake piping (ER, Am I, Part II, C16).

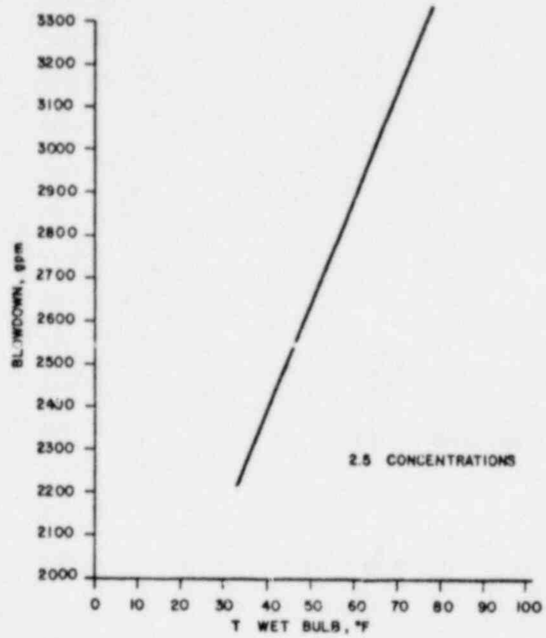


FIGURE 3.7 Mechanical Draft Wet Tower Blowdown (Constant Humidity)

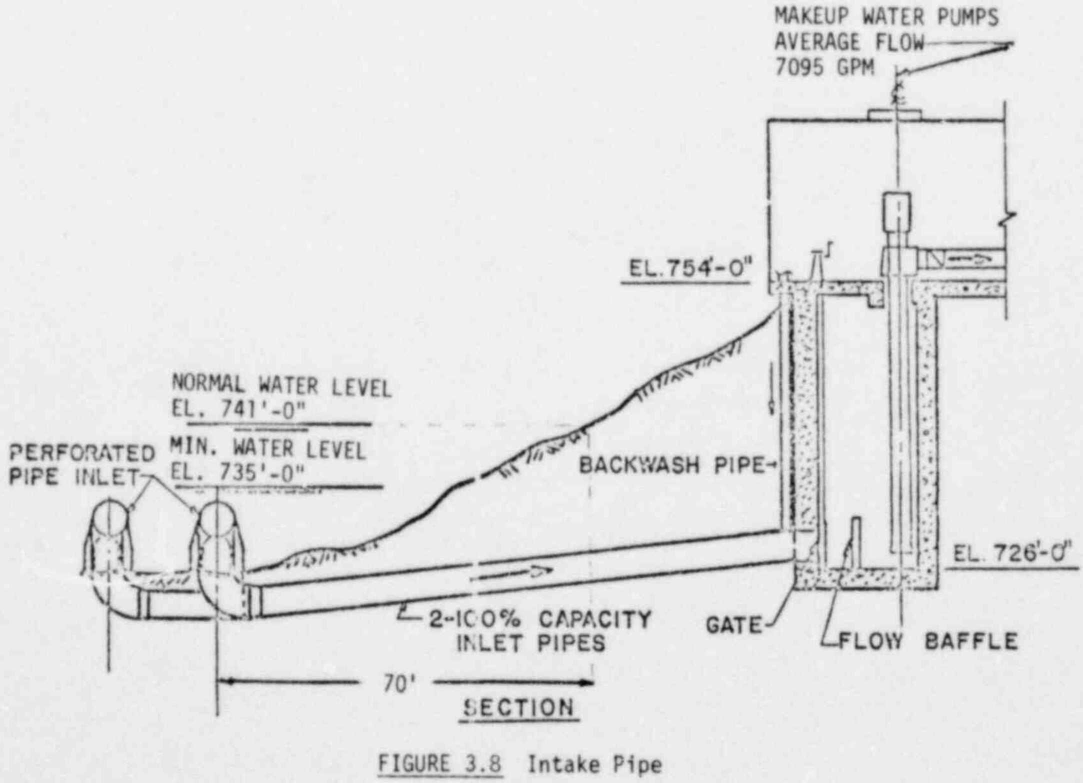


FIGURE 3.8 Intake Pipe

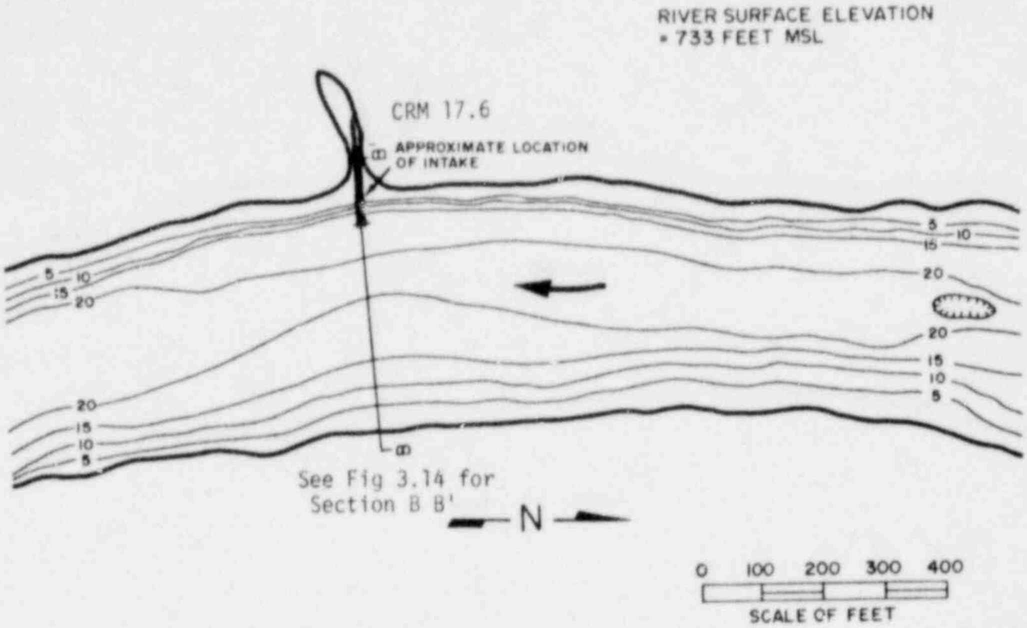


FIGURE 3.9 Bathymetry Near the Intake

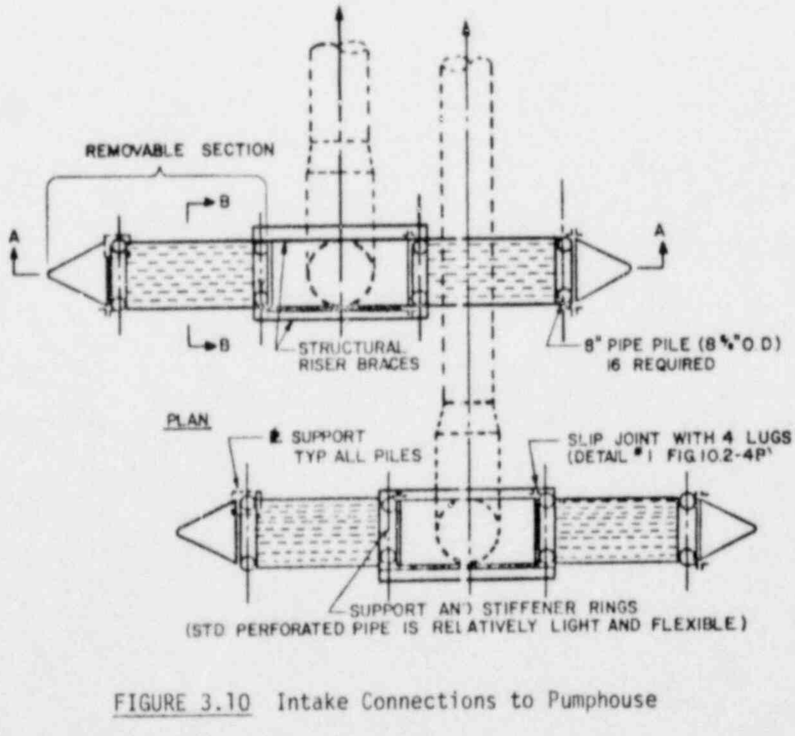


FIGURE 3.10 Intake Connections to Pumphouse

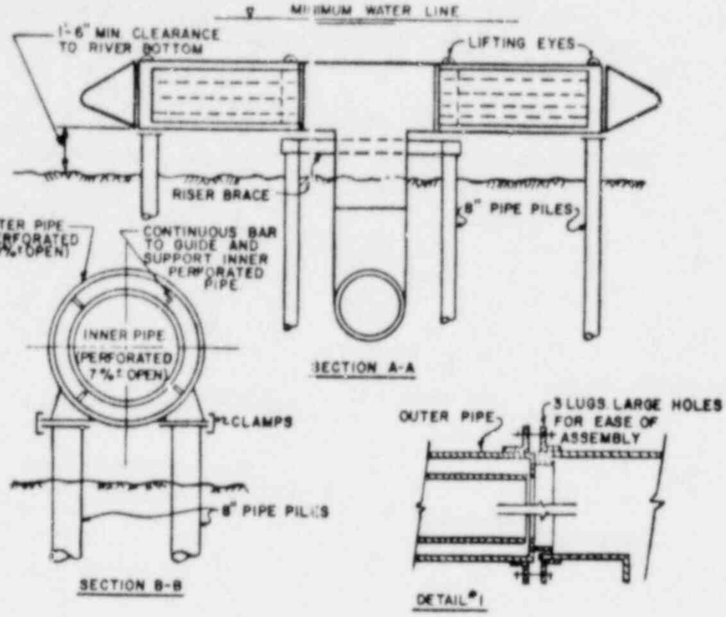
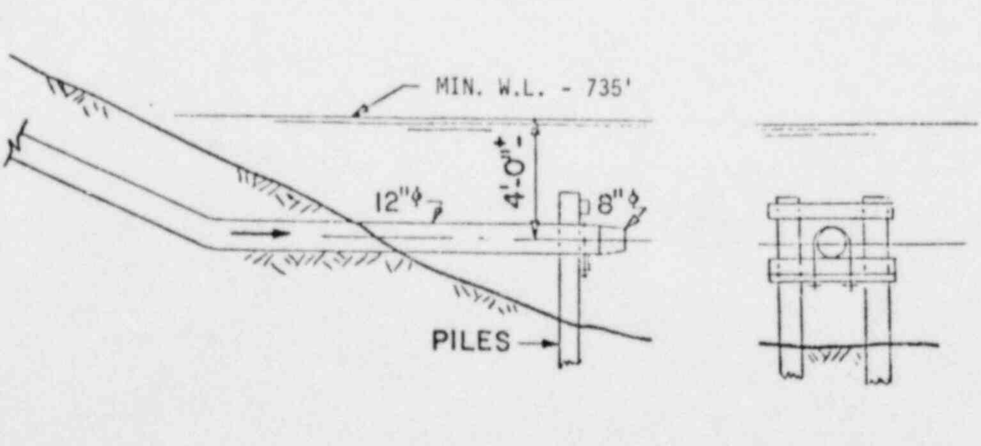


FIGURE 3.11 Intake Supporting Framework

Two river pumps would supply makeup water to the cooling tower basin. The system is designed for flow rates of 2,500 gpm to 10,000 gpm. A recirculation line would be provided to prevent pump damage when the cooling tower basin is at a high water level and the other plant demands are less than the minimum flow requirements of the pump.

3.4.3 The Discharge

A submerged single-port discharge structure as shown in Figure 3.12 would be constructed to dispose of the blowdown (ER, Fig. 3.4-8). The outfall would be 60 to 80 ft from the shoreline and the average discharge velocity would be 15 fps. The blowdown would be discharged normal to river flow at a minimum rate of 2,500 gpm to a maximum rate of 3,470 gpm. The elevation of the discharge would be 731 above MSL, 4 ft below minimum river water level. The discharge facility location and immediate bathymetry are shown in Figure 3.13 (also Figure 6.3). Figure 3.14 shows the profile of the river in the vicinity of the discharge (ER, Am I, Part II, D19).



SIDE VIEW FRONT VIEW

FIGURE 3.12 Submerged Discharge

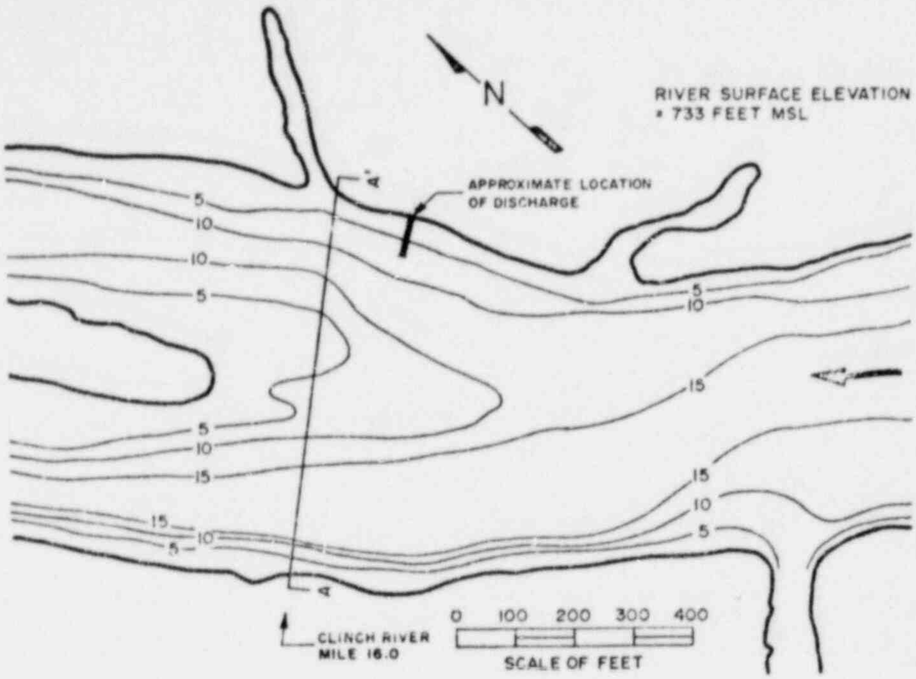


FIGURE 3.13 Bathymetry Near the Discharge

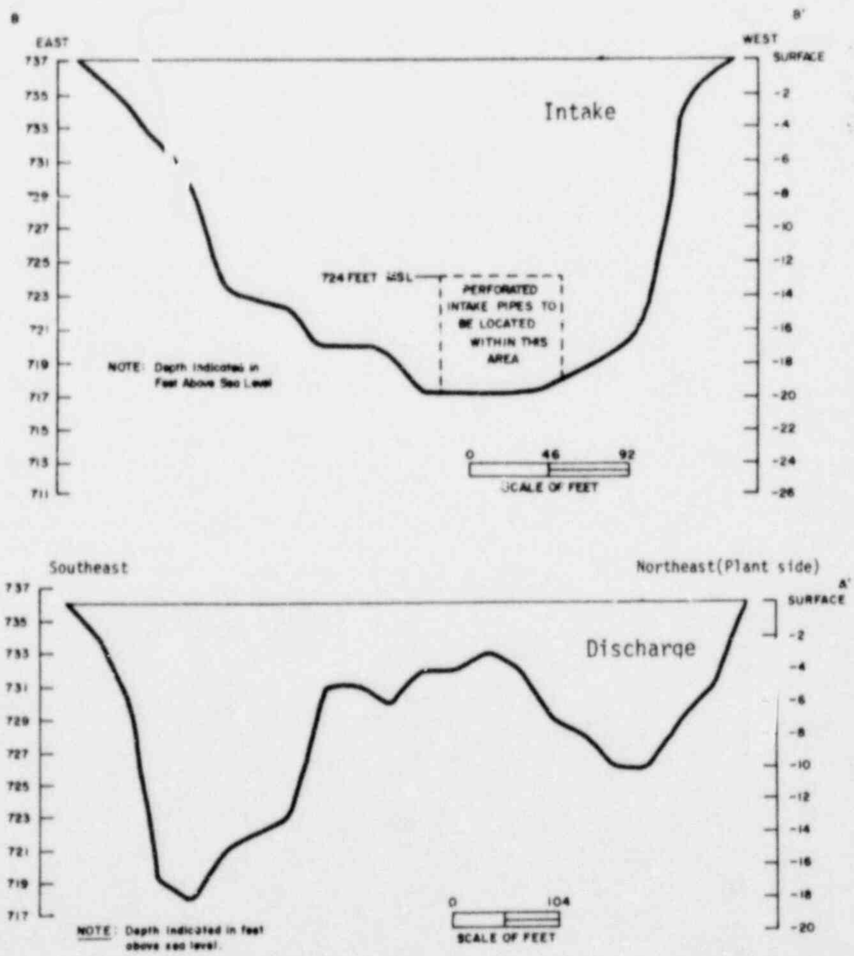


FIGURE 3.14 Cross-Sectional Profile of Clinch River Near the Intake and Discharge

3.5 RADIOACTIVE WASTE SYSTEMS

During operation, radioactive materials would be produced by fission in the core and blanket assembly fuel rods and by neutron activation of the sodium primary coolant and its trace impurities, the argon cover gas, and the corrosion products in the primary coolant. Tritium would be produced by neutron interaction with boron in the control assemblies and with lithium contaminant in the primary sodium, in addition to production by fission. Small amounts of the product materials would enter the waste streams as liquid and gaseous radioactive wastes. Aqueous liquid waste would be generated from the treatment of sodium spillage and contaminated plant components. Waste streams would be processed and monitored to reduce the quantities of radionuclides ultimately released to the atmosphere and into the river. Plant waste handling and treatment systems are discussed in the PSAR and ER; these documents contain the results of an analysis of the systems and an estimate of the expected annual release of radioactive effluents.

In the following paragraphs, the waste treatment systems are described, and an analysis based on a model of the applicant's proposed radioactive waste systems is given.

The staff's liquid and gaseous source terms were calculated by the PWR-GALE code, described in Draft Regulatory Guide 1.BB modified to apply to LMFBRs. The principal parameters used in the source term calculations are given in Table 3.2. The bases for the staff's parameters were determined from several different sources: 1) from Draft Regulatory Guide 1.BB, as applicable, 2) from a review of the literature, and 3) from the staff's evaluation and concurrence with the applicant's source term parameters.

The staff recognizes that Appendix I of 10 CFR Part 50 is applicable only to light-water-cooled nuclear power reactors. However, because of a lack of an operating experience data base for liquid metal fast breeder reactors and for lack of any other numerical guidance, the staff believes that the design objective levels of Appendix I should be considered in determining whether CRBRP radioactive releases would be "as low as reasonably achievable." Thus, as a basis for evaluation, the staff compared the calculated releases of radioactive material in liquid and gaseous effluents and the corresponding doses with the somewhat more restrictive numerical guides for design objectives of proposed Appendix I (1974). The staff's evaluation of the waste management systems of the CRBRP is given in the following sections.

3.5.1 Liquid Waste

Radioactive liquid waste would be processed on a batch basis to permit optimum control of releases. Prior to release, samples would be analyzed to determine the types and amounts of radioactivity present. On the basis of the results, the waste would be retained for further processing, recycled for reuse in the plant, or released under controlled conditions to the cooling tower blowdown. A radiation monitor automatically would terminate the liquid waste discharge if radiation measurement exceeds a predetermined level in the discharge line. A simplified diagram of the liquid radioactive waste treatment systems is given in Figure 3.15.

3.5.1.1 Intermediate Activity System

The Intermediate Activity System (IAS) would process aqueous radioactive waste generated from the washing of contaminated plant components in the Large Component Cleaning Cell (LCCC) and the Intermediate Component Cleaning Cell (ICCC). Prior to decontaminating the cells, components would be allowed to decay for a minimum of 10 days. Components would be contaminated with a film of sodium containing deposits of fission products, corrosion products, tritium, and plutonium. Based on the applicant's projected component maintenance schedule, the cleaning process would produce an average volume of 146,000 gallons of aqueous waste per year, an estimate with which the staff concurs.

The intermediate activity system would consist of two collection tanks, two filters, an evaporator, two polishing demineralizers, and two monitoring tanks for liquid analysis after processing. The aqueous waste would be collected in one of the 20,000-gal collection tanks at an input flow rate of 400 gpd. The staff calculated the collection time to be 40 days. After collection, the waste would be processed batchwise by filtration, evaporation (10 gpm) and demineralization prior to collection in one of the 22,000-gal monitoring tanks. The staff calculated the decay time during processing to be 1.3 days. The decontamination factors listed in Table 3.2 were applied for radionuclide removal in the IAS. The liquid in the monitor tank would be sampled, analyzed, and then recycled to the LCCC and ICCC for reuse in the decontamination procedure.

The applicant does not plan to release any liquid from the IAS monitoring tank to the environment. The staff assumed that approximately 90% of the monitor tank inventory would be recycled for reuse in the plant and that the remaining 10% would be discharged to the environment through the low activity system monitoring tanks. The concentrated bottoms from the IAS evaporator would be directed to the radioactive solid waste system for solidification and disposal by burial offsite.

TABLE 3.2 Principal Parameters Used in Estimating CRBRP Radioactive Releases

Parameter	Extent
Thermal Power Level	1,121 MWt
Plant Capacity Factor	0.80
Mass of Primary Sodium	1.4. x 10^6 lbs
Percent Fuel with Cladding Defects	0.50%
Component Decay Time Prior to Decon in LAS	10 days
Sodium Decay Prior to Collection in LAS	2 days
Mass of Sodium Processed in IAS	100 lbs/yr
Mass of Sodium Processed in LAS	200 lbs/yr
Fraction of Primary System Area Decontaminated	0.03
Radwaste Dilution Flow	2,700 gpm
Cover Gas Purge Flow Rate	1.75 scfm
Cover Gas Volume	409 ft^3
Cover Gas Leak Rate to Head Access Area	0.012 scc/min
Buffered Seal Leak Rate to Head Access Area	7.0 scc/min
Cover Gas Leak Rate to CAPS	1.0 scc/min
RAPS/CAPS Leak Rate to CAPS	1.0 scc/min
RAPS Charcoal Adsorber Beds Dynamic Adsorption Coefficients	
Krypton	1,800 scc/gm
Xenon	115,000 scc/gm
Argon	82 scc/gm
Flow Rate of Argon Through RAPS Beds	25 scfm
Mass of Charcoal in RAPS Beds	2,500 lbs
Fraction Argon Removed in RAPS Cryostill	0.20
Noble Gas Holdup Time in RAPS Prior to Release	70 days
CAPS Charcoal Adsorber Beds Dynamic Adsorption Coefficients	
Krypton	2,200 scc/gm
Xenon	146,000 scc/gm
Argon	92 scc/gm
Mass of Charcoal in CAPS Beds	1,250 lbs
Flow Rate of Carrier Gas Through CAPS Beds	50 scfm

Liquid Waste Processing Systems

System	Input Flow Rate (GPD)	Decontamination Factors I	Cs, Rb	Others
IAS	400	10^4	10^5	10^5
LAS	850	10^4	10^5	10^5

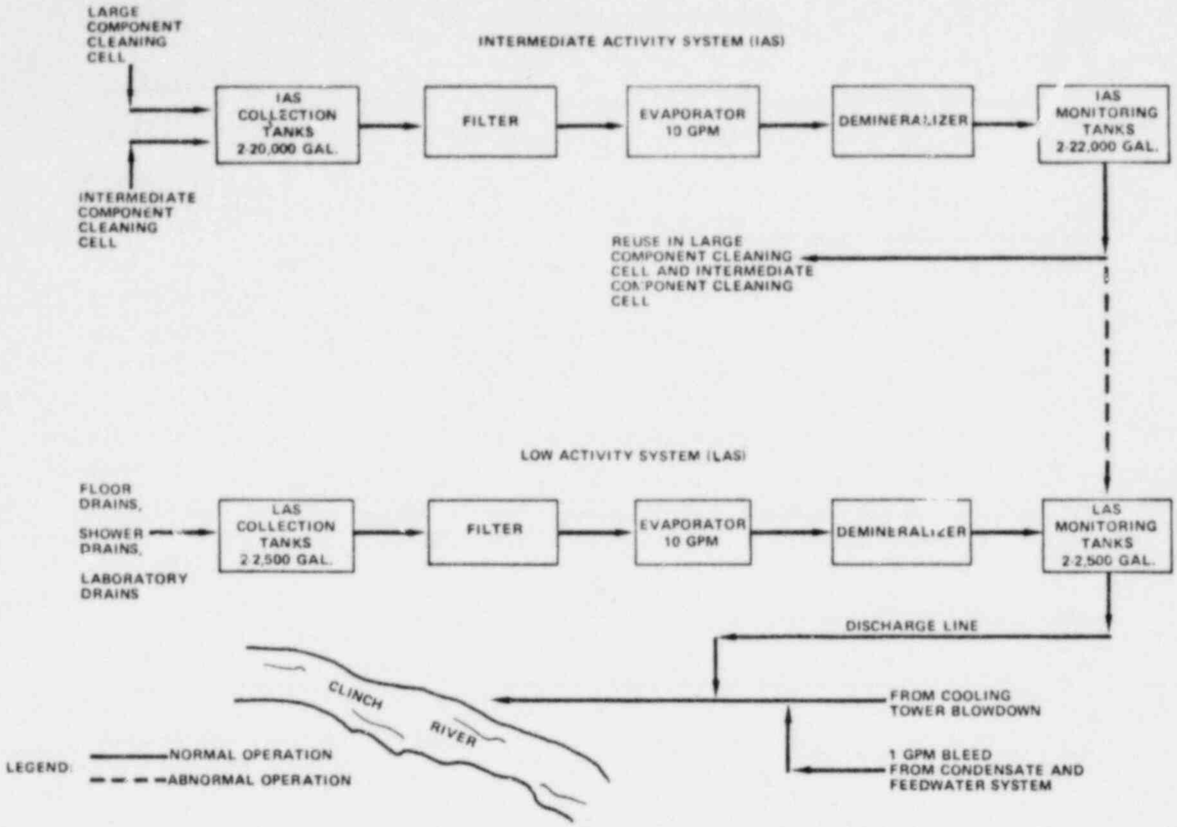


FIGURE 3.15 Liquid Radioactive Waste System

3.5.1.2 Low Activity System

The Low Activity System (LAS) would process the aqueous waste effluents from the floor drains, shower drains, and laboratory drains located in the plant and reactor service buildings. The activity in the floor drains and laboratory drains would be derived from sodium removed from the reactor for chemical analysis and from spills and cleanup during normal plant operations. To allow for decay during material handling, the staff assumed a waste decay time of two days prior to collection for subsequent processing in the LAS. The applicant estimates that an annual average drainage stream of 310,000 gallons would be input to the LAS. Considering the sources constituting the drainage system, the estimate is reasonable and the staff concurs. The low activity system would consist of two collection tanks, two filters, an evaporator, two polishing demineralizers, and two monitoring tanks for liquid analysis after processing. The waste would be collected in one of the 2,500-gal collection tanks at an input flow rate of 850 gpd. The staff calculated the collection time to be 2.4 days. After collection, the waste would be processed batchwise by filtration, evaporation (10 gpm) and demineralization prior to collection in one of the 2,500-gal monitoring tanks. The staff calculated the decay time during processing to be 0.17 day. The decontamination factors listed in Table 3.2 were applied for radionuclide removal in the LAS. The liquid in the monitor tank would be sampled, analyzed, and then as indicated by the analysis, discharged to the environment via the cooling tower blowdown stream or recycled for further processing. The staff, as well as the applicant, assumed that all of the waste from the LAS monitoring tank would be discharged to the environment. The concentrated bottoms from the LAS evaporator would be directed to the radioactive solid waste system for solidification and disposal by offsite burial at approved locations.

3.5.1.3 Balance of Plant Releases

Tritium would enter the steam-water system by diffusion from the primary to intermediate heat transport system and from the intermediate to steam-water system. Other radionuclides would not enter the steam-water system because of the pressure differentials between the primary and intermediate systems and between the intermediate and steam-water systems. To control the buildup of tritium in the steam-water system, the applicant would provide a 1-gpm bleed from the condensate and feedwater system which would be discharged to the environment via the cooling tower blowdown. The applicant estimated a tritium release of approximately 330 Ci/yr. Considering the rate of diffusion of tritium into the steam-water system, the estimate appears reasonable and the staff agrees with it.

3.5.1.4 Liquid Waste Summary

Based on the staff's evaluation of the radioactive liquid waste treatment systems, using the parameters listed in Table 3.2, the staff calculated the release of radioactive materials in the liquid waste effluent to be approximately 0.016 Ci/yr, excluding tritium and dissolved gases. In comparison, the applicant estimated a radioactive liquid release of 6.1×10^{-5} Ci/yr, excluding tritium and dissolved gases. The results differ from those of the applicant because of the staff's use of different values for assumed defective fuel, plant capacity factor, the volume of waste released from the IAS, the quantity of radioactive sodium waste input to the LAS, the decay time prior to collection in the LAS, and the evaporator decontamination factor for iodine. The staff's model also included a normalization factor of 10 to account for anticipated operational occurrences and equipment downtime. The staff believes that a normalization factor of 10 is justifiable due to the lack of operating data and experience with liquid metal fast breeder reactors.

The radionuclides expected to be released annually from each source, as well as from the plant, are given in Table 3.3.

TABLE 3.3 Estimated Annual CRBRP Releases of Radioactive Materials in Liquid Effluents

	Release (Ci/yr)[a]			
Radionuclide	Intermediate Activity System	Low Activity System	Balance of Plant	Total
^{134}Cs	(a)	(a)		(a)
^{136}Cs	1.1×10^{-6}	7.6×10^{-5}		7.7×10^{-5}
^{137}Cs	1.3×10^{-5}	2.6×10^{-4}		2.7×10^{-4}
^{131}I	1.6×10^{-5}	2.1×10^{-3}		2.1×10^{-3}
^{125}Sb	1.2×10^{-7}	2.5×10^{-6}		2.6×10^{-6}
^{129m}Te	4.3×10^{-4}	3.5×10^{-6}		4.4×10^{-4}
^{129}Te	4.4×10^{-4}	3.5×10^{-6}		4.4×10^{-4}
^{132}Te	4.9×10^{-5}	9.3×10^{-6}		5.8×10^{-5}
^{132}I	4.9×10^{-5}	9.3×10^{-6}		5.8×10^{-5}
^{89}Sr	8.1×10^{-5}	5.5×10^{-7}		8.2×10^{-5}
^{90}Sr	4.5×10^{-5}	2.1×10^{-7}		4.6×10^{-5}
^{90}Y	4.5×10^{-5}	2.1×10^{-7}		4.6×10^{-5}
^{91}Y	2.4×10^{-5}	1.6×10^{-7}		2.5×10^{-5}
^{95}Zr	4.7×10^{-5}	2.9×10^{-7}		4.7×10^{-5}
^{95}Nb	4.7×10^{-5}	2.9×10^{-7}		4.7×10^{-5}
^{99}Mo	5.9×10^{-7}	1.7×10^{-7}		7.6×10^{-7}
^{103}Ru	5.5×10^{-5}	4.1×10^{-7}		5.5×10^{-5}
^{106}Ru	6.0×10^{-5}	3.0×10^{-7}		6.0×10^{-5}
^{106}Rh	6.0×10^{-5}	3.0×10^{-7}		6.0×10^{-5}
^{111}Ag	5.2×10^{-7}	(a)		5.4×10^{-7}
^{140}Ba	1.7×10^{-5}	2.9×10^{-7}		1.7×10^{-5}
^{140}La	1.7×10^{-5}	2.9×10^{-7}		1.7×10^{-5}
^{141}Ce	4.6×10^{-5}	3.8×10^{-7}		4.6×10^{-5}
^{144}Ce	4.7×10^{-5}	2.4×10^{-7}		4.7×10^{-5}
^{144}Pr	4.7×10^{-5}	2.4×10^{-7}		4.7×10^{-5}
^{143}Pr	$1.5 \times 10^{-}$[illegible]	2.4×10^{-7}		1.6×10^{-5}
^{147}Nd	5.4×10^{-6}	1.1×10^{-7}		5.5×10^{-6}
^{147}Pm	2.7×10^{-5}	1.3×10^{-7}		2.7×10^{-5}
^{155}Eu	3.5×10^{-6}	(a)		3.5×10^{-6}
^{58}Co	1.6×10^{-4}	1.0×10^{-7}		1.6×10^{-4}
^{60}Co	2.7×10^{-4}	1.3×10^{-7}		2.7×10^{-4}
^{54}Mn	3.1×10^{-4}	1.6×10^{-7}		3.1×10^{-4}
^{51}Cr	2.9×10^{-5}	(a)		2.9×10^{-5}
^{59}Fe	1.2×10^{-6}	(a)		1.2×10^{-6}
^{182}Ta	3.5×10^{-5}	(a)		3.5×10^{-5}
^{238}Pu	3.9×10^{-7}	3.4×10^{-7}		7.3×10^{-7}
^{239}Pu	1.1×10^{-7}	(a)		2.0×10^{-7}
^{240}Pu	1.4×10^{-7}	1.2×10^{-7}		2.6×10^{-7}
^{241}Pu	1.7×10^{-5}	1.5×10^{-5}		3.2×10^{-5}
^{22}Na	7.5×10^{-7}	1.5×10^{-5}		1.6×10^{-5}
^{24}Na	(a)	1.1×10^{-2}		1.1×10^{-2}
TOTAL	2.5×10^{-3}	1.3×10^{-2}		1.6×10^{-2}
H-3			330	330

(a) Radionuclides released in amounts less than 1.0×10^{-7} are considered negligible and are not listed.

Based on the staff's evaluation of the radioactive liquid waste releases, the proposed system would be capable of limiting the release of radioactive materials in liquid effluents to less than 5 Ci/yr, excluding tritium and dissolved gases, and the whole-body and critical organ doses would be less than 5 millirems per year at or beyond the site boundary (see Table 5.12). The staff concludes that the liquid waste treatment system would reduce radioactive liquid effluents to as low as practicable levels in accordance with 10 CFR Part 50, and the staff, therefore, concludes that the system would be acceptable.

3.5.2 Gaseous Waste

The radioactive gaseous waste and plant ventilation systems would collect, store, process, monitor, recycle or discharge potentially radioactive gaseous waste generated during normal operation of the station. The gaseous waste would consist of noble gas radionuclides and tritium produced by fission and neutron activation. Xenon and krypton would result from fission in the fuel and would migrate into the primary sodium coolant by way of assumed fuel element defects. Argon and neon would result from neutron activation of the sodium coolant and potassium impurity in the sodium. Tritium would be produced from ternary fission as well as from neutron activation of coolant impurities. The staff's evaluation model of the applicant's proposed systems assumed that radioactive gaseous waste would be released from the radioactive argon processing system, cell atmosphere processing system, reactor service building ventilation system, reactor containment building ventilation system, intermediate bay ventilation system, and turbine building ventilation system. The gaseous waste and plant ventilation systems are shown in Figure 3.16.

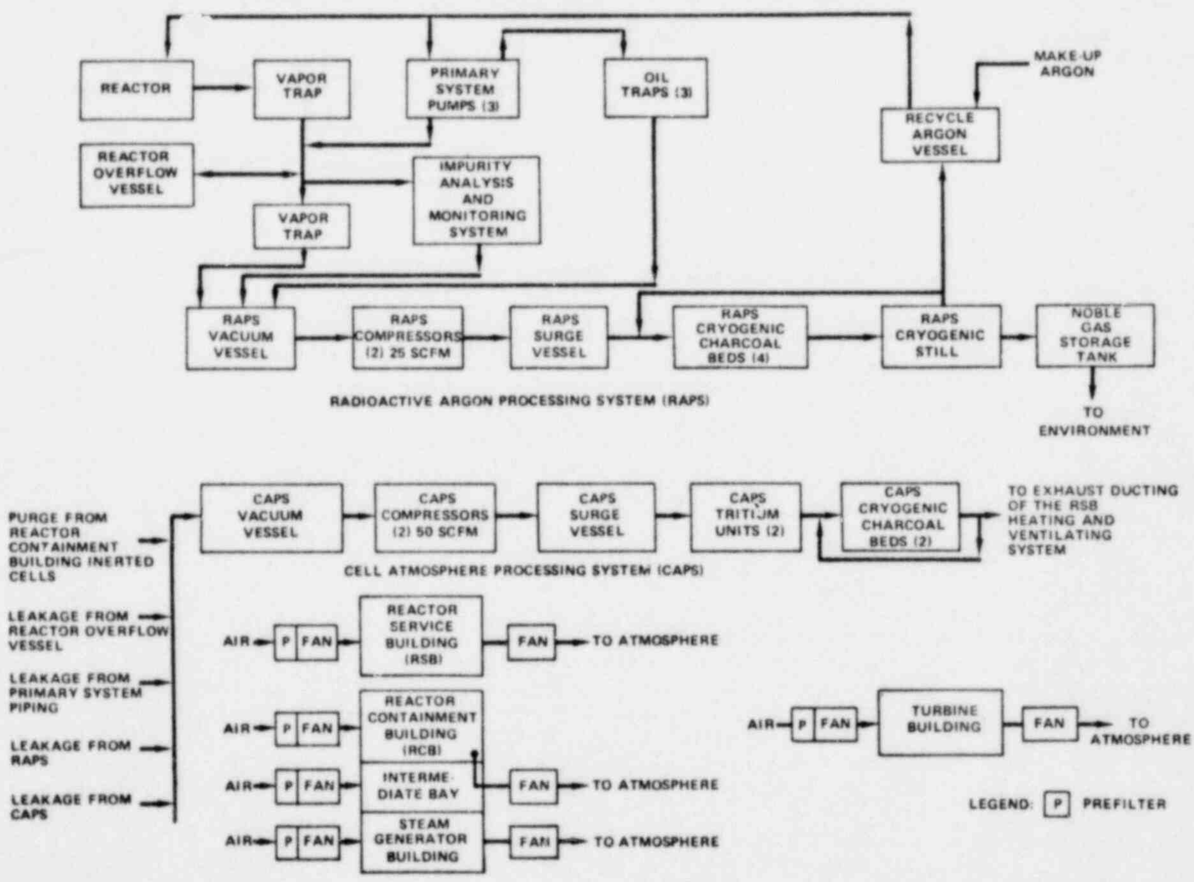


FIGURE 3.16 Gaseous Radioactive Waste Systems and CRBRP Ventilation

3.5.2.1 Radioactive Argon Processing System

The radioactive Argon Processing System (RAPS) would continuously process and recycle the primary sodium system cover gas (argon) and provide a source of low radioactivity gas for use in reactor seals. The argon cover gas would be contaminated with noble gases and small quantities of tritium produced from fission and neutron activation and migrating to the cover gas space. Most of the tritium generated would form a hydride in the primary sodium. The RAPS would consist of a vacuum vessel, two compressors, a surge vessel, four cryogenic charcoal beds, a cryogenic still, a noble gas storage tank, and a recycle argon vessel.

The RAPS would continuously draw radioactive cover gases from the spaces in the reactor, reactor overflow vessel, and primary system pumps. The gases would be collected in the vacuum vessel and transferred by a compressor to the surge vessel where they would be stored under pressure. The gases would be treated in a series of four cryogenically cooled charcoal decay beds, each containing 625 lbs of charcoal. The flow rate through the beds would be 25 scfm, made up of 21.75 scfm of recirculated throughput and 3.25 scfm of input from the surge vessel. The charcoal beds would be operated at 30 psig and an average temperature of -130°F.

Using the dynamic adsorption coefficients listed in Table 3.2, a total mass of 2,500 lbs of charcoal in the beds, and a bed flow rate of 25 scfm, the staff calculated that the decay times provided would be about 2 days for krypton, 127 days for xenon, and 0.09 days for argon. The effluent gases from the cryogenic charcoal beds would enter a cryogenic still containing liquid argon in the still bottom. The liquid argon would absorb the radioactive krypton and xenon isotopes and permit their separation from the bottoms by periodically draining, evaporating, and transferring to the noble gas storage vessel. The purified argon would be directed to the charcoal beds as recirculation throughput (21.75 scfm) and to the recycle argon vessel (3.25 scfm) for reuse in the primary system as cover gas. Although the applicant proposes to bottle gases from the noble gas storage vessel for temporary onsite storage and eventual offsite shipment to a licensed burial facility, the staff model assumes that the contents of the storage vessel would be released to the environment.

3.5.2.2 Cell Atmosphere Processing System

The Cell Atmosphere Processing System (CAPS) would collect and process the gaseous radioactivity that may leak or diffuse into the cells (containing nitrogen atmosphere) which house the reactor, Primary Heat Transfer System (PHTS), PHTS pumps and reactor overflow vessel. The CAPS also would collect and process any leakage of gases in the nitrogen or air atmosphere cells housing the RAPS and CAPS components. The major input to the CAPS would consist of nitrogen containing trace quantities of contaminated argon cover gas and tritium diffused through PHTS piping and components.

The CAPS would consist of a vacuum vessel, two compressors, a surge vessel, two tritium oxidizer units, and two cryogenic charcoal beds. The nitrogen/air gas bleeds and purges from the cells would be collected in the CAPS vacuum vessel and transferred by a compressor to the surge vessel where they would be stored under pressure. The gases would be passed through one of the tritium oxidizer units where the tritium would be converted to tritiated steam. The steam would be condensed and sent to the radioactive solid waste system for solidification for ultimate offsite disposal. The dried tritium-free gases would be treated in a series of two cryogenically cooled charcoal delay beds, each containing 625 lbs of charcoal. Although the flow input to the CAPS would be variable, the flow rate through the beds would be maintained at a constant 50 scfm by a variable-flow recirculation loop automatically controlled. The staff assumed that the charcoal beds would be operated at 35 psig and an average temperature of -140°F. On the basis of the dynamic adsorption coefficients listed in Table 3.2, a total mass of 1,250 lbs of charcoal in the beds, and a bed flow rate of 50 scfm, the staff calculated that the decay times provided would be approximately 0.61 day for krypton, 40 days for xenon, and 0.025 day for argon. The effluent gases from the cryogenic charcoal beds would be discharged to the environment through the exhaust ducting of the reactor service building heating and ventilating system at a flow rate of 3,000 cfm.

3.5.2.3 Reactor Containment Building Ventilation System

Radioactive gases would be released into the head access area of the reactor containment building (RCB) by leakage from two sources. The major source of radioactive contamination to the head access area atmosphere would stem from reactor cover gas leakage through the reactor head seals. Additional leakage of recycled argon gas (from RAPS) through the buffered reactor head seals and subsequent diffusion into the head access area would add trace quantities of radionuclides into the RCB atmosphere. The atmosphere in the head access area would be ventilated by an air stream of 12,000 cfm exhausted to the environment through the RCB ventilation system without treatment. Prior to release, the air flow from the head access area would be mixed with ventilation exhaust from other areas of the RCB and the Intermediate Bay (IB). The total flow rates from the release point, located on the IB, would be 100,000 cfm.

3.5.2.4 Intermediate Bay Ventilation System

Tritium that diffuses from the Primary Heat Transfer System (PHTS) into the Intermediate Heat Transfer System (IHTS) also would diffuse at a small but finite rate through the IHTS piping and components into the IB cell atmospheres. The cell atmospheres would be vented to the environment through the IB ventilation system having a total flow rate of 50,000 cfm. As described in the previous section, the IB ventilation flow would be mixed with ventilation air from the RCB and SGB prior to release through a common point.

3.5.2.5 Turbine Building Ventilation System

A small quantity of tritium produced in the PHTS would diffuse into the IHTS and pass into the steam-water system by diffusion through the steam generators. Tritium would be in the steam-water system in the form of tritiated water. A small quantity of tritiated water vapor would be removed by the mechanical vacuum pumps of the condenser offgas system along with noncondensable gases. The gases would be discharged into the exhaust plenum of the turbine building ventilation system having a total flow rate of 120,000 cfm.

3.5.2.6 Gaseous Waste Summary

Based on the staff's evaluation of the radioactive gaseous waste treatment and ventilation systems, using the parameters listed in Table 3.2, the staff calculated the release of radioactive materials in gaseous effluents would be about 389 Ci/yr for noble gases and 3.1 Ci/yr for tritium. In comparison, the applicant estimated a total release of 5.1 Ci/yr for noble gases and 3.1 Ci/yr for tritium. The difference between the staff's and applicant's noble gas release estimate is due to the staff's assumed release of the RAPS noble gas storage tank inventory to the environment. The staff also used a different parameter for defective fuel.

The radionuclides expected to be released annually from each source, as well as from the plant, are given in Table 3.4. No releases of iodine and plutonium in gaseous effluents are expected from normal plant operation. From its evaluation of the applicant's proposed gaseous radioactive waste treatment systems, the staff calculates that the annual air dose due to gamma radiation (total body) at or beyond the site boundary would not exceed 10 millirads, the annual air dose due to beta radiation (skin) at or beyond the site boundary would not exceed 20 millirads, the annual thyroid dose to an individual would not exceed 15 millirems (Table 5.12), and the total quantity of ^{131}I released annually would not exceed 1 Ci. These are the design objective levels of proposed Appendix I.

TABLE 3.4 Estimated Annual CRBRP Releases of Radioactive Materials in Gaseous Effluents

Radionuclide	Release (Ci/yr)[(a)] RAPS	CAPS	RCB	IB	TB	TOTAL
^{131m}Xe						
^{133m}Xe						
^{133}Xe		2	3			5
^{135m}Xe						
^{135}Xe			11			11
^{138}Xe						
^{83m}Kr						
^{85m}Kr		11				11
^{85}Kr	340					340
^{87}Kr						
^{88}Kr		5	1			6
^{23}Ne			2			2
^{39}Ar	13		1			14
^{41}Ar						
TOTAL	353	18	18			389
H-3				0.6	2.5	3.1

(a) Radionuclides released in amounts less than 1.0 Ci/yr for noble gases are considered negligible and are not listed.

The staff's calculations indicate that the radioactive gaseous waste treatment systems would reduce radioactive effluents to as low as practicable levels in accordance with 10 CFR Part 50, and the staff, therefore, concludes that the system is acceptable.

3.5.3 Solid waste

The solid radwaste system would be designed to handle, collect, and process five types of waste: 1) concentrated liquids, 2) noncompactible solids, 3) metallic sodium, 4) sodium contaminated components, and 5) compactible solids.

Concentrated liquids would consist of evaporator bottoms from the liquid radwaste system and tritium from the CAPS tritium oxidizer units. This waste would be solidified in drums prior to offsite shipment for burial at a licensed facility. The staff estimated that approximately 1,000 ft^3 of processed concentrated liquids containing 300 Ci of activity would be shipped offsite annually. The applicant estimated that approximately 1,000 ft^3 of solidified liquid radwaste containing 56 Ci of activity would be shipped offsite annually.

Noncompactible solids would include tools, contaminated filters, spent resins, metal component parts, valves, and vapor traps. This waste would be placed in drums, capped, decontaminated, and placed in temporary storage prior to offsite shipment. The sources of spent resins would be the four 10 ft^3 polishing demineralizers in the liquid radwaste system. The applicant estimated that approximately 1,500 ft^3 of noncompactible solid waste containing 500 Ci of activity would be shipped offsite annually. The applicant estimated that approximately 1,500 ft^3 of noncompactible solid waste containing 100 Ci of activity would be shipped annually.

Metallic sodium would be generated from fuel handling operations. If the sodium should be processed onsite, it would be converted to aqueous sodium nitrate solution and evaporated. The evaporator bottoms would be solidified for offsite shipment and burial. If not processed onsite, the sodium would be shipped offsite in a suitable container for processing by a licensed contractor. The staff estimated that approximately 42 ft^3 of processed sodium containing 50 Ci of activity would be shipped offsite annually. The applicant estimated that approximately 42 ft^3 of sodium waste containing 10 Ci of activity would be shipped offsite annually.

The sodium contaminated components would include the primary, intermediate, and ex-vessel storage tank cold traps. Handling of the cold traps would include placing the trap into a removal cask for subsequent offsite shipment in a special container. The final disposition of the cold traps has not yet been determined; however, the CRBRP would utilize the research and development efforts of the Fast Flux Test Facility concerning the packaging, transport and disposition of sodium contaminated waste. The staff estimated that approximately 240 ft^3 of sodium bearing waste containing 2.3×10^4 Ci of activity would be shipped offsite annually. The applicant estimated that approximately 240 ft^3 of sodium bearing waste containing 1.9×10^4 Ci of activity would be shipped offsite annually.

Compactible solids would consist of rags, paper, and rubber seals. This waste would be placed in drums and compacted by a hydraulic machine prior to offsite shipment. The staff estimated that approximately 1,000 ft^3 of compacted waste containing 5 Ci of activity would be shipped offsite annually. The applicant estimated that approximately 290 ft^3 of compacted waste containing less than 1 Ci of activity would be shipped offsite annually.

For all five types of solid waste, the staff's estimates of activity shipped offsite annually differ from those of the applicants because of the staff's higher assumed value for defective fuel (Table 3.2).

3.5.3.1 Solid Waste Summary

On the basis of its evaluation of the solid waste system, the staff concludes that the designed system would accommodate the waste expected during normal operations, including anticipated operational occurrences in accordance with existing Federal and local regulations. The waste would be packaged and shipped to a licensed burial site in accordance with NRC and Department of Transportation regulations. From those findings the staff concludes that the solid waste system is acceptable.

3.6 CHEMICAL EFFLUENTS

Normal operation would require the use of certain chemicals, some of which would ultimately be discharged to the Clinch River via the cooling tower blowdown line. The chemicals serve various functions including: 1) production of high purity water, 2) corrosion control, 3) decontamination and cleaning, 4) laboratory uses, and 5) biological growth control in the cooling water circuits.

TABLE 3.5 Chemicals or Chemical Species Expected to be in CRBRP Discharge

	Concentration of Chemicals in CRBRP Waste Streams					Discharge to River			Ambient Conditions in Clinch River[e]		Max Chemical Conc in River Under no Flow Conditions[g]			
	Cooling Tower Blowdown[a]		Neutralized Plant Wastes[b]		Sanitary Wastes	Mass[c]	Concentration[d]							
	Based on Ave River Conc (mg/ℓ)	Based on Max River Conc (mg/ℓ)	Based on Ave Discharge - 3.7 gpm (mg/ℓ)	Based on Max Discharge - 35 gpm (mg/ℓ)	Based on the Design Loading (mg/ℓ)	Discharge (lb/yr)	Ave (mg/ℓ)	Max (mg/ℓ)	Ave Conc (mg/ℓ)	Max Conc (mg/ℓ)	Conc 30 ft Below Discharge (mg/ℓ)	Percent Increase (%)	Conc 200 ft Below Discharge (mg/ℓ)	Percent Increase (%)
Total Alkalinity (as $CaCO_3$)	240	285	<'0.0	<50.0	--	--	239	286	96.0	114.00	139.00	22	123.41	8.2
Ammonia Nitrogen (as N)	0.70	2.5	--	--	0.5	6,900	0.07	2.50	0.28	1.00	1.20	20	1.08	8.4
BOD	5.30	15.00	--	--	12.0	43,000	5.30	15.0	2.10	6.00	7.40	23	6.50	8.4
Calcium	85.0	108	224.0	96.0	--	690,000	85.0	108	34.0	43.00	52.80	23	46.64	8.5
Chloride	11.8	32.5	43.0	21.0	--	63,000	11.8	32.3	4.70	13.0	16.0	23	14.1	8.5
Chlorine Residu-1	0.20	0.50	--	--	1.0	2,000	0.20	0.50	<0.05[f]	0.05	0.12	135	0.075	50.4
COD	16.8	40.0	--	--	25.0	145,000	17.80	40.00	6.7	16.00	19.60	23	17.34	8.4
Total Dissolved Solids (TDS)	355	435	13,738.0	11,920.0	--	3,040,000	373	582	142.0	174.00	235.20	35	196.85	13.1
Total Iron	0.95	1.70	--	--	--	7,700	0.95	1.70	0.38	0.68	0.83	23	0.74	8.4
Magnesium	19.5	21.3	75.0	32.0	--	158,000	19.6	21.4	7.80	8.50	10.40	22	9.22	8.5
Manganese	0.13	0.18	1.0	0.4	--	1,100	0.13	0.18	0.05	0.07	0.083	19	0.075	7.0
Copper	0.20	0.93	--	--	--	1,652	0.20	0.93	<.005	<0.01	0.15	--	[illegible]	--
Zinc	0.05	0.08	--	--	--	400	0.05	0.08	0.02	0.03	0.035	15		10.0
Nickel	0.02	0.11	--	--	--	200.4	0.02	0.11	<.01	<0.01	0.025	150	0.016	56.0
Lead	<0.03	<0.03	--	--	--	100	<103	<.03	<0.03	<0.03	--	--	--	--
Nitrate (NO_3)	3.30	5.50	3.2	1.0	66.0	28,000	3.10	5.60	1.30	2.20	2.70	23	2.39	8.7
pH	7.9	7.9	6-8	6-8	6-9	NA	6.5-8.5	6.5-8.5	7.9	8.3	--	--	--	--
Total Phosphate	0.13	1.00	1.0	0.4	5.0	2,000	0.14	1.00	0.05	0.4	0.49	23	0.43	8.4
Potassium	3.5	4.80	15.0	7.0	--	27,000	3.50	4.80	1.40	1.90	2.34	23	2.06	8.5
Silica (SiO_2)	9.80	15.3	27.0	12	--	79,000	9.80	15.30	3.90	6.10	7.48	23	6.62	8.4
Sodium	38.30	6.30	5,800.0	7,900.0	--	129,000	13.20	107.3	2.10	2.50	18.22	--	8.37	--
Sulfate	3.3	58.0	7,500.0	3,800.0	--	350,000	48	106	15.00	23.00	35.30	53	27.59	20
Total Suspended Solids (TSS)		115	<30.0	<30.0	5.0	310,000	38.00	115.00	15.00	46.00	56.35	23	49.86	8.4

(a) Includes several minor recycled waste streams (make-up water system equipment rinses, backwashes and blowdown, nonradioactive floor drains). Also includes metallic products resulting from corrosion/erosion of condenser tubing and other piping.

(b) Includes make-up water demineralizer and steam condensate polisher regeneration wastes, auxiliary boiler blowdown, and nonradioactive lab and sampling wastes.

(c) Computed as follows: Quantity from cooling tower blowdown = (Conc) (Annual Ave Blowdown = 2700 gpm) (Plant load factor = 68.5%) +
Quantity from neutralized plant waste = (Conc) (Flow = 35 gpm) (24 hr/day operation) (26 operating days/yr) +
Quantity from sanitary waste = (Conc) (Flow = 5 gpm) (24 hr/day operation) (365 operation d ./yr).

(d) Computed as $\frac{\Sigma(\text{conc})(\text{flow})}{\Sigma(\text{flow})}$, where average concentration is based on average river concentration (cooling tower blowdown) and average discharge flow (neutralized plant waste) and maximum concentration is based on maximum river concentration and maximum discharge flow.

(e) Based on 6 monthly samplings (March - September, 1974).

(f) Field test using the orthotolidine colo metric.

(g) Based on maximum chemical concentrations in the CRBRP discharge and maximum ambient concentrations in the Clinch River.

Chemicals or chemical species expected to be present in the plant's discharge are tabulated in Table 3.5 (ER, Am I, Part II, E1). The ambient levels of the same chemical species in the river prior to discharge are also provided in the table.

A comparison of the quality of plant cooling tower blowdown with Federal effluent limitations and state water quality criteria is given in Table 3.6. The plant cooling water discharge would comply with applicable Federal and State regulations. The potential effects of this discharge on the aquatic ecosystem are discussed in Section 5.4.1. A discussion of the significant chemical waste effluents is given below.

3.6.1 Circulating Water System Output

Consumptive use of water at the plant would be essentially the result of evaporation in the cooling tower. As shown in Figure 3.6, an average of 4240 gpm would be evaporated in the tower out of a makeup stream of 7095 gpm.

Concentration of dissolved salts by evaporation would constitute one of the major effects on the quality of the water passing through the plant. Dissolved solids in the water would be concentrated about 2.5 times ambient levels in the river as shown in Table 3.5. The dissolved solids in the cooling system blowdown would be diluted rapidly to near ambient levels in the river even under the conservative condition of no flow in the river.

Sulfuric acid addition would be provided on the cooling water system in the event that an unexpected increase in pH occurs beyond pH 8.5. The feed rate for the sulfuric acid cannot be determined at this time since available water quality data do not indicate that the pH will exceed 8.5. Should the pH of the blowdown extend beyond the acceptable 6.5 to 8.5 range, the blowdown valve would close automatically until the condition is corrected (ER, Sec 3.6.2).

Since wood would not be used in the cooling tower, no chemical preservatives would be added to the circulating water. In addition, the use of chemical corrosion inhibitors would not be required (ER, Sec 3.6.2).

3.6.2 Chemical Biocides

The circulating water would be chlorinated periodically to control the growth of biological slimes flourishing at times on the warm heat exchanger surfaces, restricting the flow of cooling water through the equipment and reducing the effectiveness of the heat transfer surfaces. Control of algal growths may also be needed in the cooling tower to prevent short-circuiting of water through the cooling tower. About 450 lb of hypochlorite would be injected periodically into the circulating water line upstream of the main condenser for biocide treatment of the condenser, the cooling tower, and plant auxiliary cooling equipment. Injection of hypochlorite equivalent to 3 mg/ℓ of chlorine is planned for about a 15-min period every 8 hours (ER, Sec 3.6.2).

Provisions are also being made to inject hypochlorite into the intake at the river water pumphouse to control the growth of Asiatic clams in the cooling water system. The necessity for chlorination at that point and the amount of chlorine and time required have not been established.

Chlorination of the circulating water system, regardless of the point of injection, would be accomplished in compliance with Federal effluent limitations and State Water Quality criteria ER, Sec 3.6.1). If the chlorine concentration, as measured by a recording analyzer, should exceed a preset value, alarms would sound and the blowdown would be automatically terminated. No discharge of blowdown would occur until reestablishment of acceptable levels of chlorine residuals. Residuals of free available chlorine in the blowdown would be limited to a maximum of 0.5 mg/ℓ and an average of 0.2 mg/ℓ not to exceed 2 hours in any one day (ER, Sec 3.6.2 and 5.4.3).

3.6.3 Water Treatment Waste

Approximately 96,000 gal of raw river water would be treated each day to meet the plant's domestic and process water needs. The raw river water would be treated by coagulation/sedimentation and filtration to remove particulate matter. Waste sludges (300 to 3,600 gpd) would be dewatered on gravity sludge drying beds and the dried sludge (50 to 600 lb/day) would be trucked offsite by a licensed contractor (ER, Sec 10.4.1.1.1).

An average of approximately 1440 gpd of the clarified water from the process water treatment systems would be treated further by ion exchange to produce demineralized water for the steam cycle. The ion exchange demineralization process would require a maximum of about 3,400 lb/day

TABLE 3.6 Comparison of Cooling Tower Blowdown with Federal Effluent Limitations and State Water Quality Criteria

Regulation	EPA Effluent Limitation[1] Maximum 1-day Concentration	Maximum 30 Consecutive-day Daily Avg	Tennessee General Water Quality Criteria[a]	Expected in CRBRP Discharge
All Discharges Part 423.13(a) & (b)				
pH	6.0-9.0 (range)		pH in the range of 6.5 to 8.5, and shall not flucuate more than 1.0 unit in a 24 hour period.	6.5-8.5 pH ranges. pH controlled to meet criterion.
Polychlorinated biphenyl Compounds	None		No toxic substances added that affect man or animals.	None
Low-volume waste sources Part 423.13(c)			None specified.	
Total suspended solids	100 mg/ℓ	30 mg/ℓ		<30 mg/ℓ
Oil and grease	20 mg/ℓ	15 mg/ℓ		<15 mg/ℓ
Metal-cleaning waste discharges Part 423.13(f)			None specified.	None discharged.
Total suspended solids	100 mg/ℓ	30 mg/ℓ		
Oil and grease	20 mg/ℓ	15 mg/ℓ		
Total copper	1.0 mg/ℓ	1.0 mg/ℓ		
Total iron	1.0 mg/ℓ	1.0 mg/ℓ		
Boiler blowdown discharges Part 423.13(g)			None specified.	
Total suspended solids	100 mg/ℓ	30 mg/ℓ		<30 mg/ℓ
Oil and grease	20 mg/ℓ	15 mg/ℓ		<15 mg/ℓ
Total copper	1.0 mg/ℓ	1.0 mg/ℓ		<1 mg/ℓ
Total iron	1.0 mg/ℓ	1.0 mg/ℓ		<1 mg/ℓ
Cooling tower blowdown discharges Part 423.13(i)				
Free available chlorine[b]	<0.5 mg/ℓ (max)	<0.2 mg/ℓ (avg)	No toxic substances added that affect man or animals	<0.5 mg/ℓ (max) <0.2 mg/ℓ (min)
Total residual chlorine Part 423.13(j)	Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge free available or residual chlorine at any one time.		No toxic substances added that affect man or animals	Less than detection limits (<0.005 mg/ℓ) outside of 2 hour time limit
Corrosion inhibitors	No detectable amount added.		No toxic substances added that affect man or animals.	None discharged
Dissolved Oxygen (D.O.)	None specified.		Minimum dissolved oxygen content of 5.0 mg/ℓ or 3.0 mg/ℓ in vicinity of discharge measured at a depth of 5 feet.	6.8 mg/ℓ
Turbidity or color	None specified.		There shall be no turbidity or color added in amounts or characteristics that cannot be reduced to acceptable concentrations by conventional water treatment processes.	No detectable turbidity or color added[c]
Suspended solids	None specified		There shall be no visible solids, scum, foam, oil slick, etc.	No visible solids, oil or grease added[c]
Oil and Grease				
Zinc	<1.0	<1.0		
Chromium	<0.2	<0.2		
Phosphorus	<5.0	<0.5		
Total dissolved solids	None specified		The total dissolved solids shall at no time exceed 500 mg/ℓ	<500 mg/ℓ in receiving water[c]

(a) Refers to the receiving water after a reasonable zone of mixings (ER, 14.1, Appendix to Section 2.5).
(b) Maximum and average free residual chlorine concentrations are at any given time. One-day and thirty-day averages do not apply to these limitations.
(c) After dilution in mixing zone of river.

of sulfuric acid and 2,200 lb/day of sodium hydroxide to regenerate the ion exchange beds (ER, Sec 3.6.3). The regenerant wastewater would be neutralized and filtered in the chemical waste treatment system prior to discharge in the cooling system blowdown. The chemical waste treatment system effluent would contain predominantly sodium sulfate as a dissolved salt, with smaller ionic concentrations of Ca^{++}, Mg^{++}, and Cl^{-}. The average and maximum concentrations of selected constituents of the wastewater are given in Table 3.2. Total suspended solids would be reduced to less than 30 mg/ℓ and oil and grease would be below 15 mg/ℓ.

Figure 3.17 shows the flow of the water treatment waste and all other waste streams discussed in the following paragraphs (ER, Fig 10.4-1).

3.6.4 Steam Generator System Waste Discharges

Blowdown from the steam power conversion system would consist of high purity water subjected to ion exchange and filtration in the condensate treatment system. Anticipated concentrations of total dissolved solids, oil and grease, copper and iron are below the EPA effluent limitations of 30 mg/ℓ, 15 mg/ℓ, 1 mg/ℓ, and 1 mg/ℓ, respectively (ER, Sec 3.6.1).

The condensate polishing system would generate from approximately 3,000 to 40,000 gpd of high solids waste water consisting of rinses, backwashes and spent regenerants. The wastewater would be similar to the demineralizer waste and also would be treated in the chemical waste treatment system (ER, Sec 10.4.1.1.1).

During startup, an auxiliary steam generator would be used, generating about 1 gpm of blowdown. The blowdown would be alkaline (pH 9.0-9.5) and contain about 200 mg/ℓ dissolved solids and 0.5 mg/ℓ ammonia. Hydrazine would be present in the blowdown but it would decompose rapidly to produce ammonia. Dilution of steam generator blowdown in the circulating water would reduce the added dissolved constituents to less than detectable levels (ER, Sec 10.4.1.1.1).

3.6.5 Chemical Cleaning Waste

Large components of the plant would require periodic chemical cleaning. The cleaning frequently would be done in several stages and the chemicals used would depend on the type of metal being cleaned. A typical procedure would involve alkaline and acid washes and rinses. The waste generated by those cleaning procedures would be disposed of offsite by a licensed contractor (ER, Sec 3.6.3).

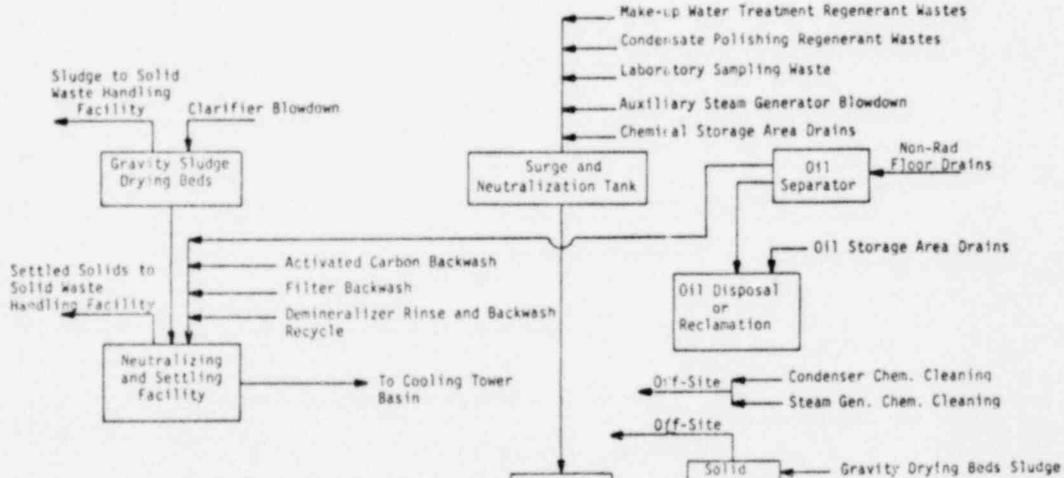


FIGURE 3.17 Chemical Waste Treatment System

3.6.6 Oily Waste

The recycled wastewater treatment subsystem would provide pretreatment of oil contaminated wastewater. Plant waste streams would be collected and segregated as to source and chemical composition. If oil contamination should be detected, the waste stream would be sent to an oil separator. The major input to the oil separator would come from the nonradioactive floor drains. Subsequent to treatment the aqueous wastes would be routed to the chemical waste treatment system and the collected oils either would be reclaimed or disposed of offsite by a licensed contractor (ER, Sec 10.4.1.1.1).

3.6.7 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) would be used in electrical equipment such as transformers. Although no spillage is anticipated, equipment containing PCBs would be protected by diking or other containment systems to avoid loss of this material to the receiving stream (ER, Tab 10.4-1).

3.6.8 Chemical and Oil Storage

Oil would be stored in accordance with the December 1973 Environmental Protection Agency Regulations on Oil Pollution Prevention (40 CFR, 112, 38 FR, 34164) to minimize potential impact on the environment. Storage of chemicals would be accomplished with appropriate diking and catchment basins to prevent loss of the chemicals to the environment (ER, Sec 5.4.4 and 7.2.1).

3.6.9 Storm Drainage

Storm drainage collected by the roofs of buildings and the yard would be routed to a catch basin for discharge to the Clinch River. A portable oil skimmer would be available to treat the storm drainage in the event of a visible oil slick on the surface of the water (ER, Sec 10.4.1.1.2).

3.6.10 Cooling Tower Drift

Drift, consisting of a fine spray from the cooling tower, would be deposited in the immediate vicinity around the tower. The anticipated rate of drift would be about 110 gpm. The chemical composition of the drift would be similar to that of the circulating water, or river water, shown in Table 3.5.

3.6.11 Nonradioactive Chemical Coolants

Waste materials such as chemically contaminated Dowtherm, sodium, and sodium-potassium alloy would accumulate in specially designed tanks and be shipped offsite periodically for treatment and/or disposal (ER, Sec 3.6.3).

3.7 SANITARY AND OTHER WASTE

3.7.1 Sanitary Waste

Facilities for treating sanitary waste would be provided during both construction and normal plant operations. The sanitary waste treatment system for the construction period would be sized for handling the needs of 2,450 persons. The maximum daily sanitary waste flow would be 61,250 gal. based on 25 gpd/person, (ER, Sec 3.7.1). The expected peak construction crew of nearly 2800 persons includes 350 technical persons who would work in Oak Ridge and visit the site occasionally (Table 4.1).

Prior to issuing the construction permit, sanitary waste generated by personnel participating in site preparation would be treated by an 8,000 gpd capacity extended aeration, activated sludge, sewage treatment unit. A screening basket and influent comminutor would be provided with the unit for pretreatment of the wastewater. The effluent from the unit would be chlorinated prior to discharge to the river. Upon issuance of the construction permit a larger extended aeration unit with a capacity of 53,250 gpd would be installed. The total treatment capacity of the two units would be 61,250 gpd. Figure 3.18 shows the general arrangement of the sanitary waste system (ER, Fig 3.7-1). Portable toilets would also be used in remote areas during the construction period. The 53,250-gpd unit would be removed upon completion of construction.

The 8000 gpd extended aeration unit described above would remain for treating the wastes produced during normal plant operation. During operating periods the maximum projected number of operating personnel is 170 and the maximum number needed during annual shutdowns is 210. In addition, a group of technical persons would be employed at the project office in Oak Ridge. The expected waste generation rate for each man is 35 gpd; therefore, about 7350 gpd of waste would be generated, which is within the capacity of the unit.

Operation of the 8000 gpd unit during normal plant operating periods would involve slow sand filtration, as shown in Figure 3.18 (ER, Fig. 3.7-2), to remove additional suspended solids after biological treatment. The extended aeration unit alone is expected to remove 60 to 90% of the suspended solids and 75 to 95% of the biochemical oxygen demand. Filtration of the biological effluent is anticipated to produce a final effluent with the characteristics given in Table 3.7 (ER, Tab. 3.7-1), State effluent criteria are also given for comparison to show that the final effluent would be within limits.

The filtered extended aeration unit effluent would be chlorinated prior to discharge in the cooling tower blowdown to give a chlorine residual complying with the State limits of 0.5 to 2.0 mg/ℓ. The dosage of chlorine to meet the above limits would be determined during startup.

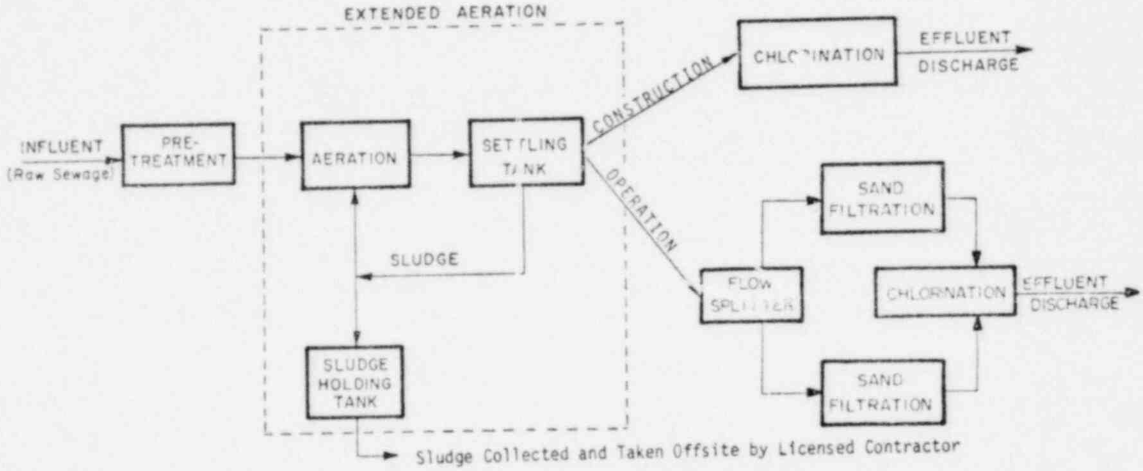


Figure 3.18. Sanitary Waste System, Construction and Plant Operation (ER, Fig 3.7-1 and -2)

TABLE 3.7 Plant Sanitary Waste System Estimated Effluent Characteristcs (ER, Tab 3.7-1)

	Sanitary Waste Effluent (mg/l)	State of Tennessee Criteria[a] (mg/l)
Suspended Solids	5	40
BOD	12	30
COD	25	--
Total Phosphate (as PO_4)	5	--
Nitrate Nitrogen (as N)	15	--
Residual Chlorine	1	0.5-2.0
Ammonia Nitrogen (as N)	0.5	5.0
pH	6.0-9.0	

[a] Source: R. A. Unger

3.7.2 Other Waste

The only gaseous effluents discharged into the atmosphere would be those in the exhaust from emergency operation or periodic testing of the 2 diesel generators, which serve the plant in case of power failure, and the diesel-driven fire pump. The generators would use 95 lb/hr; of No. 2 fuel oil with these emission rates: SO_2, 0.17 lb/hr; No_x, 1.7 lb/hr; Co, 0.34 lb/hr; particulates, 0.17 lb/hr; and heat, 1.9 million Btu/hr (ER, p 5.5-4). Testing frequency would be once per month for two hours or until normalization of operating conditions, whichever is sooner.

Trash from the plant and solid, nonradioactive chemical wastes would be disposed of offsite by a licensed contractor.

3.8 POWER TRANSMISSION SYSTEM

Two 161 kV single-circuit transmission lines would be built to loop into the TVA-owned 161 kV Ft. Loudoun K-31 line, which passes 2.8 miles east of the site. The two new lines would parallel each other and existing transmission lines, as shown in Figure 3.19 (ER, Sec 3.9). A total of 3.2 miles of corridor would be widened to accommodate the new lines.

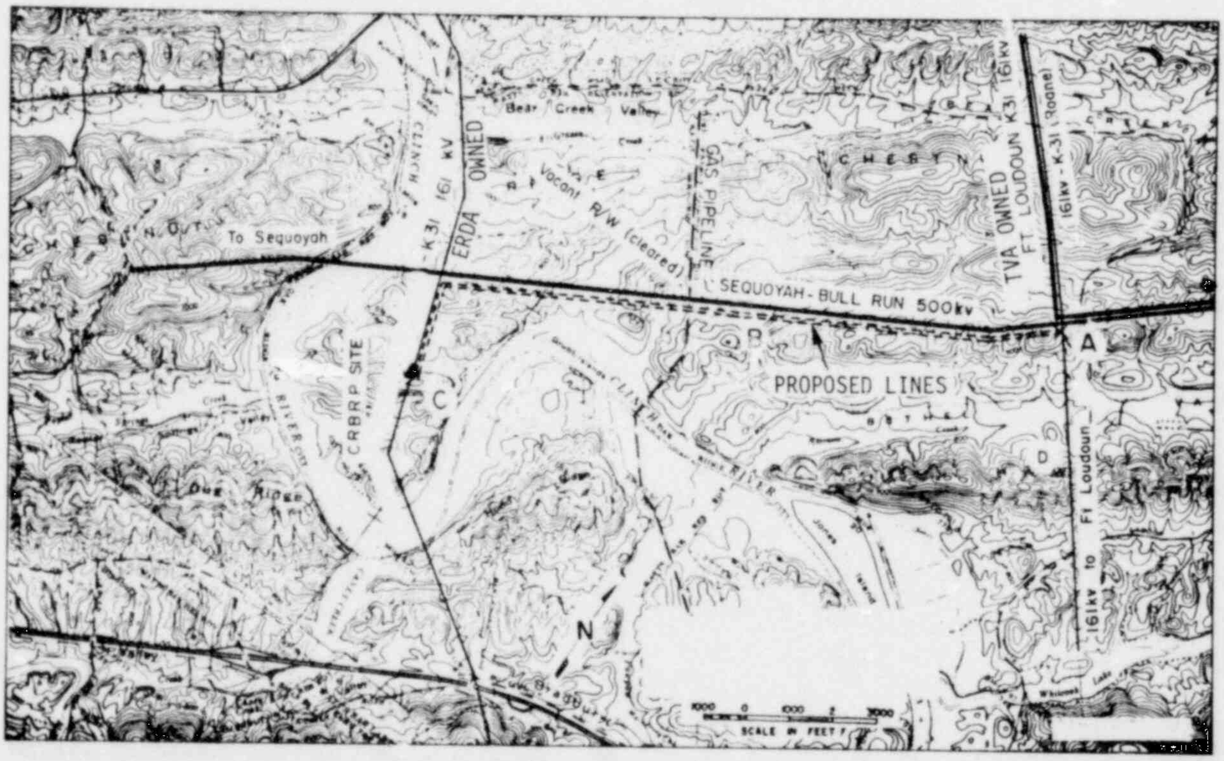


FIGURE 3.19 Proposed Transmission Line Route

Beginning at the plant switchyard, the route would follow the existing ERDA-owned 161 kV circuit in a northwesterly direction for 0.5 mile. The new lines would be installed parallel to and on the eastern edge of the existing line. There would be 75 ft between lines and a 50 ft right-of-way on the eastern edge of the corridor. The route would then turn eastward to parallel the Sequoyah-Bull Run 500 kV line for 2.7 miles. The new lines would be installed south of the present 500 kV line. There would be 100 ft separating the 500 kV line and the inner 161 kV line, 75 ft between the two 161 kV lines, and 50 ft of right-of-way on the southern edge. The existing corridor would be widened by a total of 125 ft.

About 56 galvanized steel towers 85 ft high would be used at 600 ft intervals to support the conductors. Cross arms would be of fiberglass, supporting gray insulators. The tower bases, taking up less than a total of one acre, would consist of precast concrete sections for installation in holes made 8 to 10 ft deep with augers mounted on rubber tires.

The transmission lines would pass between Chestnut Ridge and Haw Ridge and cross two small streams draining into the river near CRM 18 (ER, Sec 3.9.2). There are no railroad, highway or public road crossings, and no inhabited, cultivated, or recreational areas along this route. The area has been closed to hunting in the recent past (ER, Sec 3.9.3). No historical or archaeological sites listed in the National Register of Historic Places are in the proposed corridor. Should archaeological investigations presently underway reveal any significant site in the proposed transmission line corridor, relocation of the route or of specific towers will be considered (ER, Sec 3.9.6).

Both construction and maintenance probably would be done using access roads presently in use for existing lines (ER, Sec 4.2.1 and Fig 3.9-2). Where necessary, temporary drainage ditches, terracing and ground cover would be placed along access roads to prevent excessive soil erosion caused by heavy construction equipment (ER, Sec 4.2.1). The roads would be restored or upgraded after construction to be equal to or better than the original condition.

Nearly 54 acres of the 58-acre right-of-way would be shear cleared mechanically without any use of herbicides (ER, Sec 4.2.2). The right-of-way is 40% hardwood, 40% pine, 10% mixed, and 8% unforested (ER, Tab 2.7-5). Open burning for disposal of cleared vegetation would be done in compliance with State and Federal air pollution guidelines.

Soils of the corridor are moderately erodible, with estimates of erodibility as follows: 16.7% slight, 66.6% slight to moderate, and 16.7% moderate to severe (ER, Sec 4.2.3). Erosion control would be affected by limiting the usage of heavy equipment near streams and in areas of high erosion potential, by diverting runoff from exposed lands into settling ponds, by keeping vegetation on the land surfaces as long as possible before construction, and, where possible, scheduling construction to coincide with dry weather seasons. The applicant anticipates that some erosion and siltation would occur during construction on both the access roads and the right-of-way. However, adverse effects from erosion and siltation would be minimized by prompt restoration of land surfaces (ER, Sec 4.2.3). The right-of-way would be restored by grading where needed, fertilizing and seeding with fescue for initial cover, and allowing invasion of native species thereafter.

The applicant states that applicable portions of these guidelines were followed in selecting the routing: U.S. Department of Interior/Agriculture's Environmental Criteria for Electric Transmission Systems and the Federal Power Commission's Electric Power Transmission and the Environment (ER Am I, Part II, G7).

4. ENVIRONMENTAL IMPACTS DUE TO CONSTRUCTION

4.1 CONSTRUCTION SCHEDULE AND MANPOWER

Site preparation was planned to begin in September 1975; however, construction start now is estimated for December 1976 and the data presented herein should be considered accordingly. The applicant requested a Limited Work Authorization, effective 11 months prior to the anticipated date of the Construction Permit (CP). During the first 4 months clearing and grubbing would be done. During the last 7 months excavation would be done and the following facilities would be installed: site access roads and onsite temporary roads, railroads and spurs, construction parking areas, work and storage area, construction power and lights, concrete batch plant, sewage treatment plant and craft toilet, construction office and warehouse, fire protection system, storm drainage system, and barge unloading facility (Application, April 1975).

The construction period under the CP is expected to be 6.5 years. Assuming similarity with schedules for light water reactors, site preparation would continue, most major elements of construction would begin within one year, and construction of the cooling tower and transmission lines would begin at the start of the fourth year.

There would be three components of the CRBRP workforce: construction personnel, operations personnel, and the applicant's technical personnel. Since substantial numbers of the latter two classifications would be on site during the construction period, their presence is noted as a construction period effect. The time distribution of the work force expressed as yearly average is given in Table 4.1, showing a demonstration period of 1984-1988 (ER, Tab 8.2-1).

TABLE 4.1 CRBRP Direct and Induced Employment (man-yr)

Year	CRBRP Personnel: Construction	Operations	Technical	Total	Induced Personnel
1975	-	-	250	250	190
1976	-	-	-	-	-
1977	-	-	-	-	-
1978	170	10	350	530	360
1979	580	10	350	940	560
1980	1,280	30	350	1,660	920
1981	2,320	70	350	2,740	1,480
1982	2,300	140	350	2,790	1,520
1983	1,150	170	350	1,670	960
1984	-	170	190	360	270
1985	-	170	140	310	230
1986	-	165	90	255	190
1987	-	165	70	235	180
1988	-	160	50	210	160

The staff estimates that at the peak of construction activity in 1981-2 there would be about 2800 workers on the project. About 1230 of those would move into the area by the construction peak, based on experience at TVA construction projects (ER, Sec. 8.3.2.1). Nearly 1600 would commute from current residences.

Additional employment would be induced by the presence of a large labor force on the CRBRP project. The effect would be felt in the entire region, but nowhere so concentrated as in the immediate project area. Induced employment would arise because the purchasing power of the CRBRP labor force would create a demand for goods and services. The applicant references an Appalachian Regional Commission study (ER, p 8.2-4) showing that, for Anderson County, every economic base job generates an additional 0.75 job in local service and production activities. In considering effects (Sec 4.5.2 and 5.6), the staff adopted the 0.75 multiplier to calculate induced labor effects from the operating force and 0.5 for the construction workers. A lower value is used for construction because of its temporary nature. Based upon an analysis similar to that used by the staff in Section 5.6, about 1000 additional school-age children would be present in the area at the peak of construction, deriving from the 1230 directly employed workers moving into the area and perhaps as many as 480 new residents from the resulting induced employment (Table 4.1).

Several other large facilities are currently under construction in the area. The major projects are the Kingston Steam Plant, Watts Bar Nuclear Plant, Exxon Nuclear Fuel Plant, and ERDA construction at Oak Ridge.

4.2 IMPACTS ON LAND USE

4.2.1 Onsite and Immediate Vicinity

Construction of the CRBRP and related facilities would disturb temporarily about 170 acres of forested land of which about 5% is in hardwood, 21% in pine plantation, 8% in natural pine, 25% in cedar-pine, 15% in hardwood-cedar, 1% in hardwood-pine, and 9% in hardwood-cedar-pine. About half of the acreage, including a 32-acre borrow pit for structural fill (Figure 3.3), would be disturbed temporarily and would be revegetated after construction. About 73 acres would be permanently disturbed (ER, Tab 4.1-1) including 24 acres for access roads and railroads (both onsite and offsite), 8 acres for settling ponds, 4 acres for principal plant buildings along with 30 acres for associated grading (Section 2.1), 2.5 acres for barge unloading area, 0.5 acre for river intake area, and 4 acres for other structures and laydown areas. The 73 acres represents about 5% of the land on the site and about 0.2% of the forested land on the adjacent Oak Ridge Reservation.

Land to be disturbed would avoid the "natural areas" discussed in Section 2.7.1. The rare wildflowers (Section 2.7.1.1) would not be affected since they are more than 1 mile distant from the area that would be disturbed by plant construction (ER, Am I. Part II, B7). No rare or endangered animal species occur in that area (ER, Sec 4.1.1.6). The staff concludes that the loss, for the life of the plant, of 73 acres for production of biota would not constitute a significant impact since there are thousands of similarly forested acres in the vicinity (Section 2.7.1).

Timber of commercial value on the construction areas would be harvested and removed from the site in accordance with the ERDA Forest Management Program (Strock, 1975). The remaining plants and brush would be burned in accordance with a fire prevention and protection plan which the applicant intends to develop (ER, Sec 4.1.1.7). Conventional garbage would not be incinerated on the site (ER, Sec 4.1.1.5) but collected and disposed of offsite by a licensed contractor. The staff's opinion is that surrounding forested areas would sustain no significantly adverse effects in view of the applicant's plans for fire prevention control procedures and limited onsite burning in conformance with State and Federal air pollution requirements.

Locations of access roads, railroads, and borrow pits are shown in Figure 3.3. The present access road (River Road) would be used after paving and improvement, and temporary unpaved roads would ring the construction area. The new railroad would pass between the present access road and the river on the west side of the site with spurs going into the construction area.

Top soil on the areas to be excavated would be removed to a depth of 0 to 12 inches and stockpiled on 10 acres southeast of the plant for use in later landscaping. Beneath the topsoil, about half of the excavated materials would satisfy requirements for structural fill. Excess would be stockpiled for backfill. Additional backfill would be obtained from the 32-acre borrow pit (Figure 3.3). Building materials (sand, stone, slate, limestone) would be quarried offsite and probably trucked in. Surface soils of the borrow pit would be stockpiled for revegetation of the pit at the end of construction. Drainage ditches would be constructed around the periphery of all stockpile areas and at the base of all excavation slopes. Drainage water would be collected in sumps for distribution to settling basins about 500 ft from the shoreline west and south of the plant, prior to discharge into the river (ER, Fig 4.1-3). Seeding, burlap protection and tree planting would be used as appropriate to prevent soil erosion.

After completing construction, surfaces not a part of the permanently committed land would be graded and revegetated. Land undisturbed by construction would be managed, both during and after construction, under the ERDA Oak Ridge Forestry Management Program (ER, Am I, Part II, B6). The program would, however, be terminated at TVA's request for any part of the site needed for development.

Moving construction equipment and disturbing land would result in temporary adverse effects such as erosion, siltation and interferences with some community life patterns. Based upon the staff's review of pertinent plans discussed in the two paragraphs above, the extent of such effects would be at a practicable minimum during the brief periods of their occurrences. The long-term effects would not be significant.

Historic and archaeological resources, except for the Hensley cemetery and the Indian Mound, are at distances sufficient to have no involvement with the construction plan. Borrow pit activity would be restricted so as not to interfere with the two nearby sites (ER, p 4.1-3). The staff's opinion is that they would be unaffected. The State archaeologist's opinion is that the applicant has given adequate consideration to archaeological resources. The State Historic Preservation Officer concurs that no structures of historic interest remain in the area (App C).

4.2.2 Transmission Lines

The staff concludes that erosion and air pollution control practices (Section 3.8) would be adequate to prevent adverse impacts on terrestrial biota in the area and that historical and archaeological resources would be adequately protected. The shift in land use of nearly 54 acres from woodland to open area would have no significant impact on wildlife because of the large area of land with similar woodland vegetation nearby, 1289 acres of forest on the site and 29,443 acres of forest on the Oak Ridge Reservation.

4.3 IMPACTS ON WATER USE

Raw water for fire protection, sanitary facilities, compacting fill, controlling dust, and making concrete would be obtained from the river. The maximum requirement is expected to be 50,000 gpd, representing about 0.002% of the river's annual average flow. This small withdrawal is expected to have no significant effect on navigational and recreational uses of the river or on any downstream uses.

For erosion control in dewatering and related activity the applicant plans to use drainage ditches at the base of stockpiles and excavation slopes, a storm water drainage system, and a system of diversion channels leading to settling basins before discharging water to the river. The staff would require that discharged water not exceed the 50 mg/ℓ EPA instantaneous maximum for suspended solids (Table 9.5.3-2). The staff's opinion is that dewatering is expected to have no significant aesthetic or other effect on the river.

The applicant has not indicated the procedures to be used in disposing of the 40,000 m^3 of material to be dredged in preparation for building the intake structure and, particularly, the barge-unloading facilities. The staff's opinion is that protective measures (Section 4.4.2, par 2) and the plan to do major construction elements in sequence would give protection sufficient to insure only temporary, minor adverse impacts upon the aesthetic quality and navigational and recreational uses of the river.

Transmission line construction is expected to have temporary impacts at stream crossings but these will be minor due to siltation control.

4.4 ECOLOGICAL IMPACTS

4.4.1 Terrestrial

Construction would result in the harvesting of some timber and the destruction of other plant and animal life on 170 acres concerned with the plant and 58 acres in connection with the transmission lines, both on and off the site. Of this land, 97 acres in connection with the plant and all 58 acres for the transmission lines, according to the applicant's plans, would be revegetated by the end of the construction period and 73 acres would be disturbed for the life of the plant. In the forested acres, animals would be either killed or displaced to surrounding woodland where they would compete for space and food with populations already present. The net effect of the construction would be a small increase in open, brushy habitat, a decrease in forest habitat with the resultant favoring of wildlife such as quail and rabbits that prefer open areas, and decreases in populations of woodland species. No new "edge" would be created along the transmission line route, since existing corridor merely would be widened. None of the estimated shifts in animal populations is greater than 10% of the corresponding population on the site (ER, Sec 4.1.1.6). No rare or endangered plant or animal species is known to occur on the land affected by construction. The staff's opinion is that the impact on terrestrial biota would be minimal in view of the fact that the amount of land affected would be less than 1% of similar available land onsite and the Oak Ridge Reservation.

The staff's opinion is that the applicant's commitments to restrict erosion (Section 3.8 and 4.2.1) and chemical releases (Section 4.5.1 (3), (16), (17), (18) and (23)) would be adequate to protect the terrestrial ecosystem from significantly adverse effects from those sources.

4.4.2 Aquatic

The staff's opinion is that the precautions to be used in constructing plant buildings and transmission lines (Section 4.2.1 and 3.8) would assure minimum effects upon aquatic resources. No significant effects are anticipated in the river channel, since it would not be modified.

The river pumphouse and intake structure would be built behind a temporary cofferdam to allow dry excavation for the structures. The staff recommends installation and removal of the cofferdam between August and March when fish are not spawning [consistent with the applicant's plans, Section 4.6.1.1 (2)] or at other times if no adverse effects can be substantiated. Disposal consistent with State and Federal regulations for dredged material and pumped water (TWQCB, 1973 and EPA, 1974) will be required by the staff. The 1900 m^3 of riverbank and bottom to be excavated or dredged would result in a temporary loss of benthic organisms in the disturbed area. The loss would be of minor consequence when compared to the total river biomass and the disturbed area would most likely be quickly repopulated after completion of construction.

The discharge pipe would be constructed on land; very little disturbance of the river is expected. Some excavation would take place, but no dredging. The staff's opinion is that construction of the discharge pipe would be of little consequence to the aquatic ecosystem.

About 38,000 m^3 of material would be dredged to accommodate the 80 ft x 250 ft barge-unloading facility to be located in an inlet cove adjacent to the proposed railroad and access road (ER, Fig 4.1-3). Disposal procedures would be required to meet all applicable Federal and State regulations. Sequential construction is planned in this order: fill, drive piling as needed, dredge bottom, place stone bottom and platform, and dredge river to needed depth. The staff would require that closing and reopening the inlet cove be done between August and March when fish are not spawning or at other times provided no adverse effects can be shown. All aquatic life would be lost temporarily in the area of the facility. The loss would not be significant since much of the land is dry during parts of the year and upon completion of construction, new habitat would be opened for population by aquatic organisms of the area.

Plans for mitigating the effects of disposing of chemicals, sanitary wastewater and solid waste are discussed in Section 3.6 and 3.7. The staff's opinion is that disposal of those materials would have insignificant effects upon the aquatic ecosystem.

In summary, the aquatic ecosystem is expected to sustain no significant impact from constructing the plant and transmission lines. To measure impacts, the staff would require monitoring during construction, as specified in Section 6.1.4.

4.5 IMPACTS ON THE COMMUNITY

4.5.1 Social

Social impacts would be experienced mainly in Anderson, Roane, Loudon, and Knox counties. The principal social impacts, in the opinion of the staff, would be increased traffic (particularly on State Road 58), increased burdens on community services (schools, libraries, police and fire protection, local government), probable growth in unregulated housing development, and some localized increase in noise and dust.

Anderson County (pop. 60,300)

The largest municipality in Anderson County is the city of Oak Ridge, with a 1970 population of 28,319 (ER, Tab 2.2-1). At first glance, one might suspect that the City of Oak Ridge would bear the burden of the social impact because it is the largest municipality within 10 miles of the site. Oak Ridge would be effectively closed to the CRBRP construction force, however, because of the local housing situation. Local ordinances prohibit mobile homes; permanent housing is relatively expensive compared to surrounding areas and in short supply (ER, p 8.1-7). Presently, 64% of ERDA employees at Oak Ridge facilities live outside of the city, many of them commuting from Knoxville (ER, Fig 8.1-4). Consequently, CRBRP construction workers moving into the vicinity probably would not locate in Oak Ridge.

The second largest municipality in Anderson County is Clinton, with a 1970 population of just under 5,000. Clinton is only about 20 miles from the CRBRP and could attract some of the CRBRP workers. The relatively high tax rates in the county, however, may be cause for some of the labor force to locate outside the county.

The two school systems in Anderson County are the Oak Ridge city schools and the county schools. Enrollment statistics for the two systems are shown in Tables 4.2 and 4.3. The data indicate a

TABLE 4.2 Oak Ridge School Use and Capacity[a]

School	Grades	Enrollment	Capacity
Cedar Hill Elementary	K-6	442	455
Glenwood Elementary	K-6	445	472
Linden Elementary	K-6	885	905
Willow Brook Elementary	K-6	483	495
Woodland Elementary	K-6	507	679
Jefferson Jr. High	7-9	757	1000
Robertsville Jr. High	7-9	833	1080
Oak Ridge High	10-12	1578	1650
TOTALS		5930	6736

(a) Exclusive of special education.

TABLE 4.3 Anderson County School Use and Capacity

School	Grades	Enrollment	Capacity
Andersonville Elementary	K-6	231	300
Briceville Elementary	K-8	459	450
Claxton Elementary	K-6	717	750
Dutch Valley Elementary	K-6	221	200
Fairview Elementary	K-6	259	240
Lake City Elementary	K-8	735	750
Marlow Elementary	K-6	194	220
Medford Elementary	1-8	233	200
Norris Elementary	K-6	282	260
Norwood Elementary	K-6	544	425
Rosedale Elementary(2)	K-8	120	300
Shinlint Elementary	K-6	405	380
South Clinton Elementary	K-6	390	470
Clinton Jr. High	7-9	1108	1000
Glen Alpine Jr. High	7-9	270	275
Norwood Jr. High	7-9	375	350
Clinton Sr. High	10-12	1186	1000
Lake City Sr. High	9-12	625	650
Norris Sr. High	9-12	409	400
TOTALS		8764	9620

(a) Exclusive of special education
(b) A remote school

14% excess capacity in the Oak Ridge schools and a 10% excess capacity in the county schools. In the opinion of the staff, these data show nearly complete utilization of the school systems and any substantial increase in enrollment could create problems.

Roane County (pop. 38,881)

Harriman and Kingston, both in Roane County and about 5 and 10 miles from the site, would probably sustain a large part of the social impact of the proposed project. Of the total Roane County population in 1970, 8,734 resided in Harriman and 4,142 in Kingston (the County seat) (ER, Table 2.2-1). The two small communities, with no firm zoning regulations and with public services of modest size, are not prepared to handle a large influx of people. Roane County is particularly vulnerable to a worker influx because of the absence of land use controls. Unregulated growth could strain schools and other community services, already stretched to the limit in some areas. School enrollments and capacities for the city of Harriman are given in Table 4.4. They show a 23% excess capacity currently (2975/2420 = 1.23). However, on a planning basis, most school systems provide for a 10% contingency factor so the 23% excess is not really very large. Furthermore, utilizing full capacity is not always possible without expensive bussing if the schools are located away from the current student population. On balance, the staff concludes that the Harriman schools could accommodate up to 200 additional students, a reserve that probably would be adequate for the student increase in Harriman, resulting from plant construction. Similar data for schools operated by Roane County are given in Table 4.5. Roane County shows a current excess capacity of 10% (7405/6729 = 1.10), representing essentially complete utilization of the school system. Any additional students would result in overcrowding.

TABLE 4.4 Harriman City School Use and Capacity

School	Grades	Enrollment	Capacity
Margrave Elementary	5-6	105	125
S. Harriman Middle	6-8	275	350
Walnut Hill Elementary	K-3	195	250
Cumberland Middle	6-8	305	500
Central Elementary	K-5	390	450
Bowers Elementary	K-5	485	550
Harriman High	9-12	665	750
TOTALS		2420	2975

TABLE 4.5 Roane County School Use and Capacity

School	Grades	Enrollment	Capacity
Cherokee Elementary	5-8	724	730
Dyllis Elementary	K-8	227	270
Edgewood Elementary Spec. Ed. Center		150	180
Emory Heights Elementary	K-8	150	240
Kingston Elementary	K-4	707	750
Midtown Elementary	K-8	306	350
Midway Elementary	K-6	404	440
Oliver Springs Elementary	K-8	525	575
Pond Grove Elementary	K-6	196	240
Redgeview Elementary	K-6	1030	1080
Midway High School	7-12	344	420
Oliver Springs High School	9-12	405	480
Roane County High School	9-12	760	810
Rockwood High School	7-12	801	804
TOTALS		6729	7405

Loudon County (pop. 24,266)

Lenoir City (pop. 5,324) and parts of Kingston Pike leading into Lenoir City can be expected to sustain some of the social impacts of the proposed project. Although permanent housing is relatively scarce in this area, many mobile homes are expected since they are not prohibited. Loudon is a small county. Any appreciable influx of workers would cause many changes in the character of the area and strain current community services. County schools already are fully utilized. Schools operated by the county are listed in Table 4.6. All except Browder, Glendale, and Loudon High are full, and those three are nearly at capacity. Schools operated by Lenoir City are listed in Table 4.7. Lenoir City schools have a 14% excess capacity, which is minimal for future planning needs. In the opinion of the staff, Loudon County (including Lenoir City) cannot accommodate a large increase in school age children without adding facilities.

TABLE 4.6 Loudon County School Use and Capacity[(a)]

School	Grades	Enrollment	Capacity
Browder Elementary	1-8	104	150
Eatons Elementary	K-8	752	Full
Glendale Elementary	1-8	108	140
Highland Park Elementary	K-8	404	Full
Loudon Elementary	K-4	436	Full
Philadelphia Elementary	K-8	304	Full
Davis Elementary	1-3	128	140
Steekee Elementary	K-8	264	Full
Greenback Elementary	K-12	513	Full
Loudon Jr. High	5-8	340	Full
Loudon High	9-12	590	650

(a) Special education excluded

TABLE 4.7 Lenoir City School Use and Capacity

School	Grades	Enrollment	Capacity
Lenoir City High	9-12	905	1000
Lenoir City Middle	5-8	499	500
Nichols Elementary	K-4	427	500
West Hill Elementary	K-4	101	200
TOTALS		1932	2200

Knox County (pop. 276,293)

The city of Knoxville, with a 1970 population of 174,587 (ER, Table 2.2-1), probably would absorb a large number of the CRBRP workers. The resulting social impact of a few thousand people in this case would not be significant, however, because of the large size of the city. Already 6,500 commuters a day leave Knox County to work in Anderson County (4,000 of them at the ERDA facilities in Oak Ridge) (ER, Figs. 8.1-3 and 8.1-4).

4.5.2 Economic

The economic impact of construction of the CRBRP on the surrounding area would be felt in the private and public sectors. In general, the economic impact on the private sector would be beneficial. Direct project construction payroll is estimated by the staff to have a present value of $245 million through the year 1983; the actual payroll is escalated at a rate of 8% (Table 4.8). The tabulation shows that the payroll generated by induced (secondary) employment would add another $40.6 million through 1983 for a total present value of $285.6 million. The staff estimates that about 40% of the total, or an amount with a present value of about $120 million, would be spent in the local economy. The remainder would be divided between savings and purchases of goods or services from outside the region.

The economic impact on the public sector would depend upon the balance between tax revenues generated by the project and the need for increased public spending to provide tax supported services to the primary and secondary work force. The project would not contribute directly to the tax base of the local area through the payment of property (plant and land) taxes or sales and use taxes on materials and supplies used in construction since the project is on nontaxable government (TVA) land. That leaves only two sources of taxes for the project to contribute to the public spending load placed on the local area as a result of the project: direct and indirect taxes from payroll spending, and ERDA in-lieu-of-tax payments. The staff estimates the total state sales tax generated by the payroll spending between 1976 and 1983 to be $4.2 million, based on a $286 million payroll (Table 4.8), a 3.5% tax rate, and an assumption that 42% of payroll is spent for taxable items (Section 5.6.1).

A local sales tax of 1.5% may be added to the 3.5% state sales tax at local option. That could generate 42.86% (1.5/3.5) of the state sales tax for local puposes if the local area levies this tax, yielding maximum local revenues of $1.8 million (present value) during the period 1976 to 1983, according to a staff estimate.

The staff's conclusion is that the portions of taxes such as state sales tax, gas taxes, cigarette taxes, and liquor taxes, for example, that are returned to the communities would not in themselves be equal to the cost of the public services which must be provided by the communities. Such taxes are relatively small compared to the receipts communities get from personal property taxes. Any ERDA (or TVA) in-lieu-of-tax payments are still a subject of speculation. The degree is unknown to which such public sector money would be available to provide for the cost of public sector services.

4.5.3 Aesthetic

The plant would be located in a fairly isolated place and would be visible to the public from only a few vantage points. These points are mainly from the Gallaher Bridge (about 1-1/2 miles away), and a few scattered residences on the opposite bank of the river.

The most noticeable visual feature would be the domed reactor containment building, which is about 170 feet tall. The outer surface would be insulated and covered with a surfacing material harmonizing with other building finishes.

TABLE 4.8 Direct and Induced Payroll Effects[a]

Year	Direct[b] Payroll	Induced[c] Payroll	Total Payroll
1976	$ -	$ -	$ -
1977	-	-	-
1978	16,900,000	2,520,000	19,420,000
1979	25,100,000	3,920,000	29,020,000
1980	39,600,000	6,440,000	46,040,000
1981	62,400,000	10,360,000	72,760,000
1982	62,000,000	10,640,000	72,640,000
1983	39,200,000	6,720,000	45,920,000
Construction Subtotal	$245,200,000	$40,600,000	$285,800,000
1984	$ 10,800,000	$ 1,890,000	$ 12,690,000
1985	9,300,000	1,610,000	10,910,000
1986	7,300,000	1,330,000	8,630,000
1987	6,600,000	1,260,000	7,860,000
1988	5,600,000	1,120,000	6,720,000
Demonstration Period Subtotal	$ 39,600,000	$ 7,210,000	$ 46,810,000
Grand Total	$284,800,000	$47,810,000	$332,610,000

(a) An 8% escalation rate and 8% discount rate applied to 1975 dollars.
(b) Derived from Table 8.2-2 ER after subtracting $16,500/man-yr for technical classifications to correct for payroll benefits and office expenses.
(c) Derived from induced employment (see Table 4.1) by applying a factor of $7,000/man-yr.

In the opinion of the staff, the CRBRP would not form an objectionable visual intrusion on the landscape.

4.5.4 Dust and Noise

Dust would be controlled by water sprinkling on construction areas and on roads (ER, p 4.1-11), in addition to road paving and revegetation (Section 4.2.1). Blasting noise would be minimized by using small multiple blasts within a 4-month period (ER, p 4.1-3). Noise would also result from operating heavy equipment. At 0.5 mile from the site, truck and rock drill noise up to 64 dBA would exceed the 55 dBA threshold for outdoor annoyance (EPA, 1974). At 1 mile the threshold would be exceeded only by the rock drill at 58 dBA, during excavation and finishing. Noise would be muffled by surrounding forest. The staff's opinion is that dust and noise and other potentially adverse effects from blasting and heavy equipment would have minor adverse effects and they would be experienced only by the few residents immediately south of the river.

4.6 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

4.6.1 Applicant's Commitments

The following summarizes commitments made by the applicant to limit adverse effects during construction.

4.6.1.1 From the ER, Section 4 and 6.1.1.2.1

1) Open burning would conform to State and Federal air pollution requirements.

2) Ash and other inorganic waste would be buried about 3 feet. The graded surface would be seeded with appropriate vegetation to prevent soil erosion.

3) Blasting would be restricted to small multiple charges over a 4-month period.

4) Depth of the borrow pit would not exceed 25 feet and the sides, a 2 to 1 slope (horizontal to vertical). Encroachment upon the Hensley Cemetery and the Indian Mound would be avoided. Reclamation would consist of returning subsoil and topsoil and seeding native grasses and forbs.

5) In constructing the barge-unloading facility, river siltation would be controlled by doing major construction elements in sequence.

6) Disposal of construction chemicals would be in accordance with applicable regulations. Control of waste oil would be supervised. Treatment would be given solid and liquid wastes from shop, machinery repair, and cleanup areas.

7) Garbage from the plant and transmission line construction would not be burned. It would be discarded by a licensed contractor in regulated disposal facilities.

8) Treated sanitary wastewater discharged to the river would meet standards of the Tennessee Department of Public Health. Chemical toilets would be used in remote areas, with approved disposal of wastes.

9) General erosion control would consist of leveling rutted areas, maintaining contours where possible, leaving as many tree stands as possible in the plant construction area, constructing drainage ditches at the base of stockpiles and excavation slopes, rip-rapping major diversion channels where erosive velocities are indicated, holding up drainage water in settling basins before discharge to the river, developing a storm drainage system for site and transmission line access roads and spoil laydown, landscaping as soon as construction schedules permit, providing burlap protection to seeding on slopes, and planting trees where possible.

10) Truck traffic would be confined offsite to established routes and, onsite, to paved roads under strict control by a security force.

11) Dust would be controlled by sprinkling roads and construction areas.

12) Existing roads and other accesses are expected to meet construction and maintenance needs for the new transmission lines (ER, Fig 3.9-2). Construction access roads would be restored to equal or better than original condition.

13) Chemicals would not be used in clearing land.

14) During transmission line construction, areas of high erosion potential would be given protection by limiting the use of heavy equipment and attempting to schedule activity during favorable dry weather.

15) Additional erosion control during transmission line construction (see 12) would consist of backfilling around tower bases immediately after erection, and grading the right-of-way followed by fertilization and reseeding as quickly as practicable.

16) Stream disturbance at transmission line crossings would be controlled by restricting construction vehicles to bridges and/or stream banks.

17) Relocation of the transmission line route would be considered in the event that current onsite archaeological studies reveal resources of value in the present routing. State and Federal agencies would be consulted as to National Register eligibility of any historic values identified (ER, Sec 3.9.6).

18) Construction would not be done in marshland; monument areas; scenic, recreational and historic areas; and national forests.

19) A fire prevention and control plan would be developed and applied.

20) Siltation impacts would be reduced by dredging and constructing behind temporary dams all such structures as intake channels that require disturbing the soil-water interface.

4.6.1.2 From ER Am I, Part II

1) Prior to construction, the construction plant manager would be provided with locations of critical ecological elements. On the ground inspections of species and community locations would be made semi-annually.

2) Construction of the intake, discharge, and barge facilities would be scheduled so as to mitigate environmental impacts.

4.6.2 Staff Evaluation

Based on its review of the anticipated construction activities and the expected environmental effects therefrom, the staff concludes that the measures and controls committed to by the applicant, as summarized above, are adequate to ensure that adverse environmental effects will be at the minimum practicable level with the following additional precautions:

a. The applicant should set aside an appropriate buffer zone around and up-slope of cover type vegetation 32 and 33 on the north edge of the site (ER, Sec. 2.7.1.3.4) to ensure their preservation and protection during the construction period.

b. Water discharged from settling basins must have less than 50 mg/ℓ of suspended solids and a pH of 6 to 9.

c. Work schedules staggered with those of other plants probably would be needed to avoid unreasonable congestion on Route 58 in Roane County.

d. Installation and removal of the cofferdams for the intake and the barge unloading facilities should be conducted during the August to March period unless there is evidence showing that those activities at other times would not adversely affect fish spawning.

e. Local costs for additional public services needed by construction workers and other project personnel and their families may exceed the local benefits from the project. These costs and benefits should be assessed by the applicants to determine the need for offsetting in-lieu-of-tax payments.

5. ENVIRONMENTAL IMPACTS OF PLANT OPERATION

5.1 LAND USE

Use of the site for the CRBRP would be consistent with the present industrial zoning for the site and adjacent land on the Oak Ridge reservation. Dedication of the land as a site for the plant represents an improved use of the land, which is presently forested.

Results of the University of Tennessee onsite archaeological investigations will be made available to the public (Section 2.3). Indian artifacts on the site are south of the proposed plant and would not be disturbed. Family members would continue to have access to the Hensley cemetery which is also south of the plant location. Proof of family membership to plant security personnel could be an inconvenience to some cemetery visitors such as those coming from a distance and not familiar with plant security. The staff's opinion is that plant operation would have essentially no impact upon other archaeological and cultural values since they are at sufficient distances away. The State archaeologist's opinion is that the applicant has given adequate consideration to archaeological resources. The State Historic Preservation Officer concurs that no properties of historic interest remain in the area (Appendix C).

The plant would have an insignificant adverse visual impact upon the area. Structures would be partially visible from Gallaher Bridge and scattered residences south of the river. Building finishes would harmonize with each other. Ridges and hills would provide a natural screening.

Cooling tower fogging and icing are expected to have insignificant effects upon local transportation routes (Section 5.3.3). Cooling tower noise at the 2200 ft minimum exclusion distance would be about 52 dBA (ER, Sec 5.1.8.4), already somewhat below the 55 dBA threshold for outdoor annoyance (EPA, 1974). There would be no noise problem in the surrounding areas from operation of the plant.

5.2 WATER USE

Plant operation would result in the consumptive use of 10 cfs of river water, about 0.2% of the annual average river flow rate. During the infrequent periods of no flow (the most severe was 29 days, 10 years ago) the consumptive use would represent well under 0.1% of the capacity of the Watts Bar Reservoir, for a 29-day no-flow period.

The most severe condition is unlikely to occur since any potential long periods of no release at Melton Hill Dam would be coordinated by TVA with CRBRP requirements (ER, Sec 2.5.1.3). The staff's opinion is that river water consumption by the plant would represent a small, justifiable diversion with negligible effect on downstream uses including the ORGDP intake at CRM 14.4.

Chemicals released by the plant would be diluted to insignificantly low concentrations several miles above the nearest downstream uses of the river for public water supplies at Lenoir City and Harriman, 10 and 11 miles away (Section 5.4.1).

The staff's opinion is that groundwater supplies would not be affected. Supplies on the south side of the river would not be influenced by plant operation, since groundwater flow is toward the river from both sides. There would be no wells and, therefore, no consumptive use on the site. Liquid and solid waste would not be discharged to onsite land (Section 3.6 and 3.7), except for a small amount of cooling tower drift (Section 5.3.3), resulting in no measurable effect on groundwater.

Plant operation would have no effect on fishing and navigational use of the river. Only 1% of the commercial catch from Watts Bar Reservoir was taken within 10 miles of the site in 1972. Only one sport fishing party per day was observed during the base line monitoring (Section 2.7.2). The main channel is near the opposite shore and would not be influenced by the plant (Figure 3.13).

As discussed in Section 3.7, sanitary sewage discharges would meet all applicable standards and would have no significant effect on the river's water quality.

5.3 HEAT DISSIPATION SYSTEM

5.3.1 Water Intake

5.3.1.1 Impingement

The intake system would consist of two perforated pipes placed about 2 ft above the river bottom. Each pipe, 3 ft in diameter and 18 ft long, would be capable of handling the entire plant water requirement. Passage of debris and aquatic biota past the pipes will be facilitated by aligning the pipes with river flow. Several aspects of the system should help reduce fish impingement and entrapment: 1) low intake velocities (0.3 fps through the perforations when both pipes are operating or 0.5 fps when only one pipe is operating) that would be relatively uniform due to internal sleeving of pipes; 2) clear escape pathways in all directions except directly into the perforations (about 3/8 in. dia.); 3) low approach velocities (0.12 fps at 3/4 in. distance); and 4) elimination of need for trash racks or vertical traveling screens (ER, Sec 3.4 and 10.2).

The ability of fish to maintain their position in water currents varies with species, size, water temperature, and dissolved oxygen. There are three types of swimming speeds: 1) cruising speed - maintained for hours, 2) sustained speed - maintained for minutes, and 3) darting speed - single effort, not sustained. Fish normally use their cruising speed for long-distance movement such as migration, sustained speed for locomotion through difficult areas, and darting speed for feeding or escape. Figure 5.1 shows relative swimming speeds of some fish species found in Clinch River (Bell, 1973). For most freshwater fishes, the darting speed is about ten times the body length per second (Gray, 1957). A few species have sustained speeds almost equally fast. Smallmouth bass fry (Micropterus dolomieui) 20-25 mm (0.065-0.08 ft) long, acclimated between 5 and 30°C, have sustained speeds ranging from 0.16 to 1.02 fps depending on water temperature (Larimore and Deuver, 1968). Striped bass (Morone saxatilus) approximately 25-40 mm (0.08-0.13 ft) long can maintain themselves in currents of 1 fps (Kerr, 1953). Based on the swimming speeds of white crappie (Pomoxis annularis) and channel catfish (Ictalurus punctatus) a maximum approach velocity of 0.75 fps has been recommended for some power plants (Moyer and Raney, 1969). To avoid significant loss of organisms through impingement or entrainment, approach velocities at the water intake generally should not exceed 0.5 fps (Jensen, 1974).

At the plant only organisms that cannot withstand the intake current and that would not pass through 9.5 mm perforations are expected to be impinged on the intake pipe. Such susceptible organisms would consist mainly of fish larvae and weakened or stressed juvenile and adult fish.

The paucity of data on the swimming speeds for the relatively large number of fish species in the vicinity prohibits a quantitative assessment of impingement losses. An estimate was made using the following conservative assumptions.

- Susceptible larvae and juveniles uniformly distributed throughout the water column,
- All fishes remain in the river throughout their periods of susceptibility,
- An average low river flow of 4300 cfs for spring and early summer months, which would tend to concentrate susceptible fishes to maximum densities,
- Maximum intake pumping rate of 22.3 cfs (10,000 gpm),
- Impingement mortalities of 100%, and
- All susceptible fishes impinged and none entrained.

Impingement losses are estimated to be 0.5% of the susceptible fish passing the perforated pipes, based upon the plant water intake as a percentage of the river flow at the plant. The hydrodynamics of the perforated pipes and the low approach velocities should reduce further the impingement losses. The staff concludes that impingement would not be a problem at the CRBRP.

Since there would be no trash racks and conventional intake traveling screens, trash rack debris and screen washings are not a consideration. The applicant stated that the perforated pipes would be fitted with a back flush cleaning system. Weekly back flushing would be increased to a daily frequency for slack water conditions. The applicant plans a model study to determine best methods to prevent interception of large pieces of debris. If need for a deflection device such as a protective dolphin is indicated, the study would consider movement of bottom sediment caused by river flow past the deflection device (ER, Am I, Part II, C15).

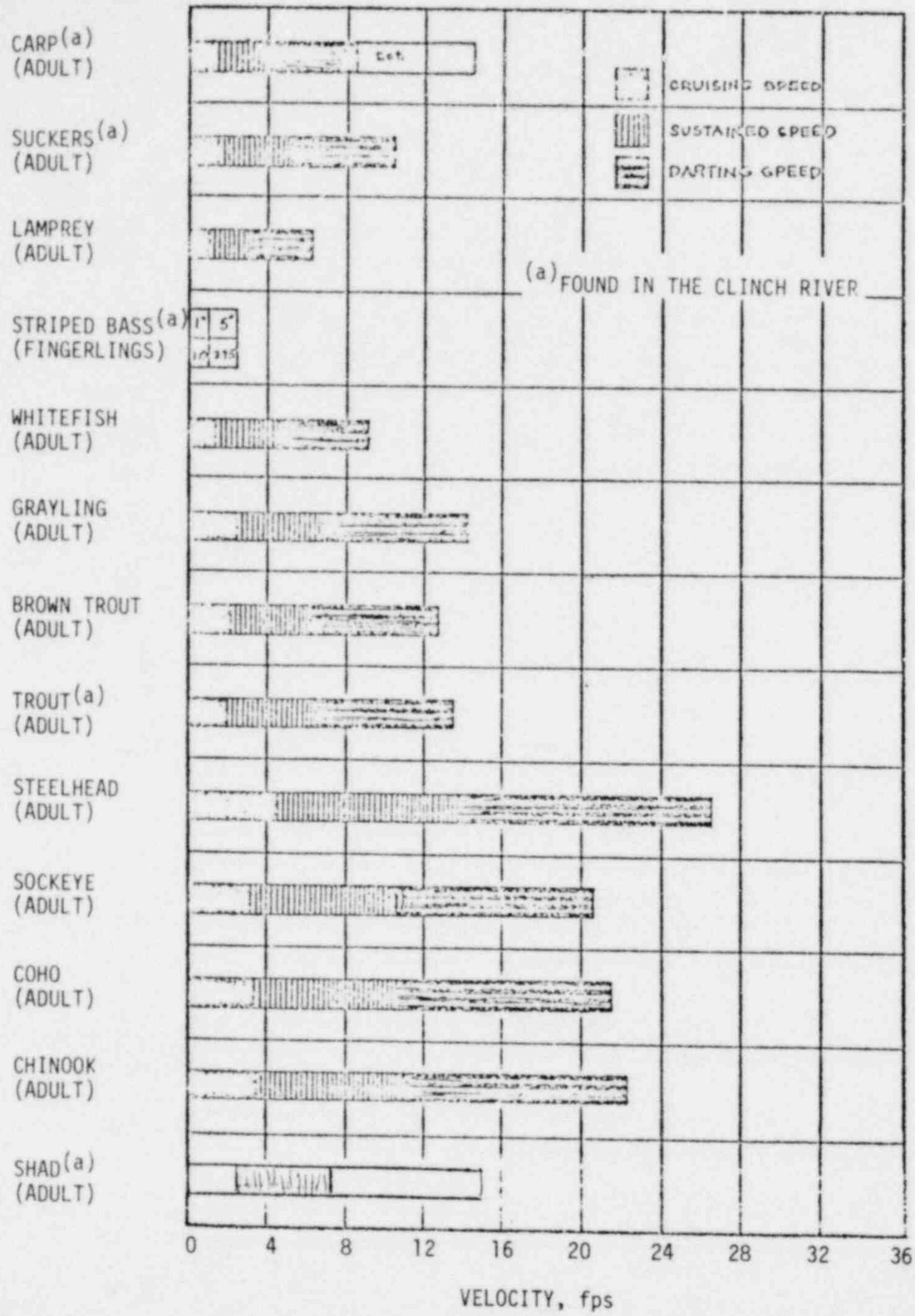


FIGURE 5.1 Fish Swimming Speeds (Bell, 1973)

A potential problem with the intake system is the clogging of intakes by the Asiatic clam (Corbicula). Dead spaces and areas of very low velocities within the perforated pipes may cause Corbicula larvae to settle out, become attached, and clog the pipes. Partial obstruction of the pipes and perforations would tend to increase approach and intake velocities and the potential for greater impingement and entrainment losses. Secondly, there would be an impact associated with the cleaning of the pipes. The applicant is investigating several design features to preclude any potential problem: 1) chlorination of lead-in pipes, 2) use of anti-fouling paint on the pipes, and 3) scrubbing the intake pipes either in place or reconditioning them out of water. Normal intake pipe maintenance would include back flushing, in-place scrubbing by scuba diver, and removal of sections for major repair. During the first year of operation at least one routine inspection of the water intake would be made by scuba divers (timed for Corbicula infestations). One or more sections of the pipe would be removed and inspected (ER, Am . Part II, C17 through C19). The staff concludes that the applicant's maintenance plans are adequate to prevent any significantly adverse effects. Technical specifications, developed at the plant operating license stage, would include monitoring to identify any problem at the intake requiring correction.

Entrapment results from the creation of areas within an intake structure where fish may congregate and be denied free passage to other parts of the river. Since the proposed perforated pipe intake design does not require intake forebays or other design features that could entrap fish, entrapment is not expected by the staff.

5.3.1.2 Entrainment

Phytoplankton, zooplankton, drift invertebrates, ichthyoplankton (fish eggs and larvae), and other organisms incapable of avoiding the intake velocities and yet small enough to pass through the 9.5 mm (3/8 in.) pipe perforations would be subject to passage through the plant cooling system (entrainment). Entrained organisms would be exposed to a sudden maximum temperature rise of about 16.7°C (30°F) across the condensers. In addition, they would experience the physical and chemical stresses of pumping and passing through the cooling tower before return to the river. Since most entrained organisms would be killed, the staff assumes 100% mortality for all entrained organisms.

The applicant estimated entrainment mortalities based on the maximum intake pumping rate of 22.3 cfs (10,000 gpm) as a percentage (<0.5%) of the average monthly summer discharge from Melton Hill Dam of 4800 cfs and the average winter discharge of 5100 cfs and concluded that entrainment losses would not be significant. The staff made an independent analysis using average and low-flow conditions at the plant. Based on average monthly releases from Melton Hill Dam for the past 10 years, average flow is about 4800 cfs and low flow 1000 cfs unless Melton Hill Dam should be shut down. The special condition (29 days of extended zero discharge) is not anticipated in the future, but if it should occur, the applicant stated that Melton Hill Dam releases would be regulated to meet plant requirements (ER, Sec 2.5.1.3 and Am I, Part II, C10).

The entrained phytoplankton, zooplankton, drift invertebrates and ichthyoplankton all would suffer the same mortalities. Based on the fraction of total river flow withdrawn by the plant, at a river flow of 4800 cfs, the average loss would be 0.46% of the entrainable organisms; under 1000 cfs low flow conditions, the maximum loss would be 2.2% (for assumptions, see Table 5.1).

Phytoplankton net weight biomass losses per day based on mean chlorophyll a concentration of 3.8 mg/m^3 and a maximum pumping rate of 22.3 cfs would be 34.5 kg/day or 76 lb/day; whereas, under minimum pumping rate of 3.7 cfs (40% load factor) the minimum operating losses would be 5.7 kg/day or 12.5 lb/day. For the zooplankton organisms the maximum biomass losses would be 17 g/day or 0.04 lb/day based on biomass densities of 250 μg/ℓ; whereas, the minimum losses would be 2.8 g/day or 0.01 lb/day. Since biomass estimates have not been made for ichthyoplankton, the number of eggs and larvae lost per day were calculated based on maximum density found ($0.48/m^3$) from March through August 1974. The maximum and minimum losses would be 26,000/day and 4500/day, respectively. Note that out of the 310 ichthyoplankters collected, 95% were unidentified fish eggs, of which a large number may have been spawn of coarse fish whose loss would not affect seriously the presently utilized fishery resources of the area, and 5% were larvae (13 sucker and 1 sauger).

Table 5.1 summarizes the estimated entrainment losses and underlying assumptions. The estimated maximum, minimum and average entrainment losses derive from baseline information gathered from March through October 1974, a period of generally higher aquatic production than during winter. Consequently, use of spring and summer standing crop measurements for calculating annual entrainment losses probably would give inflated loss estimates. Organisms killed in the cooling tower system and returned to the river may become part of the food web. That is especially true for phytoplankton because the same amount of primary produced organic carbon that passes through the plant should still be retained within the food web for the ecosystem. The model used to predict entrainment losses assumed uniform distribution of entrainable organisms, which usually is not the case in aquatic ecosystems. Plankton often tend to occur in patches and many larval fishes tend to school. Since the minimum depth of the perforated pipes from the water surface would be 9 ft, the potential is good for not drawing water from the photic zone where concentrations of entrainable organisms may be highest. Daily ichthyoplankton losses reflect only the season of availability, usually March through August, and are not average daily losses throughout the year. If the fecundity rates of the individual fish species and their seasonality are placed in perspective, average daily numbers lost probably would be very low when compared to the total available in the ecosystem.

In summary, entrainment losses would be small both as to numbers, 2.2% or less of the organisms passing by the plant, and as to biomass, as shown in Table 5.1. The staff concludes entrainment losses would have an insignificant impact on the aquatic ecosystem in the vicinity of the plant.

TABLE 5.1 Summary of Estimated Entrainment Losses

Organisms	Ave. Loss (%)	Max. Loss (%)	Max. Loss (Wt. or No.)	Min. Loss (Wt. or No.)
Phytoplankton	0.46	2.2	34.5 kg/day (76 lb/day)	5.7 kg/day (13 lb/day)
Zooplankton	0.46	2.2	17.1 g/day (0.04 lb/day)	2.8 g/day (0.01 lb/day)
Drift Invertebrates	0.46	2.2	-	-
Ichthyoplankton	0.46	2.2	26,000/day	4500/day

Assumptions:

1) Organisms susceptible to entrainment are uniformly distributed throughout the water column.

2) Average river flow of 4800 cfs with low-river flow of 1000 cfs,

3) Maximum pumping rate of 22.3 cfs with minimum rate of 3.7 cfs,

4) 100% entrainment mortalities,

5) All susceptible organisms are entrained and none impinged.

6) Percent losses are based on maximum pumping rate of 22.3 cfs with average and low river flow conditions.

7) Weight or number losses are based on maximum and minimum pumping rates.

5.3.2 Water Discharge

5.3.2.1 Thermal Plume Characteristics

To predict river temperature rise induced by plant blowdown discharge, a 1:12 physical model was constructed. Since periods of no flow due to zero release from Melton Hill Dam would result in the greatest potential thermal impact (Sec 2.5), the induced temperatures in the near field of a near-stagnant ambient condition were measured in the model. Four cases were analyzed: two typical cases (winter and summer) and worst cases (winter and summer). Conditions are given in Table 5.2.

TABLE 5.2 Conditions for Physical Model Cases

	Ambient River					Plant Discharge				Jet, Initial		
Cases	Water Temp (F°)	Flow Rate (cfs)	Velocity (fps)	Pool Elevation[d] (ft MSL)	Stratification	Atmospheric Wet Bulb (°F)	Blowdown Temp (°F)	Blowdown Flow[h] (gpm)	Blowdown Flow[h] (cfs)	Temp Differential at Jet (F°)	Jet Velocity (fps)	Distance to Surface Jet Diameter
Winter, Typical (Jan/Feb/Mar)	43.9[a]	5338[c]	1.39	736	No	43.3[e]	74.9[a]	2500	5.57	31.0	15.96	7.5
Summer, Typical (Jul/Aug/Sep)	65.7[a]	4777[c]	0.63	741	No	73.2[a]	89.3[a]	3240	7.22	23.6	20.68	15.0
Winter, Worst (Jan)	33[b]	~650	0.17	735	No	56.2[f]	79.8[g]	2810	6.26	46.8	17.93	6.0
Summer, Worst (Jun)	78[b]	~1300	0.17	739	Yes	74.4[f]	89.6[g]	3280	7.31	11.6	20.94	12.0

(a) ER Table 3.4-4
(b) CRM 21.6 data, 6/62-9/72
(c) ER Table 2.5-3
(d) ER Table 2.5-5
(e) ER Table 3.4-3
(f) Bull Run Steam Plant Data, 1/70-12/73
(g) ER Figure 3.4-2; account taken of cooling effect of makeup flow.

Estimated river surface areas that would be encompassed by the 1° and 2°F plant isotherms are given in Table 5.3. Table 5.4 gives maximum temperatures at the surface and mid-depth induced by each of the four cases. Table 5.5 gives the estimated percent of river cross-section that would be occupied by the 5°F and 2°F plant isotherms (ER, Am I, Part II, D8).

TABLE 5.3 Estimated Areas Inside Surface Isotherms

Case	Area of 1°F Isotherm (ft^2)	Area of 2°F Isotherm (ft^2)
Winter		
Typical[a]	2,200	0
Worst[a]	43,000[b]	4,300[b]
Summer		
Typical[b]	200	0
Worst[b]	0	0

(a) See Table 5.2 for river water temperature and flow rate, and temperature differential at outfall jet.
(b) Estimated from extrapolated dimensions (length and width) of areas enclosed by isotherms.

TABLE 5.4 Predicted Maximum Temperatures

Case	Surface Temperature Increase °F	Surface Temperature °F	Mid-depth Temperature Increase °F	Mid-depth Temperature °F
Winter				
Typical[a]	1.9	45.8	2.9	46.8
Worst[a]	4.8	37.8	5.8	38.8
Summer				
Typical[a]	1.3	67.0	1.9	67.6
Worst[a]	0.8	78.8	1.0	79.0

(a) See Table 5.2 for river water temperature and flow rate, and temperature differential at outfall jet.

TABLE 5.5 Estimated Part of River Cross-section Occupied by 5°F and 2°F Isotherms

Case	5°F Isotherm	2°F Isotherm
Winter		
Typical[a]	negligible	less than 8%
Worst[a]	less than 8%	no more than 30%
Summer		
Typical[a]	negligible	less than 6%
Worst[a]	negligible	negligible

(a) See Table 5.2 for river water temperature and flow rate, and temperature differential at outfall jet.

Based upon physical modeling the thermal change produced by the discharge would be small. All cases suggest that the submerged plant jet would mix rapidly. Beyond a short distance, the heated area would extend from the river bottom to the surface. Vertical mixing would progress so quickly that a temperature rise of more than 2°F at the surface would occur at a maximum of 250 ft from the discharge pipe under hypothetical winter worst conditions. Model results also show that the

2°F isotherm would encompass no more than 30% of the river's cross-sectional area. In every model case the area enclosed at the water surface by the 2°F isotherm did not exceed 0.1 acre. The acreage also would not be exceeded under design capability operation with discharge temperatures a few degrees above ambient. Figures 5.2 and 5.3 represent the thermal plumes for typical winter and summer conditions. The small sizes of the plumes are evident (ER, Am I, Part II, D8d).

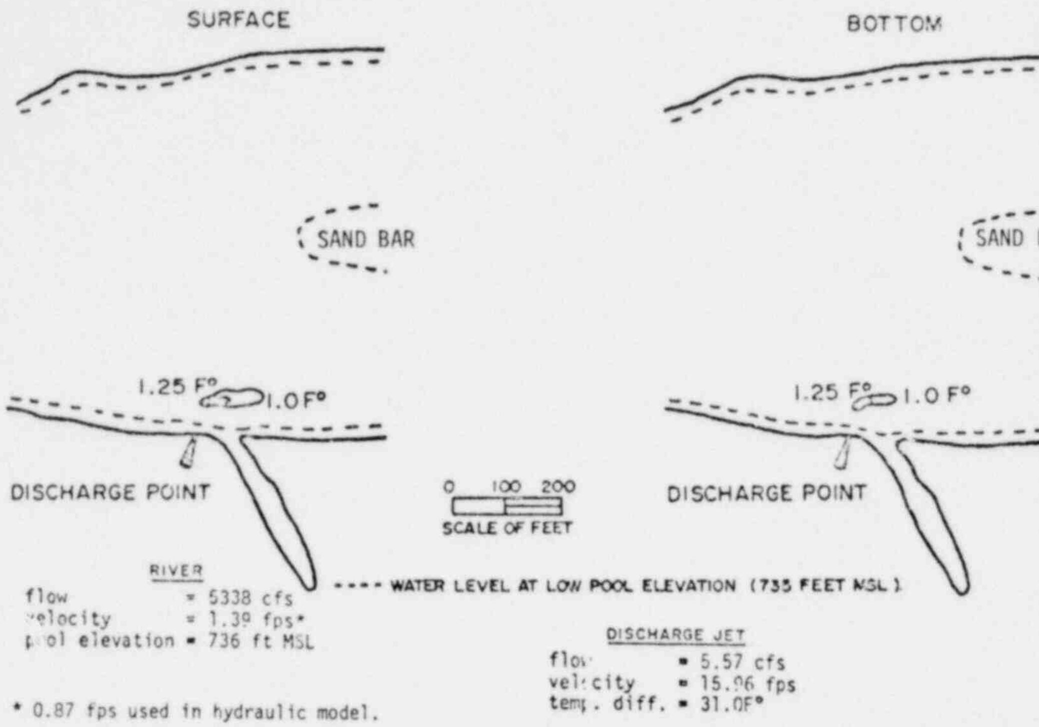


FIGURE 5.2 Thermal Plumes, Winter Typical
(ER, Am I, Part II, D8, p A1-197)

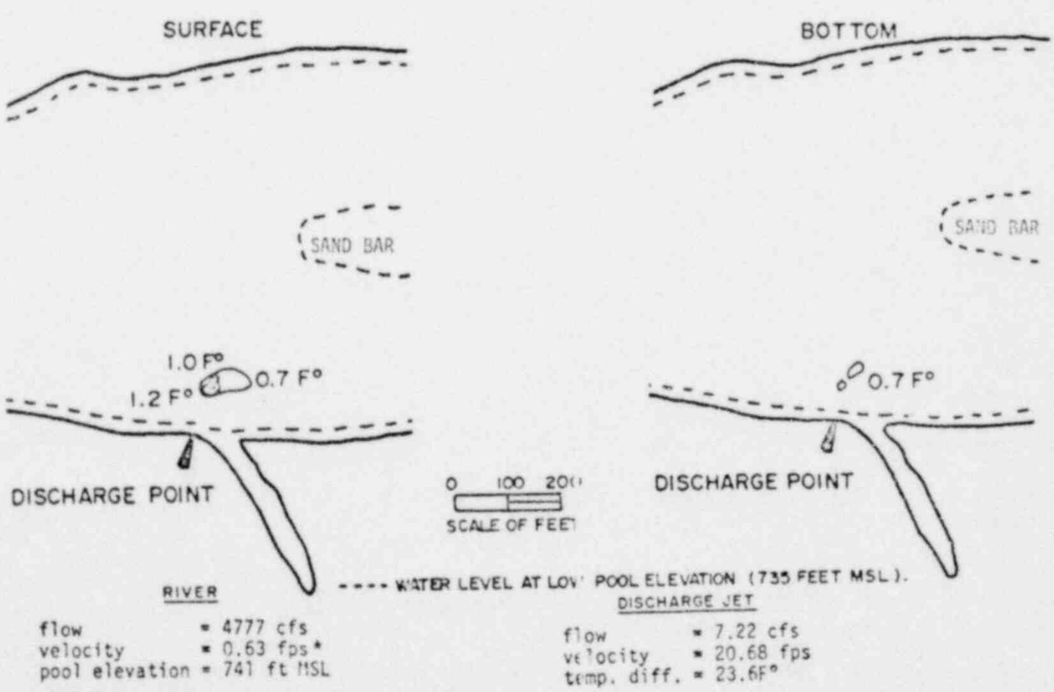


FIGURE 5.3 Thermal Plumes, Summer Typical
(ER, Am I, Part II, D8, p A1-198)

The staff performed an independent analysis of the submerged thermal plume using a three-dimensional model (Baca, 1971). Three cases were modeled for the purposes of cross-checking the applicant's predictions, namely: summer typical, winter typical, and winter worst. Winter worst would produce greater change than summer worst (Table 5.5). The data used in the physical model (Table 5.2) were used in preparing the model input data for the three cases. As illustrated in Figure 5.2, the mathematical model results show excellent agreement with the data developed from the physical model study, for the summer and winter typical conditions. The comparisons for the winter worst conditions show poor agreement between mathematical and physical model results; the mathematical model predicts a more rapid dilution. The gradual dilution predicted by the physical model probably is the result of thermal buildup in the flume. Thermal buildup problems commonly occur in flume experiments using relatively small cross-flow velocities, because of the finite size of the basin and the time required for the thermal field to reach the steady state. Consequently the staff believes that the physical model results for the winter worst conditions are very conservative in estimating the rate of dilution. Table 5.6 presents the temperature differentials for the plume centerline and the associated volumes predicted by the staff's mathematical models.

Based upon the small size of the thermal plume (less than 200 ft) and the more than 1.5-mi distance between intake and discharge, the staff's opinion is that recirculation would not likely occur even under extended periods of no flow or reverse flow. Recirculation with the plume from the Kingston plant, 9 miles distant, would be even less likely.

Tennessee water quality standards apply to measurements made at mid-depth after reasonable mixing. Maximum temperatures at such a point may not exceed 86.9°F and maximum temperature differential must be less than 5.4°F. However, a reasonable mixing zone has not been specified by the applicant or the regulating agencies. Determining whether the proposed thermal effluent would comply with the Tennessee Water Quality criteria is not possible until a "reasonable mixing zone" is defined (General, 1971).

5.3.2.2 Thermal Plume Effects

There is little evidence that the plant's thermal discharge would have a measurable effect on river biota. Even if the very unrealistic assumption of 100% mortality is made for organisms passing through the 2.5°C surface isotherm, less than 8% of the biota passing through the plume during worst case winter conditions would be lost, and less than 1% for worst case summer conditions. Exposure to temperature increases greater than 2.5°C would have a duration of less than 60 seconds.

Phytoplankton would sustain little damage if temperatures do not exceed 34°C (93°F) (Patrick, 1969). Zooplankton can survive ΔT as high as 20°C (36°F) (Davies, 1974). A temperature increase of 7.2°C (13°F) produced no harmful effects upon crustaceans and diptera larvae (Markowski, 1959). Stonefly, caddisfly and mayfly larvae acclimated to 10°C (50°F) showed 96 hr median tolerance limits ranging from 21-30°C (70-86°F) (Nebeker, 1965). Temperatures above 30°C (86°F) are not suitable for many benthic organisms (Jensen, et al., 1969). (Benthic macroinvertebrates could potentially be affected to a greater degree than other organisms because of their extended exposure to the thermal plume.) However, the 25.6°C (78°F) maximum river temperature recorded in the plant vicinity plus a ΔT of 2.5°C (4.5°F) gives a potential maximum temperature of 28.1°C (82.6°F), below temperatures reported harmful for most organisms.

Ichthyoplankton generally are more sensitive to temperature differences than most other planktonic organisms. Fish egg temperature tolerances are generally lower than those for fry or adults (Levin, et al., 1970). Most fish in the plant vicinity have demersal or adhesive eggs normally not distributed in the water column. Ichthyoplankton presence in the river is seasonal (usually April through August) and consequently would not be subject to winter thermal regimes.

Fish are able to detect and avoid temperature gradients in both vertical and horizontal planes and generally will avoid lethal temperatures (Alabaster, 1969). Freshwater fish can detect temperature differences of less than 1°C (Levin, et al., 1970). At Lake Monona, WI, fish avoided a power plant thermal discharge area when temperatures reached 35°C (98°F); however, several species of fish maintained themselves at selected temperatures within the mixing zone (Neill, 1970). The majority of 70 Lake Michigan fish collected from a discharge plume had body temperatures lower than that of the discharge water (Spigarelli, et al., 1974). The investigators concluded that the fish were regulating their movement between the warm and cool areas around the heated effluent or just recently had moved into the heated water area. Most of the fish found in the Clinch River are warm water species. The recommended provisional maximum temperatures for various species of warm water fishes, including some found near the plant, are given in Table 5.7.

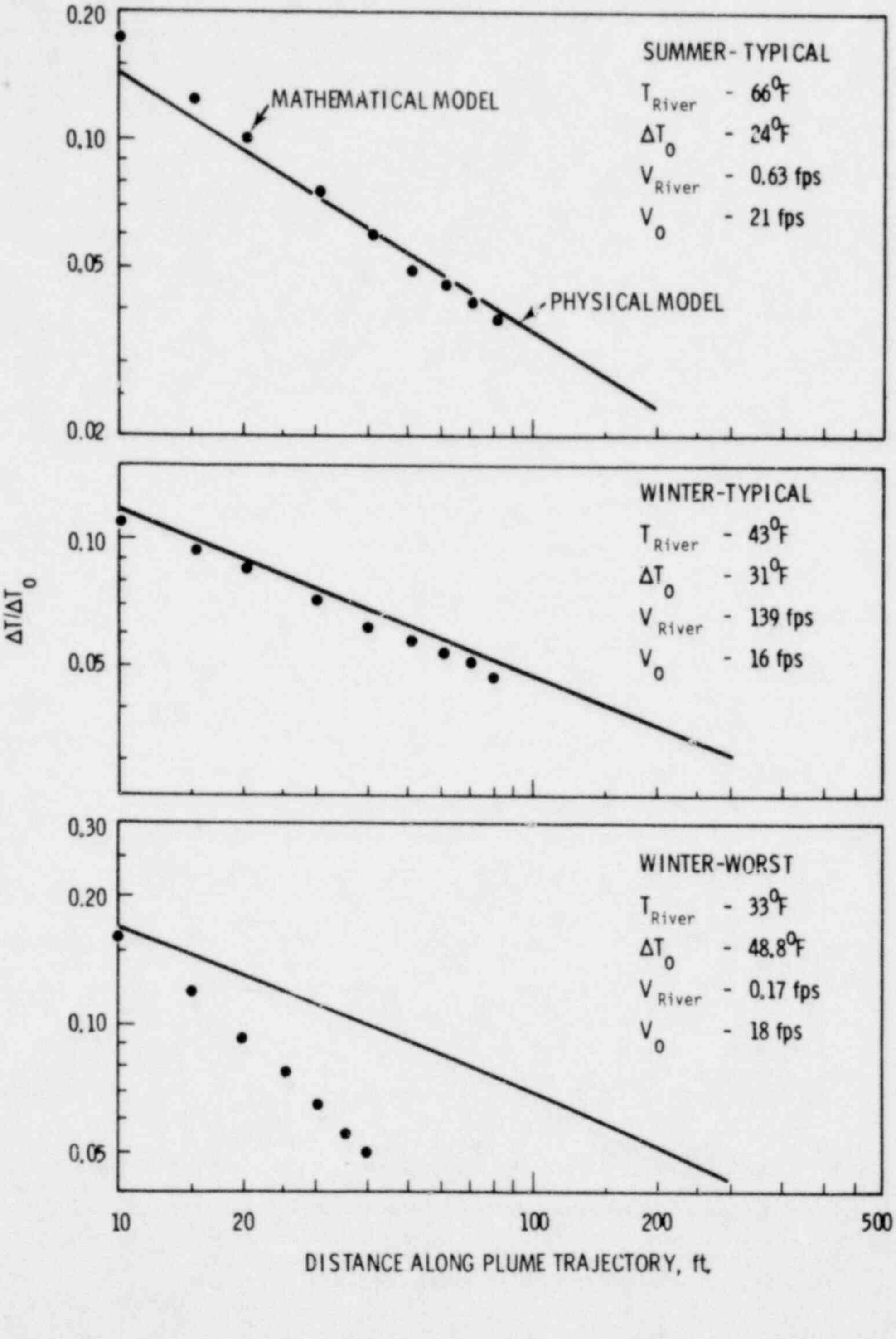


FIGURE 5.4 Comparison of Physical and Mathematical Model Studies

TABLE 5.6 Plume Predictions

Vertical Distance ft	Summer Typical ΔT °F	Summer Typical Cumulative Plume Volume ft^3	Winter Typical ΔT °F	Winter Typical Cumulative Plume Volume ft^3	Winter Worst ΔT °F	Winter Worst Cumulative Plume Volume ft^3
4.00	24.0	<1.0	31.0	<1.0	46.8	<1.0
4.01	7.3	7.8	6.2	1.3	14.0	7.6
4.03	5.4	20.7	4.6	32.8	10.5	19.2
4.05	4.5	34.7	4.2	50.6	9.1	30.9
4.07	4.1	47.7	3.7	71.3	8.5	38.3
4.10	3.7	63.2	3.4	107.1	7.5	56.1
4.30	2.6	191	2.6	275	5.3	159.0
4.50	2.2	312	2.3	425	4.4	298
4.70			2.2	471	4.0	375
5.00	1.8	630	2.0	775	3.5	575
6.00			1.7	1400	2.8	1080
7.00	13	1790	1.6	1570	2.5	1630
8.00			1.4	2500*	2.3	2100*
9.0	1.1	2910				
12.0	1.0	4570				
14.0	.9	5640*				

*Volume of plume when it reaches water surface.

TABLE 5.7 Provisional Maximum Temperatures Recommended as Compatible with the Well-Being of Various Fish and Their Associated Biota (FWPCA, 1968)

Maximum Temperatures (°F)	Well-Being Parameter	Fish Species
93	Growth	catfish, gar, white bass, buffalo, carpsucker, gizzard shad
90	Growth	largemouth bass, drum, bluegill, crappie
84	Growth	perch, walleye, sauger
80	Spawning, Egg Development	catfish, buffalo, gizzard shad
75	Spawning Egg Development	largemouth bass, white bass
48	Spawning, Egg Development	walleye, sauger

Table 5.8 lists the estimated effects of increasing water temperatures on the fish community of the Tennessee River (Bush et al., 1973). The Clinch River empties into the Tennessee River about 15 miles below the plant. With prolonged exposure to 32°C (89.6°F), the temperature that seems to be critical for most of the fish species, 51% of the fish species would be expected to be lost from the system. The maximum temperature predicted would be 37.1°C (98.8°F) at the point of discharge under extreme conditions (no river flow and highest water temperature and atmospheric conditions). Temperatures lethal to fish potentially could be reached at the effluent discharge point and in the extremely small area around it, but fish would need to remain in the near vicinity of the effluent discharge for an extended period of time before they would suffer mortalities from the elevated temperatures. Their ability to maintain themselves in that area for long periods is questionable because of the high current velocity (20 fps) of the plant discharge. Although fish are attracted to the discharges of thermal power plants, creating productive sites for sports fishing, the small increase in temperature over a very limited area is not expected to enhance sport fishing near the CRBRP.

TABLE 5.8 Estimated Effects of Increasing Water Temperature on the Fish Community of the Tennessee River[a] (Bush et al., 1973)

°C	°F	Species Within Preferred Temperature Range %	Species in Suboptimal Temperature Conditions[b] %	Species Expected to be Lost from the System %	Species Expected to be Lost from the System
12	53.6	100	0	0	
14	57.2	99	1	0	
16	60.8	99	1	0	
18	64.4	97	3	0	
20	68.0	96	4	0	
22	71.6	72	28	0	
24	75.2	61	39	0	
26	78.8	51	48	1	Brook trout
28	82.4	21	78	1	
30	86.0	15	81	4	Shovelnose sturgeon, brown trout
32	89.6	6	43	51	Skipjack herring, rainbow trout, blue sucker, smallmouth buffalofish, largemouth buffalofish, highfin carpsucker, carpsucker, spotted sucker, hogsucker, silver redhorse, shorthead redhorse, river redhorse, black redhorse, golden redhorse, white sucker, longnose dace, white bass, walleye, sauger, log perch, gilt darter, dusky darter, speck darter, greenside darter, Tennessee snubnose darter, Johnny darter, goldstripe darter, banded darter, redline darter, spottail darter, Cumberland fantail darter
34	93.2	1	30	69	Stoneroller, golden shiner, bluntnose minnow, river chub, blotched chub, spotfin chub, bigeye chub, common shiner, popeye shiner, mimic shiner, Tennessee shiner, silver shiner
36	96.8	0	12	88	Muskellunge, blue catfish, channel catfish, flathead catfish, brown bullhead, stonecat, smallmouth bass, black crappie, white crappie, warmouth, longear sunfish, orangespotted sunfish, redear sunfish
38	100.4	0	1	99	Gizzard shad, threadfin shad, carp, largemouth bass, spotted bass, rockbass, bluegill
40	104.0	0	0	100	White streaked killifish

(a) Based on preferred and lethal temperature data for adult and juvenile fish. Where specific data for a species were unavailable, data from closely related species were used.

(b) The temperature range above the preferred temperature and below the lethal temperature, a range in which most species of fish are considered stressed, with adverse effects on activity, growth and survival.

In summary, the staff judges the impacts from the thermal discharge upon the aquatic biota to be insignificant. The highest isotherm predicted with definable boundaries, 2.5°C (4.5°F), can occur only during the winter season under no river flow conditions and would encompass <8% of the river's cross-sectional area and <0.01 surface acre of water. Due to the small size of the plume, small rise in temperatures, small quantity of water discharged (~7 cfs) and short exposure time (<60 sec), the impacts from the thermal discharge would not produce a significant change on the aquatic ecosystem. However, the applicant has stated that water flow by the plant would be regulated in the future to meet plant requirements and to prevent extended periods of no river flow. Detailed information on how maintenance of river flow near the CRBRP would be coordinated with the release of water at Melton Hill Dam has not been developed. After the plant begins operating, river flows should be monitored to identify potentially harmful periods of no flow.

5.3.2.3 Cold Shock

Cold shock is the thermal stress resulting from a rapid decrease in temperature that can occur immediately after plant shutdown. The most adverse result of cold shock would occur during the winter, when ΔTs are at their highest. Because the small area within the 2.5°C isotherm would not be able to support large numbers of fish, fish loss is unlikely to result from interruption of heated effluent.

5.3.2.4 Scouring

The effluent discharge was described in Section 3.4.3. Physical modeling of the discharge demonstrated that the plant would produce a localized scour hole. Under the four cases analyzed the area of the scour hole would be as follows: winter no flow, 7.2 m^2; winter average flow, 8.4 m^2; summer no flow, 6.4 m^2; and summer average flow 10 m^2. The scour hole would produce a permanent loss of habitat to the benthic macroinvertebrates. However, the staff concludes that the impact would not be significant due to the small area affected.

5.3.3 Atmospheric Heat Transfer

The visible plume from the cooling tower possibly could extend up to 6 miles from the site about 6% of time during plant operation. However, a large majority of the plumes probably would extend no more than 1.5 miles (ER, Am I, Part II, A2). The 684 MWt (0.61 x 1121 MWt) waste heat from the cooling tower would be comparable to the waste heat from the ORGDP (K-25) cooling towers (500 to 1500 MWt). Hanna (1974a) calculated that the visible plume from the K-31 and K-33 mechanical draft towers also could extend up to 6 miles. However, plumes of that length would occur with a natural cloud deck and not be very noticeable. At the K-25 location, the length of the visible plume is typically 100 to 200 meters (Hanna, 1974b). A typical plume rise range of 200 to 400 meters should occur for the various atmospheric stability classes (ER, App to Sec 5.2 and 5.3). Cloud development has been initiated by the K-25 cooling towers about 10% of the time (Hanna, 1974b). On one occasion, light snowfall extending many kilometers downwind of the towers was reported (Culkowski, 1962).

Major plume sources in the area of the plant include three mechanical draft cooling towers at K-25 2.5 miles from the site, and smoke plumes from the Kingston and Bull Run steam plants 9 and 15 miles from the site, respectively. Additionally, very small plume sources are located at X-10 and Y-12, on the reservation. The only interaction of plumes from those sources and the plant cooling tower plume would be from the K-25 towers. Only with a constant wind from the northern sector coupled with stable atmosphere could the K-25 plume reach lengths interacting with the plume at the site (ER, Am I, Part II, A1). Other sources are either very small (X-10 and Y-12) or at such great distance and height (Kingston and Bull Run) above the plant plume as to have negligible interaction.

The model for calculating plume length frequency employs a Gaussian equation for dispersion of water vapor and considers plume rises for various stability classes (Hanna, 1974c; Briggs, 1970 and 1974). Site meteorological data were used except for humidity data from Bull Run, northwest of the site. The model gives conservative results, specific for the CRBRP cooling tower.

The applicant estimated that fogging and possible icing conditions would occur about 11% of the time or approximately 40 days/yr (ER, Am I, Part II, A4). Based on this estimate, fogging conditions could occur at distances of 4.5 miles NE from the site for very short periods of time. Since natural fogging probably would exist already, the applicant's estimates are unrealistically high. Calculations of fogging for the K-25 towers predict that about 100 extra hours of fog per year would occur at distances of 100 to 200 meters from the towers when naturally occurring rain or fog is absent (Hanna, 1974a). No extra fog is predicted under the above conditions at distances greater than 2 km.

Fogging from the plant tower possibly could have some small effect on local transportation routes. Based on data supplied by the applicant (ER, Am I, Part II, A4), the staff concluded that the potential for fogging would exist 3.6 hr/yr and 2.4 hr/yr along Interstate 40 at Caney Creek and Gallaher Bridge, respectively. Additionally, the potential for fogging due to the plant tower will exist 2.4 hr/yr at ORNL. Monitoring fog and ice impact of tower operation would be a part of the technical specifications at the operating license stage.

Drift deposition was modeled using a diffusion type equation that includes the spatial rate of change in droplet concentration as a function of their radii, size changes due to evaporation or condensation, chemical concentrations, and atmospheric conditions (Roffman, et al., 1973). Plume height calculations used in drift calculations accounted for moisture in the plume and possible condensation (Hanna, 1972). Data collected at the site along with humidity data from Bull Run were used for input.

Drift from the cooling tower would have a composition similar to that of the circulating water. Based upon onsite meteorological data, a conservative drift rate of 0.05%, and a concentration of 375 mg/ℓ of total dissolved solids in the circulating water, worst-case deposition would be about 52 lb/acre/mo, or 620 lb/acre/yr, 0.3 miles to the northeast. Estimates of the mineral content of litter-fall range from approximately 500 lb/acre/yr for cedar glade areas to 1200 lb/acre/yr for white pine plantations (ER, Am I, Part II, B1). Thus the deposition from drift would add about the same amount of minerals normally returned to the soil surface each year in cedar glade areas and about half the minerals normally cycled in a white pine plantation through litter-fall. No account was taken of mineral runoff and leaching in the soil profile. Both processes would substantially reduce the mineral quantities accumulated in the soil from drift. Drift from the K-25 towers has been extensively investigated (Lee, et al., 1973, Shofner, et al., 1973, and Hanna, 1974a). Although the K-25 area towers have a rather large drift rate (0.08 to 0.12%) as compared to that anticipated for the CRBRP tower (0.005 to 0.008%) and somewhat near the same cooling capacity, measured effects of K-25 cooling tower drift can be used to estimate CRBRP drift effects on vegetation. Growth of tobacco beyond 600 m downwind from the tower base was almost unaffected, based upon measuring leaf sizes of this comparatively sensitive plant (Jallouk, et al., 1974). The staff concludes that drift deposition from the CRBRP tower would have no important effect on vegetation or fauna.

There would be no measurable increase in rainfall or icing due to plant drift, based upon none observed from K-25 using standard collection devices.

The staff's opinion is that the impacts from operating the mechanical draft tower would be regarded primarily as minor aesthetic and nuisance factors rather than health or safety problems.

5.4 OTHER NONRADIOLOGICAL EFFLUENTS

5.4.1 Impacts of Chemical Effluents

The chemicals that will be discharged in waste water to the river were discussed in Section 3.6. Table 3.2 cites maximum and average ambient concentrations, neutralized plant waste, sanitary waste, mass discharge and maximum concentrations in the river under no-flow conditions 30 ft and 200 ft downstream of the point of discharge. Most of the chemicals, after dilution under no-flow and maximum ambient concentrations, would be below levels reported to be toxic to aquatic organisms or below the concentration found in 95% of the U.S. waters supporting a good mixed fish fauna (McKee and Wolf, 1963 and Becker and Thatcher, 1973).

In the case of copper a 1 mg/ℓ discharge limit has been set for boiler and metal cleaning wastes from power plants (EPA, October 1974). Some authors have recommended concentrations as low as 0.02 mg/ℓ as the safe level for aquatic biota (McKee and Wolf, 1963). Under extreme conditions (no river flow and maximum river ambient), copper concentration 30 ft downstream (4.5°F isotherm boundary) would be 0.15 mg/ℓ; whereas, 200 ft downstream (2°F isotherm boundary) the concentration would be 0.06 mg/ℓ. At a distance of 300 ft downstream the concentration would be 0.015 mg/ℓ. At that point the plume would occupy <30% of the river's cross-sectional area under worst case conditions. The staff concludes that copper toxicity would not be a problem for two reasons. First, potentially toxic concentrations of copper could occur only in a 0.1 acre area. Secondly, only the extreme case would present a potential problem, which would be corrected by increased release of water from Melton Hill Dam.

Little is known about the toxicity of iron to fish. Its toxicity depends on a number of factors including its valence state, whether it is dissolved or in suspension and pH of the water. Toxicities have been reported from 0.1 mg/ℓ to 1000 mg/ℓ (Doudoroff and Katz, 1953). Because of the cooling tower's concentrating effect, iron concentration at the point of discharge would be 1.7 mg/ℓ under extreme conditions, giving 0.8 mg/ℓ and 0.7 mg/ℓ concentrations 30 ft and 200 ft downstream, respectively. The staff believes that iron would not be a problem because the area (<0.01 surface acre) and volume (<8% of river's cross-sectional area) are not large. The above concentrations are estimated for the most extreme case which, according to the applicant's plans, would not occur because of river flow regulation through water release at Melton Hill Dam.

The concentration of total suspended solids (TSS) in the blowdown for extreme conditions would be about 115 mg/ℓ (Table 3.5), and the increase above ambient (maximum concentration of 46 mg/ℓ) would be due to evaporation in the cooling system. The concentration of TSS at 30 ft and 200 ft downstream under extreme conditions would be 56 and 50 mg/ℓ, respectively. During zero flow conditions, some material may settle out downstream of the discharge pipe; however, the average discharge velocity should keep most of the solids in suspension. Spring flooding and other high water conditions would scour away any materials built up during low-flow periods and prevent any long-term net build-up of sediments. The staff concludes that TSS would not have adverse effects on the aquatic biota.

The condition that potentially may produce adverse copper, iron, and TSS impacts upon aquatic biota is the simultaneous occurrence of no river flow and maximum ambient concentrations of those materials. Periods of extended no flow are not expected because flow from Melton Hill Dam would be regulated to meet plant needs (ER, Sec 2.5.1.3 and Am I, Part II, C10). The technical specifications at the operating stage would require monitoring copper, iron, and TSS during plant operation in order to determine flow regulation needs for preventing potentially adverse impacts.

The biocide system was described in Section 3.6. Neither free available chlorine nor combined available chlorine would be discharged for more than 2 hr/day. The maximum release of free available chlorine would not exceed 0.5 mg/ℓ and the average would not exceed 0.2 mg/ℓ during the 2-hr period (EPA, October 1974). A chlorine residual of 0.2 mg/ℓ for 2 hr or less per day is considered acceptable for warm water fish species in the vicinity of power plant discharges (Brungs, 1973). The maximum discharge concentration of free residual chlorine would be 0.5 mg/ℓ. If the discharge concentration should exceed that value, plant discharge automatically would be shut off (Section 3.6). Because of evaporative qualities of cooling towers, reducing agents found in circulating water and intermittent discharges involving small areas, the staff concludes that the total residual chlorine concentrations would meet all Federal and State regulations and would not have significant effects upon aquatic biota.

5.4.2 Sanitary and Other Waste

The applicant's sanitary and other waste systems were described in Section 3.7. Based on a review of the proposed systems, the staff concludes that impacts from the sanitary and other waste effluents would have an insignificant effect upon aquatic biota. The systems are designed to meet the criteria of the Tennessee Water Quality Control Board. The treated effluents discharged would meet all applicable Federal and State regulations.

Plant chemicals would not be discharged on land, except in cooling tower drift (Section 5.3.3). Sewage sludge would be trucked for approved disposal offsite. Gaseous pollutants from emergency diesel generators and the diesel fire pump would be well within SO_2, NO_x, and particulate limits. Tennessee standards for nonprocess pollutants are based upon a plant's heat input to one or more stacks. Based upon CRBRP's 1.9 million Btu/hr release, the allowable emissions are more than three times expected plant emissions (Section 3.7.2: SO_2, 0.8 lb/hr (maximum 2-hr average) and particulates, 0.6 lb/hr (TN Dept of Public Health). NO_x standards apply only for heat outputs of 250 million Btu/hr and greater. Standards have not been set for nonprocess CO emission. The staff's conclusion is that no adverse environmental effects would result from operation of the diesel generators and the fire pump.

5.5 TRANSMISSION LINES

Insignificantly adverse visual impacts would result from the 3 miles of new lines on expansions of existing rights-of-way. The lines would be visible only from short distances along nearby highways serving the industrial area.

The applicant plans to control vegetation growth by mechanical cutting every 4 or 5 years at the 1-ft level and by limited use of Tordon 10K pellets, hand applied to occasional stumps (ER Am I, Part II, B2). Each year TVA's herbicide use practices are submitted to the Federal Working Group on Pest Management for official approval. Protective vegetation would be maintained along stream banks. After emergency maintenance, rutting would be repaired and disturbed drainage restored (ER Am I, Part II, G9).

The staff expects no adverse impacts from the hand application of Tordon 10K herbicide. Immediately after cutting brush, quail and other species preferring open areas would be favored. As the vegetation grows up, songbirds and game birds would be favored. Towards the end of the 4- to 5-yr maintenance cycle, the tall brush would discourage the species preferring open areas. There would be minimal impact on the 46 acres of presently unforested land, since the corridors would be maintained as an open shrubby area.

In the staff's opinion, the planned erosion control practices at stream banks and following emergency maintenance (Section 3.8) would minimize adverse impacts.

Ozone (O_3) can form in the air as a result of corona discharge around high-voltage transmission lines, particularly during wet weather. Ozone also occurs naturally, produced mainly by ultraviolet radiation and lightning discharges. Ozone is a major component of photochemical "smog". Ground-level ozone concentrations in areas distant from urban pollution generally range between 10 and 50 ppb (parts per billion) (Darley, 1966; Treshaw, 1970). The Environmental Protection Agency established the national primary air quality standard for oxidants as 80 ppb by volume (maximum arithmetic mean) for a 1-hr concentration not to be exceeded more than once per year (42 CFR 410). Ozone is known to be injurious to vegetation and animals (including humans) when concentrations exceed 50 ppb for prolonged periods (Stern). To date, however, there is no clear evidence that damage has occurred in the vicinity of high-voltage transmission lines. Analysis at two 500-kV transmission lines on a particular day in April 1972 indicated O_3 concentrations of 210 ppb at the edge of the right-of-way and 230 ppb at the center. "Background" concentration was given as 20 ppb. Two months later, measurements at the same site, a depression about 350 yards across, indicated a "background" ozone concentration of 12 ppb, with 22 ppb at the edge of the right-of-way and 25 ppb at the center. The authors attributed the high concentrations during April to a moderate temperature inversion (ORNL-4848, 1972). Corona effects and ozone production are known to increase in wet weather, which often prevails at the CRBRP site; however the staff anticipates no significant impact from operation of the 161 kV lines.

Transmission line operation creates potential for adverse effects from audible noise, corona, radio and television interference, and electrostatic induction. However, experience with 161 kV lines on the TVA system shows that the effects are minimal (ER, Sec 5.6). The staff expects no adverse impacts having any significant consequence.

5.6 COMMUNITY IMPACTS

Plant activity would represent a logical extension of other nuclear energy industrial activities on the Oak Ridge reservation. Employees of the plant would find many established residents relatively well informed about various aspects of nuclear energy, both in Oak Ridge and surrounding communities. CRBRP would blend easily into other projects familiar in some way to residents for many years. An additional nuclear based plant such as the CRBRP probably would find community acceptance in the area, assuming sufficient planning to maintain orderly growth and avoid undue congestion of public and private institutions. Potential physical impacts were discussed earlier in this chapter. Other impacts would bear upon economic conditions in local communities.

The applicant estimates an average work force of 275 employees during the demonstration stage. A multiplier of 0.75 (Section 4.1) leads to another 205 people employed in local service and manufacturing jobs in support of the CRBRP work force. The staff estimates that the new resident population would have the following composition:

Single adult workers	120	
Married adult workers	360	
Subtotal - Adult work force		480
Spouses		360
School aged children		290
Nonschool age dependents		70
Total population increase		1200

The increase in permanent population, therefore, is estimated to be 1200 people including 480 wage earners. The staff estimates that the new permanent population would require the facilities and services listed in Table 5.9. New services would not be provided in fractional quantities as tabulated. Communities generally wait until services are strained and then correct in a quantum jump, possibly over-correcting for a time.

TABLE 5.9 Community Services Required by Permanent Employment (Direct & Induced) Resulting from CRBRP Operation

Service or Facility	Factor	Required by New Population (1200 Persons)
School teachers	1/20 students	14 teachers
Other school staff	1/60 students	5 other school staff
Hospital beds	1/475 persons	2.5 hospital beds
Parks and playgrounds	1 acre/100 persons	12 acres
Library	1/25,000 persons	0.05 library
Fire stations	1/15,000 persons	0.08 fire stations
City employees	1/75 persons	16 city employees
Water treatment plant	60 gpd/person	72,000 gpd capacity
Sewage treatment plant	60 gpd/person	72,000 gpd capacity

The payroll effect of this population is estimated by the staff to be $46.8 million during the five-year demonstration period (Table 4.8), of which about $20 million would flow to the local economy. For the remaining plant life, the sum of the direct and induced payroll effect would be about $5.1 million/yr, with about $2.1 million flowing to the local economy. (All dollars are present value.)

5.6.1 Taxes

The project would not contribute directly to the tax base of the local area through the payment of property (plant and land) taxes or sales and use taxes on materials and supplies used in construction. That leaves only two taxing modes by which the project would help meet the increased public spending load in the local area as a result of the project: direct and indirect taxes from payroll and spending, and ERDA or TVA in-lieu-of-tax payments.

Taxes from Payroll Spending. The major source of tax revenue generated by the project would be the Tennessee State sales tax which is levied at a rate of 3.5% on designated items. Local communities can add to that collection an additional 1.5% maximum, which is returned to counties and often used for school systems support. For example, throughout Roane County, a 1% levy is assessed (except for Harriman, which uses a 1.5% rate), producing $775,000 in 1974, 9.26% of total county revenues (Budget, 1974). Similarly, in 1974, Loudon County collected $275,000, 6.4% of total revenues (Budget, 1975).

The staff's estimate of the present value of the total state sales tax generated from payroll spending by the direct and secondary workers associated with operation of the plant between 1984 and 1988 would be $688,000. If the maximum rate of 1.5% is applied, the present value of the local sales tax could be about $295,000. The state sales tax value is derived from the present value of the total payroll in 1983 through 1988 (Table 4.8) by assuming 42% of payroll spent on taxable items and a tax rate of 3.5%. The value is consistent with the allowance by the Internal Revenue Department of a $155/yr deduction for Tennessee sales tax for a family of 3 with an annual income of $10,500.

There would be other sources of tax revenues as a result of the CRBRP payroll. Gas taxes, hotel and motel privilege tax, cigarette taxes and liquor taxes are examples. The work force also would make some contribution to the real estate tax base either directly as property owners, or indirectly through the payment of rent. The effect of real estate taxes would depend on how much low tax base land is converted to high tax base land by construction of homes or apartments. The total value of such taxes is difficult to estimate because of the uncertainty of property assessment in the future.

In-Lieu-of-Tax Payments. The Supreme Court decision in the case of McCulloch vs Maryland (1819) firmly established the immunity of the Federal Government from taxation by the States. In practice, however, the Congress has recognized that the creation of a federal project on land formerly taxable by local government can create an inequity by reducing local tax base and federal agencies often have made some financial compensation in cases such as that of CRBRP. The Atomic Energy Act of 1954 and the Atomic Energy Community Act of 1955 establish the conditions for ERDA in-lieu-of-tax payments. The Tennessee Valley Authority Act of May 18, 1933, establishes a system of payments to states and localities affected by TVA projects. Presumably, one or both of those agencies could make some form of in-lieu-of-tax payment to the local area as compensation for burdens imposed over benefits received by the area from this project. The staff's opinion is that a study should be made to determine the magnitude of the payments that should be made and to whom they should be paid.

5.7 RADIOLOGICAL IMPACTS

5.7.1 Radiological Impact on Biota Other Than Man

5.7.1.1 Exposure Pathways

The pathways by which biota other than man may receive radiation doses in the vicinity of nuclear power plants are shown in Figure 5.5. Two comprehensive reports explain radioactivity in the environment and these pathways (NAS-NRC, 1971; Corner, 1971). Depending on the pathway being considered, terrestrial and aquatic organisms receive either approximately the same radiation doses as man or somewhat greater doses. Although no guidelines have been established to set acceptable limits for radiation exposure to species other than man, the limits established for humans generally are agreed to be conservative for other species (Auerbach, 1971).

5.7.1.2 Radioactivity in the Environment

The staff estimatedthe quantities and species of radionuclides expected to be discharged annually by the CRBRP in liquid and gaseous effluents. The estimates are given in Tables 3.3 and 3.4, respectively. Their basis is discussed in Section 3.5. For the determination of doses to biota other than man, specific calculations were made primarily for the liquid effluents. The liquid effluent quantitites, when diluted in the plant's discharge, would produce an average gross activity concentration, excluding tritium, of 4.8×10^{-4} pCi/mℓ in the plant discharge area. Under the same conditions, the tritium concentration would be 10 pCi/mℓ. Additional discussion concerning liquid dilution is presented in Section 5.7.2.

Doses to terrestrial animals such as rabbits or deer due to the gaseous effluents are quite similar to those calculated for man. For this reason, both the gaseous effluent concentrations at locations of interest and the dose calculations for gaseous effluents are discussed in detail in Section 5.7.2.

5.7.1.3 Dose Rate Estimates

The annual radiation doses to both aquatic and terrestrial biota were estimated on the assumption of constant concentrations of radionuclides at a given point in both water and air. Radiation dose has both internal and external components (Figure 5.5). External components originate from immersion in radioactive air and water and from exposure to radioactive sources on surfaces, in distant volumes of air and water and in equipment. Internal exposures result from ingesting and breathing radioactivity.

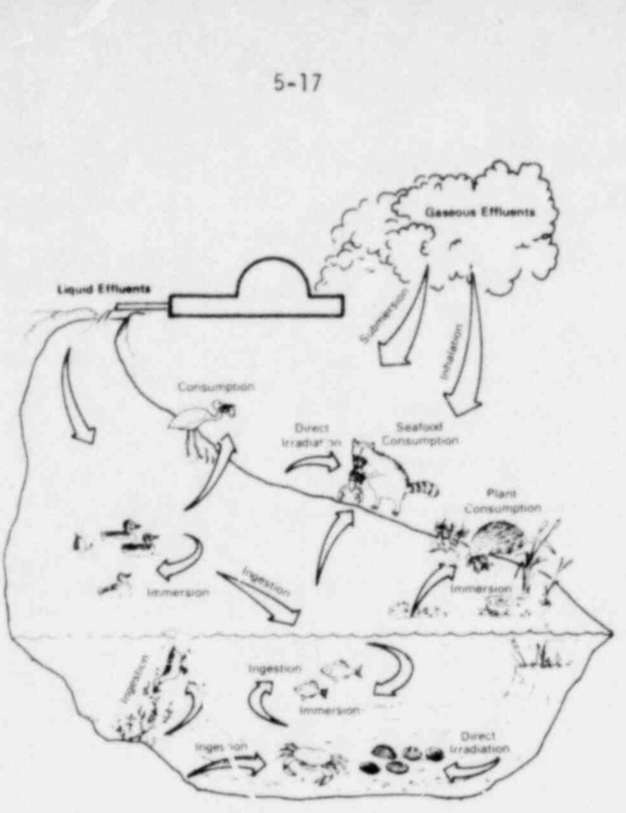


FIGURE 5.5 Exposure Pathways to Biota Other than Man

Doses would be delivered to aquatic organisms living in the water containing radionuclides discharged from the power plant, principally as a consequence of physiological mechanisms concentrating a number of elements that can be present in the aqueous environment. The extent to which elements would be concentrated in fish, invertebrates, and aquatic plants upon uptake or ingestion has been estimated. Values of relative biological accumulation factors (ratio of concentration of nuclide in organisms to that in the aqueous environment) of a number of water-borne elements for several organisms are provided in Table 5.10.

Doses to aquatic plants and fish living in the discharge region due to water uptake and ingestion (internal exposure) were calculated to be 4.1 and 2.1 mrads/year respectively for the plant's operation. The discharge region concentrations were those given in Section 5.7.1.2 and the staff assumed that the organisms would spend all of the year in water at maximum concentrations. All calculated doses are based on standard models (ICRP, 1959). The doses are quite conservative since the mobile life forms are highly unlikely to spend a significant portion of their life span in the maximum activity concentration of the discharge region. Both radioactive decay and additional dilution would reduce the dose at other points in the river.

External doses to terrestrial animals other than man are determined on the basis of gaseous effluent concentrations and direct radiation contributions at the locations where such animals in the environs of the station would receive approximately the same external radiation doses as those calculated for man. For example, a deer living at the site boundary in the SSW direction would receive a whole body dose of 0.12 mrad/year due to immersion in CRBRP gaseous effluents.

An estimate can be made for the ingestion dose to a terrestrial animal, such as a duck, which is assumed to consume only aquatic vegetation growing in the water in the discharge region. The duck ingestion dose was calculated to be about 6.4 mrads/year, which represents an upper limit estimate since equilibrium was assumed to exist between the aquatic organisms and all radionuclides in water. A nonequilibrium condition for a radionuclide in an actual exposure situation would result in a smaller bioaccumulation and therefore a smaller dose from internal exposure.

The literature relating to radiation effects on organisms is extensive, but very few studies have been conducted on the effects of continuous low-level exposure to radiation from ingested radionuclides on natural aquatic or terrestrial populations. The most recent and pertinent studies point out that, while the existence of extremely radiosensitive biota is possible and while increased radiosensitivity in organisms may result from environmental interactions, no biota have yet been discovered that show a sensitivity to radiation exposures as low as those anticipated in the area surrounding the Clinch River Plant. In summary, evidence to date indicates that no other living organisms are very much more radiosensitive than man (NAS-NRC, 1972). Therefore, no detectable radiological impact is expected in aquatic biota or terrestrial mammals as a result of the quantity of radionuclides to be released into the river and into the air by the plant.

TABLE 5.10 Freshwater Bioaccumulation Factors[a]

	pCi/kg Organism Per pCi/liter water		
Elements	Fish	Invertebrates	Plants
C	4550	9100	4550
Na	100	200	500
P	100000	20000	500000
Sc	2	1000	10000
Cr	200	2000	4000
Mn	400	90000	10000
Fe	100	3200	1000
Co	50	200	200
Ni	100	100	50
Zn	2000	10000	20000
Rb	2000	1000	1000
Sr	30	100	500
Y	25	1000	5000
Zr	3	7	1000
Nb	30000	100	800
Mo	10	10	1000
Tc	15	5	40
Ru	10	300	2000
Rh	10	300	200
Ag	2	770	200
Sn	3000	1000	100
Sb	1	10	1500
Te	400	150	100
I	15	5	40
Cs	2000	100	500
Ba	4	200	500
La	25	1000	5000
Ce	1	1000	4000
Pr	25	1000	5000
Nd	25	1000	5000
Pm	25	1000	5000
Sm	25	1000	5000
Cu	25	1000	5000
Gd	25	1000	5000
W	1200	10	1200
Np	10	400	300
Pu	4	100	350
Am	25	1000	5000
Cm	25	1000	5000

(a) From Report UCRL-50564, Rev. 1

5.7.2 Radiological Impact on Man

5.7.2.1 Exposure Pathways

Routine operation of the plant would result in the release of small quantities of fission and activation products to the environment. This evaluation provides dose estimates which can serve as a basis for a determination that releases to unrestricted areas are as low as practicable in accordance with 10 CFR Part 50 and within the limits specified in 10 CFR Part 20. The staff estimated the probable radionuclide releases from the plant based upon an evaluation of the radwaste system (Section 3.5).

Estimations were made of radiation doses to man at and beyond the site boundary via the most significant pathways among those diagrammed in Figure 5.6. The calculations are based on conservative assumptions regarding the dilutions of radionuclides in the liquid discharge and effluent gases, and the use by man of the plant surroundings. In general, radiation doses calculated by the staff are intended to apply to an average adult. Specific persons would receive higher or lower doses, depending upon their ages, living habits, food preferences, and recreational activities.

Based on experience at operating light water reactors and the staff's preliminary judgment that the magnitude of occupational radiation exposures at liquid metal breeder reactors should not be substantially different from those experienced at light water reactors, an estimate was made of the occupational radiation exposures expected to result from plant operation (Section 5.7.2.5).

5.7.2.2 Liquid Effluents

Expected radionuclide releases in the liquid effluent were calculated for the plant and are listed in Table 3.3. In the immediate vicinity of the plant discharge, the gross activity concentration, exclusive of tritium, is estimated to be 4.8×10^{-4} pCi/mℓ. Under the same conditions the tritium concentration would be 10 pCi/mℓ.

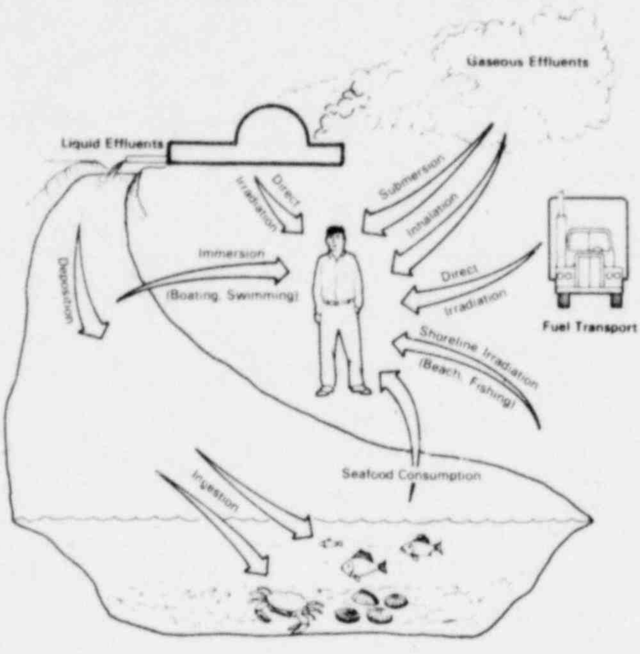


FIGURE 5.6 Pathways of Radiation to Man

The consumption of water by man would not be a potentially significant pathway, because there are no potable water intakes on the Clinch River downstream of the plant. However, the dose to a hypothetical individual who drinks 700 liters of water per year from the plant discharge region was estimated to be 0.96 mrem/yr. There are no irrigation water intakes on the Clinch River downstream of the plant; however, some cattle receive part of their drinking water from the river. The potential doses to man from ingesting beef and milk from such cattle were therefore evaluated.

Other pathways of relative importance involve recreational use of the river in the vicinity of the discharge zone. Potential individual doses from consuming fish or invertebrates caught in the immediate discharge area were also evaluated using the biological accumulation factors listed in Table 5.10 and standard models (ICRP, 1959). Humans are not expected to consume Clinch River invertebrates. However, if someone did consume 5 kg/yr of invertebrates caught in the discharge region, his dose rate would be 2.5×10^{-2} mrem/yr. Potential individual doses from swimming, boating, and shoreline recreation in the discharge region were also evaluated. Table 5.11 summarizes the potential individual doses from the liquid effluents. The radionuclides primarily responsible for the quoted doses are tritium, cesium, strontium, cobalt and tellurium. With the exception of the dose from swimming in the immediate discharge area, the dose due to plutonium radioisotopes would be less than 1% of the quoted doses. For the swimming dose, about 3% would be due to plutonium.

5.7.2.3 Gaseous Effluents

Radioactive effluents released to the atmosphere from the plant would result in small radiation doses to the public. Staff estimates of the probable gaseous releases listed in Table 3.4 were used to evaluate potential doses. All dose calculations were performed using annual average site meteorological conditions and assuming that releases would occur at a constant rate. Doses resulting from near-ground releases of radioactive gases were calculated by considering immersion in the gases, inhalation of the gases, and ingestion of food from pathways exposed to the gases (Slade, 1968; RM-50-2). Two food pathways to man would involve the ingestion by dairy and beef cattle of tritium absorbed by grass in grazing areas. The doses to an infant from ingesting milk and an adult from ingesting beef from cattle grazing at the site boundary were calculated using recognized models (RM-50-2). The following assumptions were used: the cattle grazed 12/mo/yr, an infant's milk consumption is 300 ℓ/yr, and an adult's meat consumption is 100 kg/yr.

Another food pathway to man would involve the consumption of vegetables absorbing tritium released into the atmosphere by the plant. The dose to an adult consuming 560 kg/yr of vegetables grown at the site boundary was calculated. All doses due to gaseous effluents are summarized in Table 5.12.

TABLE 5.11 Annual Individual Doses from Liquid Effluents

Location	Pathway	Dose, mrem/yr Total Body	GI Tract	Thyroid	Bone
Coolant discharge region	Fish ingestion (20 kg/yr)	5.2×10^{-2}	5.4×10^{-2}	6.0×10^{-2}	3.6×10^{-2}
	Beef ingestion (100 kg/yr)	2.2×10^{-1}	2.2×10^{-1}	2.6×10^{-1}	1.9×10^{-4}
	Swimming (100 hrs/yr)	1.3×10^{-5}			
	Boating (100 hrs/yr)	6.4×10^{-6}			
	Shoreline activities (500 hrs/yr)	3.8×10^{-2}			
	Milk[(a)] ingestion (300 ℓ/yr)	1.2×10^{0}	1.2×10^{0}	1.3×10^{0}	1.7×10^{-3}

(a) These dose rates are for an infant.

TABLE 5.12 Annual Individual Doses due to Gaseous Effluents at Site Boundary[(a)]

Pathway	Dose, mrem/yr Total Body	Skin	Thyroid
Immersion	1.2×10^{-1}	5.9×10^{-1}	1.2×10^{-1}
Inhalation	4.1×10^{-3}	4.1×10^{-3}	4.1×10^{-3}
Vegetable, meat, and milk food chains	6.3×10^{-3}	6.3×10^{-3}	6.3×10^{-3}

(a) (0.4 miles SSW), $X/Q = 2.5 \times 10^{-5}$ sec/m^3.

5.7.2.4 Direct Radiation from the Facility

Normal reactor power plant operations result in some human exposure to direct radiation (i.e., radiation from contained sources). A principal source of human exposure to direct radiation that would result from operation of the Clinch River plant would be the sodium-24 produced by neutron activation of the liquid metal coolant.

The plant design includes specific shielding of the reactor, holdup tanks, filters, demineralizers and other areas where radioactive materials may flow or be stored, primarily for the protection of plant personnel. Direct radiation from those sources is therefore not expected to be significant at the site boundary. Confirming measurements would be required as part of the applicant's environmental monitoring program after plant startup.

5.7.2.5 Occupational Radiation Exposure

Based on a review of the applicant's Safety Analysis Report, the staff determined that individual occupational doses can be maintained within the limits of 10 CFR Part 20. The radiation dose limits in 10 CFR Part 20 are based on thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of plant personnel within those limits ensures that the risk associated with radiation exposure would be no greater than risks normally accepted by workers in other present-day industries (ICRP, 1973). In the PSAR, the applicant estimated a total occupational radiation dose of about 300 man-rems, using projected occupancies and anticipated operations involving personnel in radiation areas, and projected design radiation levels at CRBRP. This is considered a reasonable estimate of expected occupational radiation exposure for those activities considered under the conditions assumed. Since there are several factors that cannot be predicted at this time (including frequency and magnitude of maintenance), a conservative occupational radiation exposure of 1000 man-rem is used for this impact statement.

5.7.2.6 Transportation of Radioactive Materials

The transportation of fresh fuel to a reactor, of spent fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is discussed generically for light-water reactors in AEC's WASH-1238 report entitled, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants." While much of the information in the report is applicable to the transportation requirements of the Clinch River Breeder Reactor Plant, there will be differences in environmental impact due to the much smaller rating of the CRBRP (439 MWe maximum vs 1100 MWe for a typical LWR), its use of plutonium-uranium mixed oxide fuel, and the relatively high number of shipments during its demonstration period. The staff has therefore analyzed the transportation effects in its consideration of the CRBRP fuel cycle (see Appendix D of this statement).

As shown in Table 7 of Appendix D, the cumulative radiation dose to transport workers and the general population along the assumed 750 miles of transportation routes is estimated to be 17 man-rem annually during the 5-year demonstration period; it would be less during the equilibrium period of operation.

5.7.2.7 Fuel Cycle Impacts

Environmental impacts from the fuel cycle facilities supporting the CRBRP and from the transportation of materials between such facilities have been considered by the staff and the results are presented in Appendix D. Table 2 of Appendix D shows the various effluents and their sources. As indicated in Table 3, the highest individual total-body dose expected is 4.1 millirem/year (probably to a transport worker). As shown in Table 4, the annual population dose would be on the order of 1.4 man-rem.

5.7.2.8 Summary of Annual Radiation Doses

The cumulative dose (man-rem) due to gaseous effluents to all individuals living within a 50-mi radius of the plant was calculated using a projected population of 987,000 persons in the year 2010 (Section 2.2).

The cumulative dose (man-rem) resulting from the consumption of fish caught downstream of the plant was estimated. The staff assumed that 4.5×10^4 kg of fish would be caught downstream of the plant where the discharge would be fully diluted by a factor of 670 over the unmixed plant discharge. The staff assumed also that the entire fish catch would be consumed by the population within the 50-mi radius.

The cumulative dose (man-rem) received from recreation by the total population was estimated by assuming that 25% of the 50-mi population would engage in 8 hr/yr each of shoreline activities, boating, and swimming (50 hr/yr for teens, 9 hr/yr for children) in the river where full dilution had taken place.

The cumulative dose (man-rem) received by the 50-mi population from ingestion of milk and beef was estimated by assuming that 1% of the milk and beef cattle would drink their water from the river where full dilution had taken place. The staff also assumed that all of the milk and beef produced from those cattle would be consumed by the 50-mi population.

The estimated dose to the 50-mi population from all sources, including natural background, gaseous effluents, consumption of fish, recreation, transportation, and occupational exposure, are presented in Table 5.13. Also shown in the table for completeness of information is annual population dose expected from the CRBRP supporting fuel-cycle facilities.

5.7.3 Evaluation of Radiological Impact

The average annual dose to an individual living, playing, and working at the site boundary and eating fish, beef, and milk exposed to plant effluents by various pathways would be 1.6 mrem/yr. This value, which is less than 2% of the natural background exposure of 0.1 rem/yr (Oakley, 1972), is below the normal variation in background dose, and represents no radiological impact. The average dose to other individuals in the 50-mi population would be significantly less than 1.6 mrem/yr.

TABLE 5.13 Summary of Annual Whole Body Doses to the Population Within 50 Miles in the Year 2010

Category	Population Dose (man-rem/yr)
Natural Environmental Radioactivity	9.9×10^4
Nuclear Plant Operation	
Plant work force	1.0×10^3
General public	
Gaseous	2.1×10^{-1}
Fish ingestion	8.4×10^{-4}
Recreation (fishing, swimming, boating)	2.0×10^{-4}
Beef ingestion	1.4×10^{-2}
Milk ingestion	1.9×10^{-2}
Transportation of nuclear fuel and radioactive waste[(a)]	1.7×10
Supporting Fuel Cycle Facilities[(b)]	1.4

(a) Most of this dose would be received outside of the 50-mi radius since it applies to persons who live along the entire shipping routes.

(b) This dose would probably be received entirely outside the 50-mi radius of the site.

Using conservative assumptions, a total dose of about 0.24 man-rem/yr would be received by the estimated 2010 population of 987,000 living in unrestricted areas within a 50-mi radius of the plant. By comparison, an annual total of about 9.9×10^4 man-rem is delivered to the same population as a result of the average natural background dose rate of about 0.1 rem/yr. Also, the 1000 man-rem estimated as occupational onsite exposure is about 1% of this annual total background dose.

Most of the 17 man-rem annual dose from transport of radioactive materials to and from the plant and probably all of the 1.4 man-rem annual dose from support fuel cycle facilities would be received outside the 50-mile radius of the plant. These are insignificant fractions of the dose from the natural background exposure cited above.

6. ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

6.1 PREOPERATIONAL

6.1.1 Hydrological

This subject is included in Section 6.1.5, Physical and Chemical.

6.1.2 Radiological

The applicant proposed an offsite preoperational radiological monitoring program identifying background radiation levels and radioactivity in the plant environs. The program would permit the applicant to train personnel and evaluate procedures, equipment and techniques, as indicated in Regulatory Guide 4.1. A description of the applicant's proposed program, to be started two years before plant operation, is summarized in Table 6.1 and 6.2, with sampling locations shown in Figures 6.1 and 6.2. More detailed information is in the ER Sec 6.2. The staff considers the proposed program adequate.

TABLE 6.1 Air and Terrestrial Monitoring Sampling and Analysis Schedule (Radiological)

		Analysis							
Sample Type	Frequency	Gross Beta	Gross Alpha(a)	Total Alpha(b)	Gamma Scan(c)	Sr-89, Sr-90	H-3	Pu	U
Air filter	Weekly(d)	x	x						
	Monthly(e)				x			x	x
Silica Gel Column	Biweekly(d)						x		
Charcoal filter	Weekly(d)				x				
Rainwater	Monthly(e)	x			x	x	x		
Heavy particulate fallout	Monthly(e)	x	x						
Soil	Quarterly(f)	x	x		x			x	x
Vegetation	Quarterly(g)	x		x	x	x		x	
Pasturage grass	Monthly(g)	x		x	x	x		x	
Milk	Weekly(h)				x				
	Monthly					x			
Well water	Monthly(h)	x	x		x				
Public water	Monthly(j)	x	x		x		x	x	
Food Crops	Twice each year(g)	x		x	x	x		x	

(a) Aliquot of prepared sample counted directly for alpha

(b) Heavy metals separated as a part of the Sr-89, Sr-90 separation process are precipitated, filtered, and counted for alpha

(c) The gamma scan includes specific analyses for at least 10 isotopes, except for milk samples which are analyzed for four isotopes and charcoal filters which are analyzed for I-131 on a single channel analyzer

(d) Continuous collection

(e) Composite sample for period indicated

(f) Soil is collected over a 2-square-foot area 1 inch in depth

(g) Vegetation (grass, weeds, leaves, etc.) and food crops are collected such that there is one pint and 3.5 liters of sample respectively for analysis after necessary preparation

(h) Grab sample at time of collection

(j) Continuous sample of the first (and only) public water supply within 10 miles of the plant

TABLE 6.2 Reservoir Monitoring Radiological Analyses

Type Sample	Collection Frequency	Analyses*
Fish	Quarterly	Gamma scan, gross alpha, gross beta, Sr-89, Sr-90, and Pu.**
Sediment	Quarterly	Gamma scan, gross alpha, gross beta, Sr-89, Sr-90, and Pu.
Water	Note+	Gamma scan, gross alpha, gross beta, Sr-89, Sr-90, tritium, Pu, and U.++
Periphyton	Note▽	Gamma scan, gross alpha, gross beta, Sr-89 and Sr-90.▽▽
Asiatic Clams	Quarterly	Gamma scan, gross alpha, gross beta, Sr-89, Sr-90, and Pu will be determined on shells only.

*The activity of at least 10 gamma-emitting radionuclides will be determined with a multichannel gamma spectrometer. Sr-89, Sr-90, Pu and U will be determined by appropriate radiochemical techniques.

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

+Continuous sequential sample, analyzed monthly.

++Pu and U analyses done on samples from CRBRP intake and discharge and Oak Ridge Gaseous Diffusion plant discharge and Pu at ORGDP intake.

▽Collected monthly, composite sample analyzed quarterly.

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

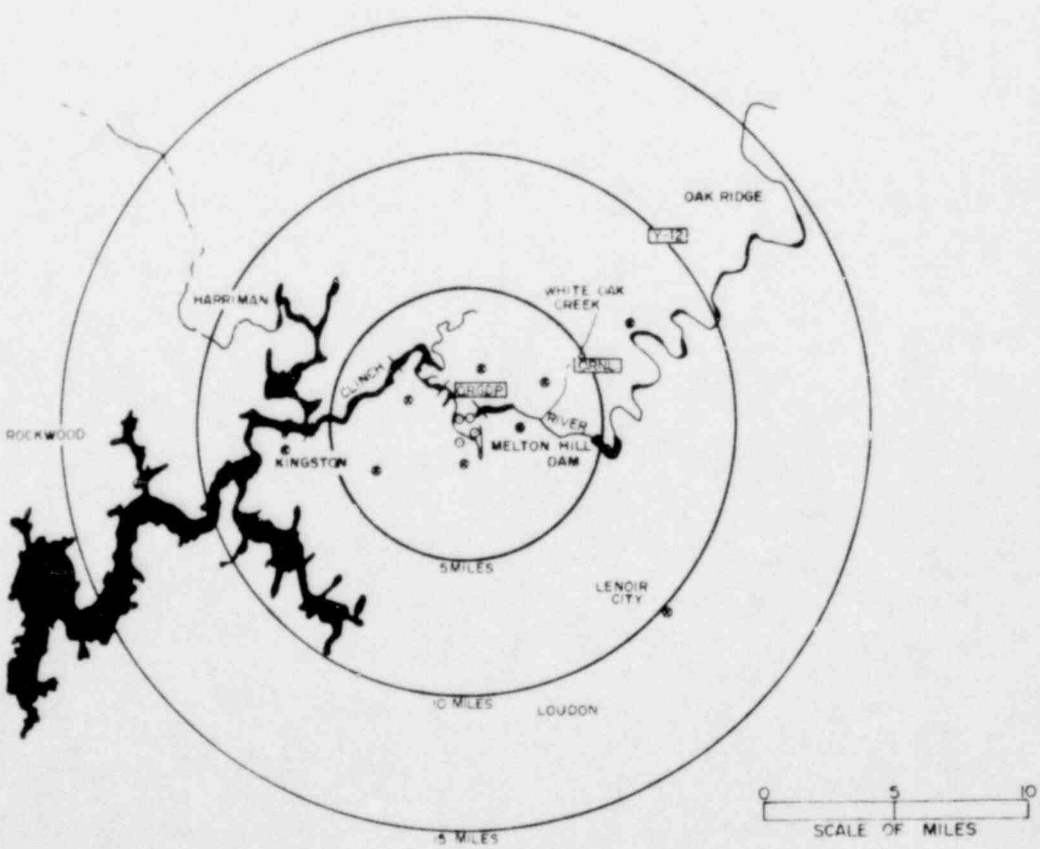


FIGURE 6.1 Atmospheric and Terrestrial Monitoring Network for CRBRP

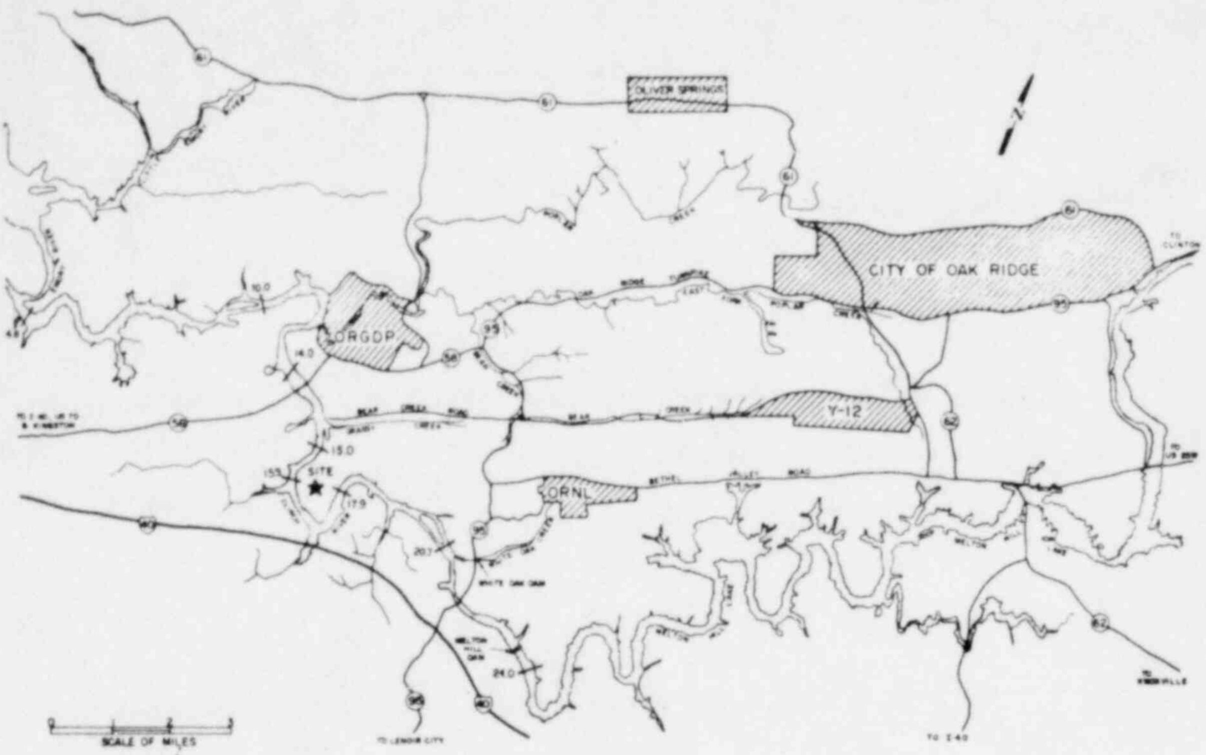


FIGURE 6.2 Reservoir Monitoring Network For CRBRP

6.1.3 Meteorological

Since April 1973 a temporary 200 ft instrumented tower has been in operation 0.4 miles SW of the reactor site. The data acquisition equipment is located in a mobile trailer unit at the base of the tower. Although the terrain is generally irregular and wooded, the tower is located in a reasonably representative and exposed area.

The measurement system consists of the following sensors (ER, p 2.6-19):

Wind Sensors - Climet Model 011-11 wind speed sensor and Climet Model 012-11 wind direction sensor are presently located at the 33, 75 and 200 ft levels of the tower. Operating range of the wind speed sensor is 0.6 to 90 mph, with an accuracy of 1% of true value or 0.15 mi/hr, whichever is greater. The direction sensor operates through a range of 0-540° with an accuracy of ±3°.

Dry Bulb Temperature - Aspirated Aerodet Model R-22.3-3E100 platinum resistance temperature sensor is presently located at the 33 ft and 75 ft tower levels. The sensor range is -20°F to 120°F with accuracy of ±0.6°F.

Temperature Difference - A measuring bridge of two dual opposing platinum resistance thermometers, aspirated directly, determine the temperature difference between the 75 and 200 and the 33 and 200 ft tower levels. The range of the system is -40°F to +40°F. In the range -5°F to +5°F, the maximum probable error is ±0.24°F.

Humidity - At the base of the tower, a hygrothermograph measures the humidity in the range of 0 to 100%. For this instrument, the maximum possible error is ±4% of the indicated value.

Rainfall and solar radiation values are not recorded at the site.

The wind and temperature data are recorded on both an analog and a digital system. An extensive calibration program for the instruments along with an adequate data reliability program should insure the required data recovery rate in the future.

The onsite system, in terms of accuracy of dewpoint and delta temperature measurements, and system recovery rate fails to meet standards required in Regulatory Guide 1.23. Since the staff's site visit, the applicant has installed a dewpoint sensor with the required accuracy. The applicant's improved inspection and maintenance program is expected to raise the recovery rate.

In evaluating atmospheric dispersion conditions, joint frequency distributions of wind speed and direction by atmospheric stability class were used, based on the vertical temperature gradient collected onsite during the year starting June 1, 1974. The wind speed and direction at the 75 ft level and the vertical temperature difference between the 75 and 200 ft levels were the bases of the dispersion estimates. Data recovery for the period was 96%.

The relative atmospheric dispersion (X/Q) values were estimated with site data at the various distances and directions from CRBRP listed in Table 5.12. The estimation was based on the assumption that effluents released from the site would be transported in the atmosphere according to Gaussian distribution (Sangendorf, 1974).

6.1.4 Ecological

6.1.4.1 Aquatic

The baseline program began in March 1974 with the main purpose of identifying biological communities, their spawning habits and the presence of rare and endangered species. Sampling transects and locations according to biological type are shown in Figure 6.3 (ER, Fig 6.1-1 through -9). Sampling schedule is given in Table 6.3 (ER, Tab 6.1-1), and methods and frequencies in Table 6.4 (ER, Tab 6.1-2).

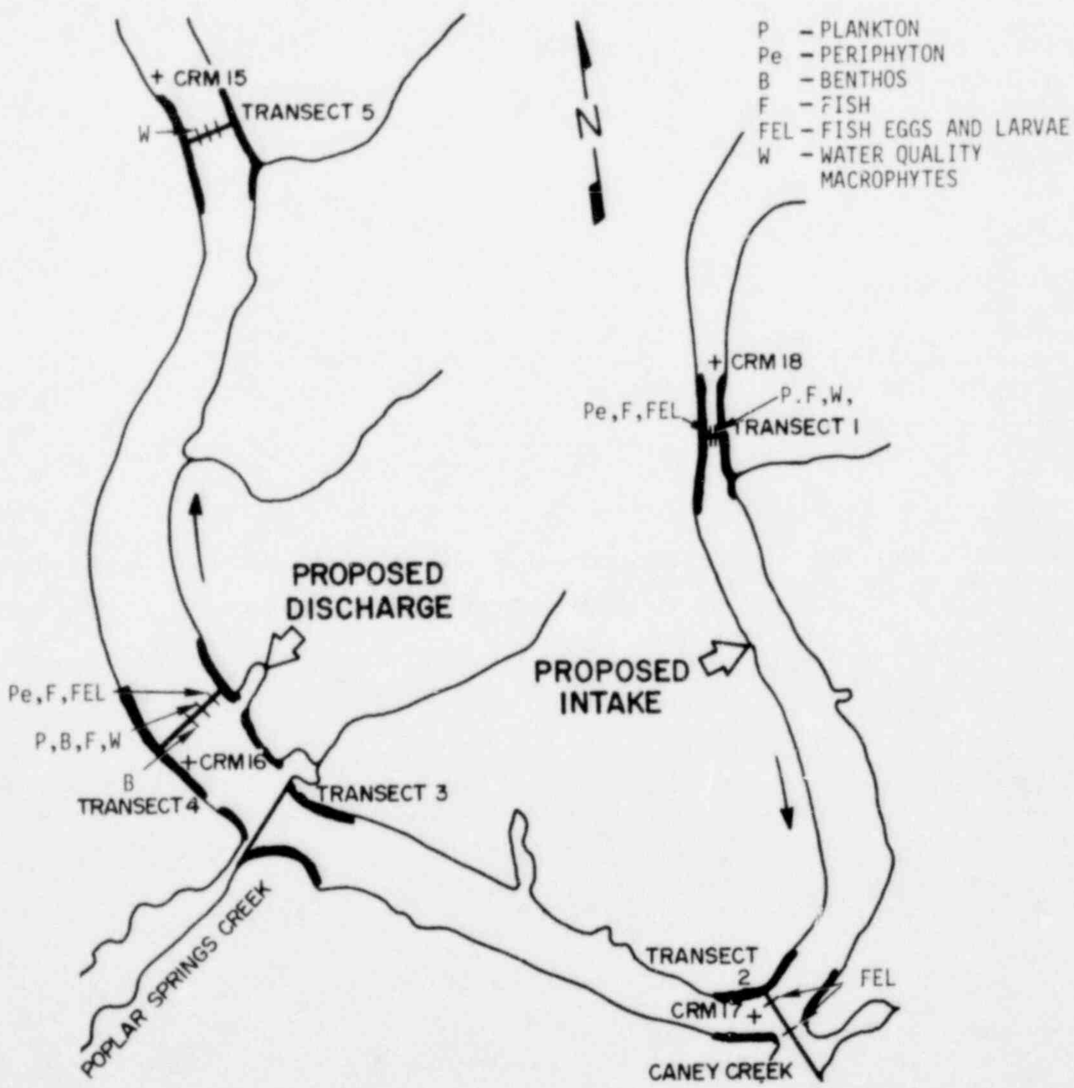


FIGURE 6.3 River Sampling Transects for Baseline Monitoring

TABLE 6.3 Aquatic Baseline Sampling Schedule[a]
(ER, Table 6.1-1)

	J	F	M	A	M	J	J	A	S	O	N	D
Biological Parameters												
Bacteria	X		X		X	X	X	X	X		X	
Phytoplankton	X		X		X	X	X	X	X		X	
Zooplankton (tows)	X		X		X	X	X[b]	X	X		X	
Zooplankton (pumping)	X		X		X	X	X[b]	X	X		X	
Periphyton	X			X			X			X		
Benthos (dredging)	X		X		X	X	X	X	X		X	
Benthos (artificial substrate)	X		X		X	X	X	X[c]	X		X	
Macrophytes			X		X		X					
Fish Populations	X		X		X	X	X	X	X		X	
Fish Eggs and Larvae			X[d]	X[d]	X[d]	X[d]	X[d]	X[d]				
Fish Food Preference	X		X		X	X		X	X		X	
Physical and Chemical Parameters												
Field Measurements	X		X		X	X	X	X	X		X	
Routine Lab. Analyses	X		X		X	X	X	X	X		X	
Additional Analyses	Once at the beginning of the study and once after six months.											
Sediment Analyses												
Particle Size and Organic Content	X		X		X		X		X			
Heavy Metal Content	Once at the beginning of the study.											
Total Phosphate Content	Once at the beginning of the study.											

(a) ER Table 6.1-1.
(b) A decision would be made at this point, after completion of four field trips, whether to continue sampling using towing or pumping.
(c) Continued use of artificial substrates after August would depend on results collected to that date.
(d) Biweekly.

TABLE 6.4 Biological Sampling Methods for the Aquatic Baseline Survey (ER, Table 6.1-2)

Parameter	Sampling Frequency	Sampling Method	Analyses
BIOLOGICAL			
Bacteria			
Standard plate count Total coliform count Fecal coliform count Fecal strep. count	Once each month in Jan., March, May-Sept. and Nov.	surface collection (one foot below surface) using sterilized glass containers	(1) concentration expressed as colonies/100 ml (2) analyses according to "Standard Methods"*
Phytoplankton	Once each month during Jan., March, May-Sept. and Nov.	(1) van Dorn bottle (2) surface collection	(1) identification to the specific level, when practical (2) number/liter (3) species diversity (4) percent composition--major groups (5) biomass (chlorophyll a method including measurement of chlorophyll b, c and pheophytin a content ratio)
Zooplankton tows	Once each month during Jan., March, May-Sept. and Nov.	(1) vertical tows (2) 0.5 meter diameter, 0.76 mesh plankton net with TSK outside and inside flow meters	(1) identification to the specific level, when practical (2) number/liter (3) species diversity (4) composite biomass (volume by displacement or measurement of cells depending on abundance)
Zooplankton pumping	Once each month during Jan., March, May-Sept. and Nov.	(1) submersible pump (2) filtered through a 0.76 mesh plankton net (3) surface, mid and bottom collections	(1) identification to the specific level, when practical (2) number/liter (3) species diversity (4) composite biomass (volume by displacement or measurement of cells depending on abundance)
Periphyton	Once each month during Jan., April, July and Oct.	(1) plexiglass slides on floating racks (2) 2-4 week exposure period	(1) identification to the specific level, when practical, of species of all groups of algae (2) species diversity (3) autotrophic index
Benthos artificial substrate	Once each month during Jan., March, May-Sept. and Nov.	(1) hardboard, multi-plate sampler suspended 1 to 2 feet above bottom (2) continued use beyond August will depend on data collected to date	(1) identification to the specific level, when practical (2) number/m^2 (3) species diversity (4) composite biomass (blotted wet weight and ash free dry weight)
Macrophytes	Once each month during March, May and July	(1) collection by hand (2) quantitative sampling within quadrates if substantial growth encountered	(1) identification to the specific level, when practical (2) composite biomass (blotted wet weight and ash free dry weight) (3) construction of vegetation map if substantial growth encountered
Fish populations	Once each month during Jan., March, May-Sept. and Nov.	(1) electroshocking (2) gill nets (3) scale collection of 7 most abundant species	(1) species composition (2) relative species abundance (3) percentage game, rough and forage fish (4) species diversity (5) length and weight determinations (6) condition factor of 7 most abundant species (7) length by age-growth curves of 7 most abundant species
Fish eggs and larvae	Once every two weeks during March through August	(1) stationary bottom 1,000 ichthyoplankton net with TSK inside and outside flow meters (2) pumping using submersible pump 1 to 2 feet from bottom	(1) density (number/m^3) (2) stage of development (3) species identification, when practical
Fish food preferance	Once each month during Jan., March, May, June, Aug., Sept. and Nov.	collection of stomachs from each of the 7 most abundant fish species	(1) identification of food items to the most specific taxon practical (2) number and percent abundance of food items (3) percent fulness of stomach (4) net weight of stomach contents

Preconstruction-construction monitoring would be initiated 6 months prior to site preparation activities (ER, Sec 6.1.2). It would emphasize limnological and fish studies. Limnological studies would involve 2-week exposures of artificial substrates to identify species and relative densities of benthic organisms. Ponar grab samples would be used for biomass and species diversity determinations of the benthos. Ponar grabs also would be used to classify substrate type. For the phytoplankton population, biomass estimates would be determined by chlorophyll a measurements along with cell enumeration and percent composition by major taxonomic groups. Artificial periphyton substrates would be suspended within the photic zone at the locations of the artificial benthos substrates. The percent composition of the major taxonomic groups and the autotrophic-heterotrophic index would be calculated. Zooplankton would be sampled by a 1/2 m-net employing vertical tows; results would be expressed as composite biomass estimates differentiated by species. Monthly samples would be taken at replicate control stations located at CRM 17.9 and 19.0 (above intake) and test stations below the discharge at CRM 14.4 and 15.4. Monthly sampling would be conducted from March through November with only one sampling period during the winter season.

The applicant states that fish are able to avoid areas of excessive siltation and turbidity. Neither chemical nor thermal impacts are anticipated from construction activities; therefore, fish monitoring is not planned during construction (ER, Sec 6.1.1.2.2 and Am I, Part II, C20 and C21). Ichthyoplankton would be sampled in duplicate weekly, starting two years prior to plant operation from April through July by a metered net for five-minute durations, at one station above the intake and one below the discharge. Ichthyoplankton would be taken from three positions within the water column: shoreline (embayments), channel surface and deep channel.

In general, the staff finds the overall preoperational monitoring adequate. The staff would require the applicant to submit a detailed monitoring program, to start 2 years before plant operation, including the following: location of sampling transects, frequency of sampling, sampling methodologies and analyses to be used.

6.1.4.2 Terrestrial

If threatened or unique species and/or communities are discovered during baseline operations, TVA would determine whether appropriate measures can be implemented to preserve and protect them (ER, Sec 6.1.4.3.4).

Monitoring during preconstruction-construction calls for identifying "critical ecological elements" by means of the baseline study as defined in Table 6.3 (ER, Table 6.1-5). The applicant plans to provide the plant construction manager maps and photographs showing the locations of critical elements so that they may be avoided during construction. Semi-annual inspections of species and community locations are planned. In addition, spring, summer, and fall-winter inventories of water fowl and shorebirds would be made (ER, Am I, Part II, B8).

The staff finds the preconstruction-construction monitoring acceptable provided that results from the terrestrial ecology baseline study are used to define the "critical ecological elements" and that contractor activities are monitored to assure that sufficient protection is provided for critical terrestrial resources (Section 4.6.1).

6.1.5 Chemical and Physical

During the baseline program, sampling was done at 3 transects in the river (Figure 6.3). Measurements were scheduled (Table 6.3) for parameters identified in Table 6.6 (ER, Table 6.1-2).

During preconstruction-construction TVA plans to assemble water quality data by sampling at CRM 23.1 (Melton Hill Dam tailrace) and CRM 15.9 (immediately below the plant discharge) (Figure 6.4) (ER, Fig 6.1-10). Bimonthly sampling would be done for one year, then quarterly, and back to bimonthly for 2 years before plant operation. Routine measurements would be temperature and dissolved oxygen in profile, pH, alkalinity, coliforms (total and fecal), turbidity, color (true and apparent), hardness, conductivity, solids (suspended, dissolved and total), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogens (organic, ammonia, nitrite plus nitrate), phosphate (soluble and total), iron (ferrous, filterable and total), sodium, potassium, chloride, sulfate, silica, calcium, magnesium, copper, nickel and zinc. The applicant plans to measure additional constituents according to need indicated by construction or plant design. Moreover, perimeter monitoring (pH, temperature, DO, conductivity, coliforms, solids, and turbidity) is planned on a flexible basis for such major actions as extensive earth moving, dredging, and shoreline alteration (ER, Sec 6.1.1.2.1).

The staff's opinion is that the preconstruction-construction program is adequate. The staff would require the applicant to submit a monitoring schedule supporting the aquatic ecology program outlined in Section 6.1.4.1 two years before plant operation.

TABLE 6.5 Terrestrial Baseline Monitoring Summary
(ER Table 6.1-5)

Parameters	Sampling Frequency	Sampling Method	Sampling Location	Statistics and Analyses
Floristic Survey	Monthly surveys (March through September)	General floristic survey.	Entire site	Presence or absence of species in various habitat types.
Vegetative Ground Cover	Three surveys (Spring, summer and fall)	Point-centered circular 0.01 acre quadrants.	Twelve communities	Identification of ground cover and shrubs. Calculations to determine relative frequency, density and importance values.
Woody Vegetation	One survey (Summer)	Nested circular plots (0.1, 0.05 and 0.01 acre) for trees, saplings and woody understory, respectively.	Twelve communities	Identification of overstory species. Calculations to determine relative density, basal area and frequency. Also determine importance value, site index, productivity, merchantable timber by species, size class and quality.
Mammal Survey	Five times per year (March, May, August, October, and December)	Live trapping and snap trapping of small mammals. Direct observation and secondary signs such as dens, scats and tracks.	5 gr [illegible] 6 tr[illegible]	Species identification, vigor, sex, weight, species fluctuation and habitat preference. Calculations to determine relative population estimates or trap night indices.
Avifauna Survey	Quarterly (to include major seasons and migratory periods)	Direct observations, calls and songs while conducting walking surveys during migratory periods and systematic observations on permanent transects.	Eleven communities and edge areas	Species seasonal utilization, annual fluctuations, relative abundance and species diversity of residents.
Herpetofauna Survey	Two surveys (late spring and mid-summer)	Direct observations	General search of entire site	Species identification and relative abundance.

TABLE 6.6 Sampling Methods for the Aquatic Baseline Survey Physical and Chemical (ER, Table 6.1-2)

Parameter	Sampling Frequency	Sampling Method	Analyses
PHYSICAL AND CHEMICAL			
A. Field measurements - Temperature (profile) - Dissolved oxygen (profile) - Water velocity and current direction (profile) - pH (surface, mid, bottom) - Specific conductivity (surface, mid, bottom) - Light penetration (profile) - Water depth	Once each month in Jan., March, May-Sept. and Nov.	(1) temperature, pH, DO and conductivity measured by Hydrolab unit and additional electronic recording units (2) light penetration measured by submarine photometer (3) velocity measured by Gurley and Savonius meters; current direction by internal compass (4) water depth measured by recording Fathometer	(1) temp. in degrees centigrade (2) pH in pH units (3) dissolved oxygen in mg/l (4) conductivity in umho (5) light penetration in foot-candles and percent transmittance; determination of 1% light incidence (6) water depth in meters (7) water velocity in feet per second (fps)
B. Routine Laboratory Analyses Total alkalinity ($CaCO_3$) Hardness ($CaCO_3$) Turbidity Color (true) BOD COD TOC (total organic carbon) Chloride Chlorine residual (field method) Sulfate Sodium Potassium Solids Dissolved Settleables Suspended Volatile Fixed (by difference) Total Volatile Fixed (by difference) Nitrogen NO_2 NO_3 NH_3 Phosphate Total - PO_4 Ortho - PO_4	Once each month in Jan., March, May-Sept. and Nov.	"Standard Methods"*	(1) concentration expressed in parts per million (2) turbidity in Jackson turbidity units (3) color in color units (4) "Standard Methods"* used in all analyses except for sodium and potassium in which case "Methods for Chemical Analysis"** is used
C. Additional Analyses Chlorine demand Fluoride Nitrogen gas Silicate Calcium Magnesium Molybdenum Selenium Tin Aluminum Manganese Zinc Copper Mercury Silver Arsenic Cadmium Chromium Lead Nickel Cobalt Iron (total) Organic compounds Cyanide Detergents-surfactants (MBAS) Oil and grease (solvent extraction) Phthalate esters Pesticides Organochlorines (insecticide) Atrazine (herbicide) 2-4-D (herbicide)	Once at the beginning of the study and once again after six months. Those chemicals which exceed federal or state maximal standards will be added to the routine laboratory analysis group.	"Standard Methods"*	Analyses will be done using "Standard Methods"* except for: (a) mercury, molybdenum and nickel in which case "Methods for Chemical Analysis"** is used (b, nitrogen gas in which case the Van Slyke method* is used (c) selenium in which case "Proposed Tentative Method"** is used

TABLE 6.6 (Concluded)

Parameter	Sampling Frequency	Sampling Method	Analyses
SEDIMENT			
Particle size and total volatile (organic) solid content	Once each month during Jan., March, May, July and Sept.	collection by dredge	(1) particle size determination as in "Shore Protection"† (2) total volatile solid content by combustion according to "Standard Methods"*
Total Phosphate Content Heavy Metal Content	Once at the beginning of the study	collection by dredge	acidification, then procedure as in "Standard Methods"* for metal analysis
Molybdenum Selenium Tin Aluminum Manganese Zinc Copper Mercury Silver Arsenic Cadmium Chromium Lead Nickel Cobalt Iron (total)			

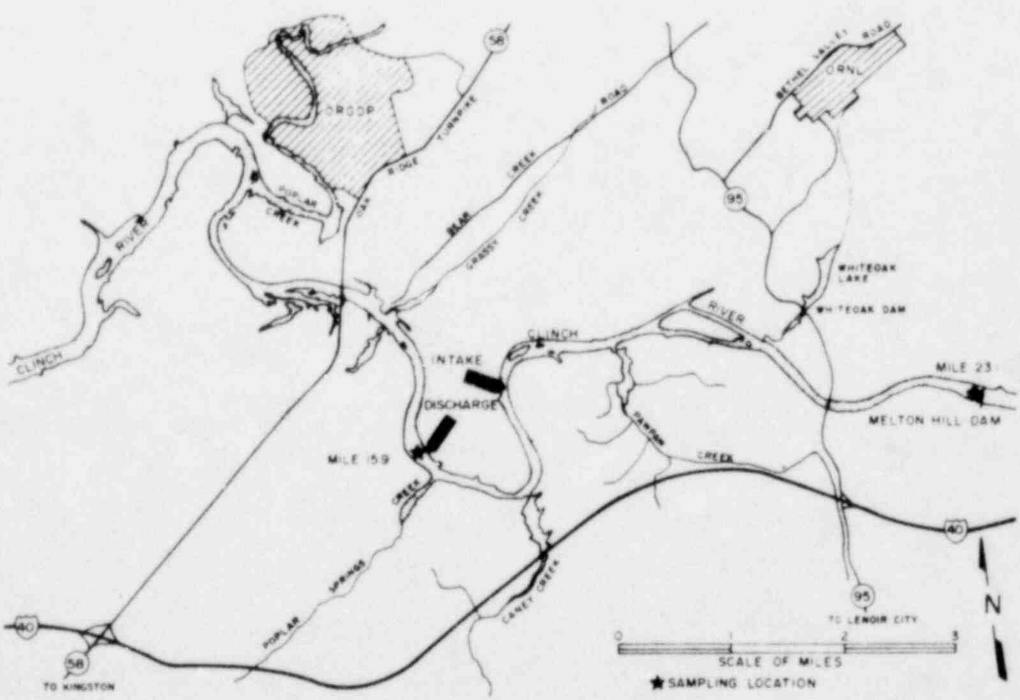


FIGURE 6.4 Sampling Locations for Physical-Chemical Monitoring, Preconstruction-Construction

6.2 OPERATIONAL

6.2.1 Hydrological

Preoperational programs would be reviewed for application to the operational phase. A brief monitoring effort may be adequate to establish the dimensions of the thermal plume. According to the modeling results (Section 5.3.2.1), a number of close-in sampling stations would be needed. Again the work would be a part of the physical and chemical monitoring (Section 6.2.5).

6.2.2 Radiological

The preoperational program would be reviewed prior to operation and some modifications, such as the addition of direct radiation monitors, would be required.

6.2.3 Meteorological

The program basically would be a continuation of the preoperational effort. The essential elements are included in Section 6.1.3.

6.2.4 Ecological

The operational aquatic monitoring program would consist of a continuation of the construction monitoring program (Section 6.1.4). Additionally, impacts from heated water discharges, such as fish distribution and behavior, impingement, and entrainment, would be defined. A detailed program subject to staff approval would be required at the operating license stage.

The applicant outlined a tentative terrestrial program for assessing the impacts of increased relative humidity, icing, and cooling tower drift (ER, Sec 6.2.5.1, 6.2.5.2 and 6.2.5.3). If icing occurs, aerial photography would be used to establish the extent of accumulation and damage; subsequently, plots would be established in the area and periodically evaluated. No firm commitment was made as to relative humidity and drift; however, an operational program may be required, subject to staff approval, at the operation licensing stage.

6.2.5 Chemical and Physical

The applicant outlined a program that essentially would continue the preoperational program, with quarterly sampling (ER, Sec 6.2.2). Routine monitoring of chlorine demand would be required. The staff would require definition of the full program at the operation licensing stage.

6.3 RELATED PROGRAMS AND STUDIES

Air quality measurements in the vicinity of the site are the responsibility of the Tennessee Department of Public Health, Division of Air Pollution Control. The department makes quarterly reports of ambient air quality data taken at Oak Ridge, Clinton, Harriman, and other stations throughout the state (AIR). Emissions to the atmosphere in the region of the site are subject to existing State regulations.

The Atmospheric Turbulence and Diffusion Laboratory of the National Oceanic and Atmospheric Administration, located in Oak Ridge, has done extensive research into air quality problems of eastern Tennessee. Information regarding their research efforts is available from the Laboratory (Hanna, et al, 1970; Hanna, 1972; Hanna, 1974; Culkowski, 1970; Culkowski, et al, 1974).

The Oak Ridge National Laboratory has in progress several types of ecological, water and radiological programs in the general area of the CRBRP site. The ORNL annual progress reports and annual ERDA environmental monitoring reports contain the findings.

7. ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

A potential impact from the operation of the CRBRP is that associated with accidents which might occur during the plant's lifetime. The applicant has submitted a Preliminary Safety Analysis Report which provides a preliminary analysis and evaluation of the design and performance of structures, systems and components of the CRBRP, including assessments of postulated accidents. The objective of the Commission's Safety Evaluation is to determine whether the risk from normal operation, from transient conditions anticipated during the life of the plant, and from such postulated accidents is acceptable. If any aspect of the design of the plant is considered to be inadequate in this regard, the staff will require the applicant to make appropriate modifications as a condition of licensing.

Accident consequences and probabilities are discussed below, as are the maximum consequences considered acceptable for very low probability design basis events. Accidents having greater consequences must be shown to be of acceptably low probability or the staff will require such features as are necessary to further reduce the probabilities and consequences.

The Commission's regulations require that an applicant design, manufacture and operate the plant to minimize the likelihood of postulated accidents. To this end, a quality assurance program is used to establish the necessary high integrity and reliability of the reactor system and other plant systems and components that would prevent or control accidents.

Protection systems that place and hold the plant in a safe condition are provided should incidents or malfunctions occur and cause deviations from acceptable operating conditions. Notwithstanding this, the conservative postulate is made that serious accidents could occur, and engineered safety features are installed to protect the public by mitigating the consequences of highly unlikely accidents. These measures are intended to assure that the design features of the CRBRP, including those stemming from the inherent characteristics of an LMFBR, are such that the plant is not likely to experience damaging faults and, if accidents should occur, their consequences will be safely controlled. For example, the primary coolant is sodium which becomes highly radioactive and will burn readily in air. Consequently, the equipment containing this coolant is housed in inerted, well-shielded cells. Should a leak occur, no fires will result and the sodium will be contained in the cells.

The procedures employed in the design and review of the CRBRP will be comparable to those employed for LWRs. For example, the rigorous design codes and standards applied to LWRs will be applied to the CRBRP; in some circumstances additional standards are employed such as, for example, on components which experience higher service temperatures. Design criteria appropriate to the CRBRP have been developed which are analogous to and based on the General Design Criteria for water-cooled nuclear power plants.

Because of measures such as these, occurrences that may be anticipated during the plant life are not expected to exceed specified acceptable limits or result in substantial releases of radioactivity. Similarly, design basis accidents will be established and their consequences will be required to be safely mitigated.

In the Commission's safety review, conservative assumptions are used in the calculation of doses from the various design basis accidents. For the Commission's site safety evaluation, extremely conservative assumptions are used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the core to the siting guidelines given in Part 100 of the Commission's regulations.

Realistically computed doses that would be received by the population from these postulated accidents would be significantly less than those conservatively calculated potential doses to be presented in the Safety Evaluation. The Commission issued guidance to applicants on September 1, 1971, requiring the consideration in environmental reports of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. This guidance has since been supplemented in the case of LWRs, including a specification of the events to be considered and the assumptions to be used in assessing their consequences. The applicant's implementation of this guidance in the CRBRP is contained in the ER (Section 7 and Appendix B).

The applicant's environmental report has been evaluated, using accident assumptions and guidance similar to those issued for LWRs. Nine classes of postulated accidents and occurrences with consequences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a low occurrence rate and those on the low potential consequence end have a higher occurrence rate. Table 7.1 lists the nine general classes as outlined in the guidance of September 1, 1971 together with analogous events in the CRBRP.

The accident categories (Classes 1-9) in Table 7.1 were organized so as to enable an assessment of the consequence of the most severe type of accident within any one class. Specific examples of events in each category and their consequences are shown in Table 7.2.

The events in Classes 1 and 2 represent occurrences which are anticipated during plant operations; and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited number of fuel failures, the events in Classes 3 through 5 are not anticipated during the plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The applicant has indicated that the probability of occurrence of large Class 8 accidents is very small. To support his conclusion, the applicant has provided substantial analyses of postulated accidents, including failure mode and effect analyses of both the reactor shutdown and decay heat removal systems, as well as a number of other analyses relating to the probability of potential accidents that might involve large releases of radioactivity. The applicant has committed to continue to pursue an extensive design review and R&D program, to assure that the likelihood of accidents is made low, as the design progresses.

The postulated occurrences in Class 9 involve sequences of successive failures that are considered to be less likely than those required to be considered in the design bases of protection systems and engineered safety features. Their consequences could be severe. However, as with LWRs, the probability of their occurrence will be made so small that their environmental impact will be acceptably low. This can be accomplished by means of defense in depth (multiple physical barriers), quality assurance for design, manufacture and operation, continued surveillance and testing, and conservative design.

A complete listing of events which must be accommodated in the design bases of the CRBRP has not yet been developed since the design is still under review. The CRBRP PSAR is currently being reviewed to determine whether two types of accidents with potentially severe consequences are sufficiently likely that additional provisions should be included in the design to further reduce the risks associated with them. These two accidents are identified as "large rupture of primary piping" and "events leading to core disruption." The applicant has provided information to support his view that such events are very unlikely and need not be considered in establishing the plant design bases. Recognizing the possibility that this view may not be sustained, the applicant has identified special provisions in the design which would be included to accommodate either or both types of events, should there be a requirement to do so.

These events have been assigned as both Class 8 and 9 events in the environmental review of this facility. For the case where such events are considered as Class 8, their consequences have been assessed by the staff by assuming that the special provisions identified by the applicant as being required are included in the design and are effective. For the case where such events are considered as Class 9, it was assumed that no special provisions were included in the design to accommodate such events.

These two events and other very unlikely events have been considered, as discussed below, to provide a preliminary perspective that the consequences associated with Class 9 events at the CRBRP would not be substantially different from those associated with Class 9 accidents in light water reactors.

As more detailed design information becomes available and the results of R&D programs are obtained, a better understanding will be gained of the likelihood and effects of core disruptive accidents and their associated radioactive releases. Thus, the risk perspectives relative to Class 9 events which are presented below will be further developed as an ongoing effort by the applicant as the design is completed and the facility constructed. This effort will p[illegible]ide an overview assessment and aid in confirming that the accident risks in the CRBRP have b[illegible]ade comparable to previously licensed reactors. It is recognized that the conduct of such a study for the CRBRP demonstration plant cannot be accomplished with the depth or precision possible for completed and operating reactors, such as those evaluated in WASH-1400, nor is this required. The important point is that systematic and disciplined evaluations of the plant design (to identify potential causes and pathways for serious accidents which could result in significant releases of radioactive material to the environment) provide additional assurance that the important safety considerations are identified so that any required design accommodation can be effectively implemented.

TABLE 7.1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	DESCRIPTION	EXAMPLES (9/1/71 LWR GUIDANCE)	CRBRP EXAMPLES-GENERAL
1	Trivial Incidents	Small spills Small leaks outside containment	Single seal failures, minor sodium leaks
2	Misc. Small Releases Outside Containment	Spills Leaks and pipe breaks	IHTS valve, seal leaks, condensate storage tank valve leak Turbine Trip/Steam venting
3	Radwaste System Failures	Equipment failure Serious malfunction or human error	RAPS/CAPS valve leaks RAPS surge tank failure cover gas diversion to CAPS Liquid Tank leaks
4	Events that release radioactivity into the primary system	Fuel failures during normal operation. Transients outside expected range of variables	Loss of hydraulic hold-down Sudden core radial movement Maloperation of Reactor Plant Controller
5	Events that release radioactivity into the secondary system	Class 4 & Heat Exchanger Leak	Class 4 & Heat Exchanger Leak*
6	Refueling accidents inside containment	Drop fuel element Drop heavy object onto fuel Mechanical malfunction or loss of cooling in transfer tube	Inadvertent floor valve opening Leak in CCP in EVTM Drop of fuel element Crane impact on head
7	Accidents to spent fuel outside containment	Drop fuel element Drop heavy object onto fuel Drop shielding cask--loss of cooling to cask Transportation incident on site	Shipping cask drop EVST/FHC system leaks Loss of forced cooling to EVST
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Reactivity transient Rupture of primary piping Flow decrease-Steamline break	S-G leaks Steamline break Primary Na storage tank failures Cold trap leaks Large rupture of primary piping** Events leading to core disruption**

TABLE 7.1 (Continued)

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	DESCRIPTION	EXAMPLES (9/1/71 LWR GUIDANCE)	CRBRP EXAMPLES-GENERAL
9	Hypothetical sequences of failures more severe than Class 8	Successive failures of multiple barriers normally provided and maintained	Successive failures of multiple barriers normally provided and maintained**

*The CRBRP has a closed cycle secondary heat transport system which separates the primary coolant from the power conversion system. Class 4 failures and coincident heat exchanger leaks therefore do not result in a significant release to the environment.

**Whether the design bases should include capabilities to accommodate these events is presently under review. A group of design features (called the Parallel Design by the applicant) is proposed should accommodation of these events be required. In the staff's environmental review, these events were treated as both Class 8 events (in which case the Parallel Design features were assumed to be included and effective) and Class 9 events (in which case the Parallel Design features were assumed not to be included).

TABLE 7.2

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

CLASS	EVENT	ESTIMATED DOSE AT SITE BOUNDARY (REM)
1.0	Trivial Incidents	1/
2.0	Small releases outside containment	1/
3.0	Radwaste System Failures	
3.1	Leaks in liquid waste storage tanks	<0.001
3.2	Failure of liquid waste storage tank	<0.001
3.3	Rupture of RAPS surge and delay tank	2.07 (whole body)[2/]
4.0	Events that release radioactivity into the primary system	<0.001[3/]
5.0	Events that release radioactivity into secondary system	<0.001
6.0	Refueling accidents inside containment	
6.1	Inadvertent floor valve opening, reactor port plug removed	<0.001
6.2	Drop of fuel assembly in loaded position	<0.001
7.0	Accidents to spent fuel outside containment	
7.1	Loss of Forced Cooling to EVTM	0.012 (thyroid), <0.001 (whole body, bone)
7.2	EVST pipe rupture @ pump suction	<0.001
7.3	Shipping cask drop	0.02 (whole body), 0.66 (thyroid)
8.0	Accident initiation events considered in design basis evaluation in the SAR	
8.1	Steam-Generator tube rupture	<0.001
8.2	Steam line break	<0.001

TABLE 7.2 (Continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

CLASS	EVENT	ESTIMATED DOSE AT SITE BOUNDARY (REM)
8.3	Large primary system rupture (parallel design only-doess not result in core disruption)	0.005 (whole body), 0.002 (thyroid), 0.020 (bone)
8.4	Loss of flow w/o scram[4/] (parallel design only)	0.29 rem (whole body), 4.4 rem (thyroid), 11 rem (bone)[5/]

[1/] These releases are expected to be in accordance with Appendix I for routine effluents.

[2/] The RAPS surge and delay tank is conservatively assumed to fail instantaneously. This accident was selected to bound the failures that might occur in the systems processing the CRBRP cover gas. It is assumed that the cell housing the tank will leak at 100 v/o per day or less. During the Commission's safety evaluation, the staff will assure that the plant criteria are consistent with that assumption.

[3/] Assumed fuel failures; the primary system is effectively isolated from the steam generators by the intermediate heat transport system. Consequently, releases are generally insignificant.

[4/] This is an example only of the general category of events leading to core disruption, and is not necessarily the most severe of the accidents that would be required to be accommodated by the special provisions of the Parallel Design.

[5/] Because this accident is still under review, a scoping analysis was performed. Further reviews are underway to better define an appropriate source term for this type of accident. The staff will require that the conservatively calculated consequences of this event to be used for the safety review of the parallel design case not exceed 150 rem to the bone, 25 rem to the whole body and 300 rem to the thyroid, and that realistically analyzed consequences be at least a factor of 10 below these above mentioned values. Therefore, the values cited for accident 8.4 represent consequences that are not likely to be exceeded.

The staff has considered the information available at this time and conducted preliminary assessments of very unlikely accidents and events involving multiple successive failures, particularly those which may result in core melting or severe core damage.

In implementing the Commission's requirements, an applicant, such as in the CRBR project, must provide a design which can safely withstand a wide spectrum of anticipated and unlikely failures and accidents. In so doing, the design is made such that the probability of accidents leading to severe core damage or substantial releases of radioactivity is very remote. To illustrate, it is expected that once or twice during the plant lifetime all offsite power will be lost. When this occurs, power to main heat transport system pumps is lost, resulting in a loss of normal flow. The reactor is shutdown but decay heat is generated and must be removed if damage to the fuel is to be prevented. Because of the importance of effective decay heat removal, redundant auxiliary feedwater systems (AFWS) are required. Even if a failure were to occur in one component of the AFWS, the event would not result in a significant release of radioactivity. To further assure that the probability of AFWS failure is extremely low, diversity of design and selection of high quality components are also provided. For example, one AFWS train includes a 100% capacity steam driven pump and is powered by batteries; the other includes two 50% capacity electric pumps and is powered by diesel generators. Yet, an additional system (the Overflow Heat Removal System) is available for use in decay heat removal on an emergency basis, if needed. A comparison of selected accident sequences with the results of similar sequences analyzed in the Reactor Safety Study (WASH-1400) provides an additional basis for gaining perspective on risks of very severe accidents in CRBRP.

For example, the loss of all offsite power for an extended period of time ($\geq$ 30 minutes) is an event which, for both LWRs and the CRBRP, requires proper functioning of decay heat removal systems. A probability of occurrence of $\approx 4 \times 10^{-2}$ per reactor year was assigned for the extended loss of offsite power in WASH-1400 (cf. Figure I 4-11). In the case of PWRs, the WASH-1400 assessment for failure of the decay heat removal systems following this event, due to a coincident failure of the auxiliary feedwater system (AFWS), is $\approx 1 \times 10^{-4}$. Thus, the probability of a core melt due to this accident sequence was assessed to be approximately 4×10^{-6} per year. This scenario also results in core melt in the CRBRP. The probability of the CRBRP losing offsite power for over 30 minutes would also be 4×10^{-2} per year. Since CRBRP AFWS system has design bases and employs components similar to those in PWRs, it is reasonable to expect that it can be designed and operated in such a manner that the probability of its failure can be made comparable to that in a PWR. In this case, the probability of a core melt in the CRBRP by this sequence would also be in the range of 4×10^{-6} per year.

The other general type of failure associated with a loss of offsite power is failure of the reactor shutdown system.* This event is not predicted to lead to core melt in current generation PWRs but could do so for the CRBRP and has the potential to cause core disruptive accidents. However, if the unavailability of the CRBRP shutdown system given loss of offsite power is sufficiently low, this scenario would not contribute significantly to the overall probability of core disruptive accidents associated with loss of offsite power. If a shutdown system were designed, constructed, and operated in such a manner that the unavailability of the shutdown system is in the range of 10^{-5} to 10^{-6} per demand, this scenario would contribute only 1% to 10% to the total probability of core disruption given loss of offsite power. The assessments that have been made of LWR shutdown systems indicate that they have system unavailabilities in this range. Thus, it appears that the CRBRP should be able to attain an unavailability in this range. Therefore, the likelihood of a core melt resulting from loss of offsite power coupled with additional failures would be comparable to that of LWRs.

While the PWR can accommodate many reactor transients combined with failure of the reactor shutdown system without core melting, the same is not true of the CRBRP. Partially due to this factor, the CRBRP includes two reactor shutdown systems. Multiple and diverse sensing and logic systems, in conjunction with two separate and diverse reactivity control rod systems, are included. The applicant has proposed a very extensive reliability engineering and development program to identify and eliminate potential weaknesses in the design and to assure that shutdown system action will occur when needed. The applicant argues that these provisions provide a substantially greater probability (than in LWRs) that the reactor shutdown system action will function properly in the event of loss of offsite power or other transient. Additional, but limited, capabilities to accommodate the effects of core disruption are being provided to further reduce the risks associated with such events (note: additional capabilities are proposed through the parallel design to accommodate a conservatively established set of conditions that might be associated with such events should it be required).

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*As used herein, shutdown system failure means failure of significant reactivity insertion by the control rods on demand.

Other events have been considered, such as a loss of coolant accident. In the CRBRP, very large ruptures of the reactor coolant boundary (that is, equivalent to the double-ended rupture of the largest pipe) may lead to core disruption. Such an event, by itself, would not do so in an LWR because emergency core cooling systems are included in the design and would prevent core damage. However, the applicant has argued that the probability of a pipe break which would progress to core disruption would be exceedingly small. The applicant has taken the position (under review) that a major failure cannot occur suddenly (using a fracture mechanics arguments) and sensors can be provided to detect smaller failures or leaks. These measures, in combination with efforts to provide a very high quality system, are considered by the applicant to render the probability of such an event so low that specific provisions to accommodate the consequences of a large pipe break are not required. The Parallel Design does include alternative features proposed to prevent a large LOCA from progressing to core melting (such as a pipe sleeve to limit the amount of sodium released), should further evaluation indicate a requirement to do so.

The staff's preliminary assessments of events of the type in Table 7.3, such as the ones discussed above, indicate that some of the events considered are likely to have similar or less likelihood of progressing to core melting and disruption in the CRBRP compared to LWRs. On the other hand, for some events, a shutdown system substantially more reliable than in LWRs must be shown or the consequences of the event must be controlled, or both, if accident risks for those events are to be made comparable to similar events in LWRs. We believe that the technology exists or can be developed in a timely manner to accomplish this goal in the CRBRP and that the costs to do so would not be prohibitive.

In Appendix B to the CRBRP ER, the applicant presented an assessment of the consequences of core disruptive accidents for the CRBRP, which in turn is based on material provided in Appendix F of the PSAR. The applicant's conclusion was that the consequences would not exceed the values of 10 CFR 100. The staff's assessment of the possible consequences of events progressing to core disruption led to the following grouping or scenarios:

I. Primary system remains intact; no major release of radioactive materials.

II. Primary system initially intact but ultimately fails due to ineffective long term decay heat removal (of the order of hours or more);

(a) With special provisions for containment decay heat removal,* containment is maintained. Sodium and some fission products are volatilized and leak to outer containment and are ultimately released to the atmosphere; resultant consequences are within 10 CFR 100.

(b) With no special provisions for containment decay heat removal, the steel liners in the reactor cavity fail either through penetration of the core debris or due to excessive steam pressure (from water released in heated concrete structures). The reactor cavity atmosphere would be pressurized beyond its design value in two hours or less. Ultimately, the sodium boils off. Outer containment fails due to overpressurization. Core debris may continue to penetrate into concrete. Fission products are volatilized and released. Consequences may exceed 10 CFR 100 guideline values.

III. Primary system seals fail due to excessive mechanical and/or thermal loads. Some sodium fuel vapor and fission products are expelled into the head access area. Longer term consequences as in II above.

IV. Primary system fails due to excessive mechanical loads. Outlet piping (three loops) fails and sodium is expelled into the reactor guard vessel. Substantial quantities of fuel, sodium or sodium vapor and fission products are released to the outer containment. Initial failure of the containment due to these effects is possible. Longer term consequences as in II above.

The processes and phenomena that can potentially be operative and affect the sequences or scenarios involving core disruption include: fuel failure mechanisms, locations, timing and coherence; fuel relocation; thermal interaction of fuels and other materials with coolant and structures, recriticality conditions; thermal to mechanical energy conversion; and the dynamic mechanical and thermal loadings on structures.

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*The applicant has proposed to provide an ex-vessel core catcher, with cooling of the sodium pool to accommodate a loss of primary system integrity through core melting. The applicant has additionally proposed that the head access area be sealed and made leak tight should such events be considered in the design basis. Such a feature would also mitigate Scenarios I-IV or a range of such scenarios.

TABLE 7.3

GENERAL CLASSES OF EVENTS POTENTIALLY LEADING TO CORE MELTING OR DISRUPTION

	Initiating Event	Coincident Failures or Conditions
A.	Reactivity Transients	(1) No Reactor Trip (RT), no Pump Trip (PT), ramp terminated at trip point, or
		(2) No RT, PT, ramp terminated, or
		(3) No RT, PT, ramp continues beyond trip point, or
		(4) No RT, no PT, ramp continues
B.	Loss of Heat Sink Transients	(1) No PT, no RT, or
		(2) PT, no RT, or
		(3) PT, RT (complete loss of sink only), or
		(4) Loss of one loop, no RT
C.	Single Unlikely Faults	
	. Large Gas Bubble (leads to limited duration reactivity insertion and channel voiding)	
	. Moderator in the Coolant (leads to limited duration reactivity insertion)	
	. Assembly Failure and Propagation, no RT	
	. Primary System Rupture	(1) PT, no RT, or
		(2) PT, RT, or
		(3) No PT, RT, or
		(4) No PT, no RT
	. Larger than Design Basis External Event (tornado, earthquakes, etc.)	

NOTES ON TABLE 7.3

1. Reactivity transients include both anticipated and unanticipated transients - from inadvertent rod withdrawal at normal speed to hypothesized multiple failures of the rod controller system. Core melting dose not result with those reactivity addition rates unless coincident failures of the shutdown systems occur. The consequence is an increasing fuel temperature which, depending on the conditions, may result in fuel failure or hot channel boiling in times ranging from seconds (rapid transient - ten's of cents per second or more) to minutes or more. Core disruption does not result unless other coincident failures occur.

2. The coincident conditions relate to the type of failure of the reactor protection system that might be postulated. For example, no RT, no PT might be attributed to a failure of the sensing devices or multiple electronic failures. PT, no RT might result from a mechanical failure of both reactor shutdown systems.

3. Loss of heat sink transients include such events as a pump failure where of the order of 15 - 20 minutes is available before reactor shutdown is required as well as events such as a loss of offsite power where reactor shutdown is required on the order of 8 - 10 seconds. The loss of offsite power/failure-to-scram event has been considered in depth in contemporary fast reactor safety evaluations, in part because of the demands for prompt shutdown action and in part because the consequences of this type of event may be more severe than other core melt accident scenarios.

The applicant has argued that severe mechanical damage is not physically realizable and that future R&D will confirm this view. This matter is being considered in the staff's safety review. The staff's preliminary finding is that the CRBRP is capable of accommodating a wide range of core disruptive events, and consequently that sequence identified as Scenario IV above is very unlikely, even assuming that core distruption were to occur. The applicant's evaluation of the realistic consequences of events leading to core disruption (which concluded that the primary system would remain intact) indicated that, with the special provisions outlined above, events of this type involved relatively modest releases of radioactivity to the environment and since the probability of such events is extremely low, the risks of accidents of this type are very low. The staff's preliminary assessment supports this view. However, the longer consequences of such events, without the special provisions outlined in II.a above, could be severe.

Some perspective on the magnitude of the consequences of a large release of radioactive material can be gained from the Reactor Safety Study. For the equilibrium core of a 1000 MWe LWR and the largest release fractions assumed therein, no early (< 1 year) fatalities and only about 1% and 5% of the latent cancer fatalities are attributable to plutonium and strontium isotopes, respectively (i.e., the rest are attributable to other fission products). A comparision of the equilibrium core in the CRBRP to that assumed in WASH-1400 shows that the inventory of significant fission products is about three-fold lower and the plutonium inventory is not significantly different. Although sufficient information is not available to reach firm conclusions on the release fractions potentially associated with the spectrum of possible core disruptive accidents, the release fractions for all isotopes except strontium and plutonium cannot be more than a factor of two higher since the assumed fractions in WASH-1400 were between 0.4 and 0.9. Since plutonium and strontium were such relatively small contributors to the consequences, even if their release fractions were ten-fold higher, the overall consequences from a CRBRP accident would not be substantially different from those predicted by the Reactor Safety Study for LWRs. The above argument, of course, does not account for the sodium which might be released from the CRBRP. We believe that the release of massive quantities of sodium, coincident with a core melting event, would not result in significantly greater consequences than those already estimated in the Reactor Safety Study. Further work will be required and is planned to confirm this assessment. As a preliminary assessment, it appears to be within the state-of-the-art to design, construct and operate the CRBRP in such a manner that the consequences of accidents will not be significantly different from those already assessed for LWRs.

The design information and evaluations available at this time have been reviewed. Our preliminary conclusion is that the accident risks can be made acceptably low through a combination of methods. It is expected that the Commission's safety evaluation can provide the basis for determining what plant features and R&D programs are acceptable in this regard. As the safety review progresses and the design develops, more precise assessments will be performed to confirm this preliminary conclusion.

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVE MATERIAL

Within the United States over the past 25 years, there have been about 300 reportable accidents in transportation involving packages of radioactive material. About 30% involved releases of contents or increased radiation levels, and none resulted in perceptible injury or death attributable to radiation. Millions of packages of radioactive material, including more than 3600 packages of irradiated fuel, have been transported during that period by the general modes of transport.

The probability of an accident in transporting radioactive materials is small. In 1969, statistics indicated an accident rate for hazardous materials shipments of 1.69 per million vehicle-miles; rates for severe and extremely severe accidents were about 100 times smaller and 10 million times smaller, respectively (WASH-1238, December 1972). Based on a shipping distance of 750 miles and the above accident rate of 1.69 accidents per million vehicle-miles, a shipment to or from the CRBRP might be involved in an accident once in about 800 shipments. Further, assuming an average of 100 shipments of radioactive material and a total shipping distance of 100,000 vehicle-miles per year, a shipment associated with the CRBRP might be involved in a transportation accident once in about 8 years. On the basis that extremely severe (Category 5) accidents occur 10 million times less often, the probability of such an accident to a shipment associated with the CRBRP is therefore 1.25×10^{-8}/year.

Primary reliance for safety in the transport of radioactive material is placed on the packaging (WASH-1238; 10 CFR 71). Both the package design and the quality assurance exercised in its manufacture, use and maintenance must comply with the requirements of 10 CFR Part 71. The regulatory standards established by the Nuclear Regulatory Commission, The Department of Transportation, and the various agreement states provide that packaging of radioactive materials shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear criticality safety, and provide adequate heat dissipation under normal conditions of transport and under specified accident damage test conditions (WASH-1238). Thus, a breach in the containment of a package involved in an accident is unlikely to occur.

The CRBRP irradiated fuel assemblies will be producing large amounts of heat and penetrating radiation after removal from the reactor core. They will be stored at the plant for about 360 days to permit these emanations to subside before being shipped in casks to a reprocessing facility. The cask primary coolant being considered is phenyldiphenyl eutectic, although helium is a possible alternative (WASH-1535, p. 4.5-18). The spent fuel cask is assumed to be designed to carry cooled assemblies and to be built to current standards with current technology. From these assumed conditions, it appears that the consequences of extremely severe accidents would be no worse than those postulated for current LWR fuel shipments if they were involved in a similar accident. When both probability of occurrence and extent of consequences are considered, the risk to the environment due to radiological effects from transportation accidents is very low. Even extremely severe postulated accidents involving shipments of irradiated fuel and waste from a plant would result in potential doses that constitute small risk to individuals and to the general population. This is illustrated by the data presented in Table 8 which quantifies the individual and population doses resulting from the Category 5 accidents involving spent-fuel casks and low-level beta-gamma waste packages. Individual doses in Table 7.4 were calculated for an adult standing 50 meters from the accident for a ground level release. Population doses were calculated for a population beyond 50 meters and within 50 miles of the accident.

Dose estimates for spent fuel cask shipment accidents involving a fire would result in values that are about 5 orders of magnitude lower than those reported for the spent fuel case in Table 7.4 (WASH-1535).

Comparison of the data in Table 7.4 with NCRP (1971) recommendations permitting individual occupational exposures of 5 rem whole body dose and 15 rem for other organs during any one year indicates that the potential consequences are not unacceptable for a single acute exposure. In addition, the population man-rem doses can be compared with the man-rem dose received by this same population each year due to normal background radiation.

Unirradiated fuel transportation accident risks are not considered to be significant since α-emitters in the fuel do not present an external radiation hazard and since the absorption of radionuclides in the atmosphere or food chain is unlikely. The CRBRP unirradiated fuel assemblies would be shipped in packages similar to those used for shipping LWR fuel.

Considering the low probability of a shipment of radioactive material being involved in an accident, the requirements for package design and quality assurance, the nature and form of the radioactive material, and the controls exercised over the shipment during transport, the staff concluded that the risk of radiation injury from transportation accidents involving radioactive material from CRBRP would be very low.

TABLE 7.4

POTENTIAL INDIVIDUAL AND POPULATION DOSES RESULTING FROM CATEGORY 5 ACCIDENTS[a] DURING THE TRANSPORTATION OF RADIOACTIVE MATERIAL FROM THE CRBRP[(d)]

Shipment	Accident Description	Maximum Hypothetical Individual Dose (rem)		Population Dose (man-rem)	
		Lung[bc]	WHOLE BODY	LUNG[bc]	WHOLE BODY[b]
Spent-fuel cask	Rail car carrying a cask derails. All rods in 4 assemblies damaged such that the gaseous fission products are released at ground level in a short time.	36	2.8	18	1.4
Low-level beta-gamma waste package	Truck accident in which drums are ruptured and part of the combustible waste burns (5.93 Ci released).	4.8×10^{-5}	1×10^{-6}	0.14	3.0×10^{-3}

a. Category 5 accidents are the most severe postulated accidents involving spent-fuel casks and low-level beta-gamma waste packages.

b. The doses shown assume cesium was released and soluble for whole body dose calculations, but insoluble for lung doses.

c. Lung dose is the highest organ dose.

d. Doses in this table were developed from Table 4.5-35 of the Proposed FES for the LMFBR Program (WASH-1535).

7.3 SAFEGUARDS CONSIDERATIONS

Safeguards considerations for the CRBRP reflect three distinct areas of concern. These are (1) risks from an act of sabotage directed toward the plant itself, (2) risks from an act of theft or diversion from the plant of fuel containing special nuclear material, and (3) risks of either sabotage or theft during transit of fuel to or from the plant. The Commission's regulations take cognizance of these matters in 10 CFR Parts 50, 70, and 73. The requirements of these regulations are summarized in Annex A of Appendix E to this statement. Implementation of the physical protection requirements therein is evaluated in conjunction with the radiological safety review of the application. The CRBRP must have an approved security plan in effect prior to arrival of fuel on site. This plan, when taken together with the inherent protection afforded by design to stringent safety standards, should assure that there will be no significant increase in the overall risk of death, injury or property damage to the public from overt or covert acts of sabotage, theft or diversion.

7.3.1 Sabotage

Acts of sabotage directed toward operating electrical generating stations are relatively rare occurrences. Experience (McCullough, Turner and Lyerly, 1968; SAND-0069, 1975) shows that persons motivated to do damage to a public utility are far more likely to attack its transmission and distribution system rather than its generating stations. Such acts, in and of themselves, while damaging to the utility involved, do not have significant impact on the public. It is not unheard of in the industry to experience threats or acts of sabotage by disgruntled employees (e.g., during periods of labor unrest). However, the history of the utility industry suggests that it has fostered and maintained a high order of loyalty among its employees so that such threats and acts as have occurred from this source tend toward nuisances which may temporarily disrupt service, but even that is rare.

The presence of substantial quantities of radioactive materials at the CRBRP suggests the need to consider the possibility of environmental contamination as a consequence of an act of sabotage. Single acts of sabotage directed at an individual component of the plant can generally be expected to have effects which are similar to those arising from single failures. The radiological consequences discussed in Section 7.1 are therefore applicable even if the accidents represented were to be deliberately caused.

More sophisticated acts of sabotage can be postulated for which the consequences could be more severe. The probability for such situations arising from sabotage has not been established quantitatively.* However, an effective safeguards program can be established to minimize the risks involved by providing security systems and physical protection measures designed to counter potential adversary actions. The following identifies the various elements in the anticipated CRBRP Safeguards Program which are intended for this purpose:

1. Employee Screening Program to select competent, reliable, and stable individuals
2. Onsite Security Organization including armed guards
3. Qualification and Training Standards for Security Force Members
4. Security Patrols for Onsite Surveillance
5. Two continuously manned security alarm stations
6. Isolated public reception areas outside the plant protected area
7. Zoned security areas with progressively tighter security for vital areas
8. Multiple physical barriers to impede surreptitious access
9. Clear areas and lighting to assist the surveillance of outdoor protected areas, including glare-type protective lighting for emergency use

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*See Appendix E (Sec 3) for additional discussion of the "nature of the threat."

10. Perimeter intrusion alarm system, together with a closed-circuit TV system, for detection of unauthorized entry

11. Access control of persons, packages, and vehicles entering the plant protected area by utilizing protective measures such as searches, photo-identification badges, and escorts

12. Intrusion alarm systems to detect entry into vital plant areas

13. Card-key control system for vital area access doors

14. Redundant communications systems for contact with law enforcement authorities

15. Arrangements with law enforcement authorities for assistance in dealing with security threats

In addition to the above safeguards provided for countering various adversary actions, the inherent design features of the CRBRP will also supplement the safeguards objective. The safety related portions of the plant structures, systems, and equipment will be designed and constructed to provide a reasonable assurance of protection against natural phenomena and the consequences of potential accidents. These structures will be built to resist a tornado or tornado-generated missiles and forces due to high intensity seismic shock. Furthermore, the biological shielding provided for reducing radiation levels throughout the plant results in heavily reinforced and massive barriers. Thus, the inherent structural characteristics of the CRBRP results in well protected, blast resistant structures resistant to penetration and provides a facility at which intentional damage would be extremely difficult. These features, together with the additional safeguards measures discussed above, provide adequate protection against the occurrence or effects of sabotage.

7.3.2 Special Nuclear Materials Safeguards

The consequences resulting from the successful theft or diversion of SNM from the Clinch River Breeder Reactor Plant are the same as the potential consequences discussed in Appendix E resulting from the theft of material in transit.

Special safeguards will be provided at the CRBRP to prevent the successful theft of SNM. In addition to those security measures previously discussed for the prevention of sabotage, the following safeguards will also be provided:

1. Special Nuclear Material will be stored only in areas designated as material access areas. Such areas are normally restricted to the activities associated with the handling and storage of SNM.

2. Multiple barriers meeting the design criteria specified in subsection 73.2(f) of 10 CFR Part 73 will be provided for the SNM storage area.

3. All material access area ingress and egress points will be controlled. Appropriate search provisions will be established for all personnel and packages entering and leaving such areas. Personnel activities within such areas will be under observation.

4. Unoccupied material access areas will be locked and protected by intrusion alarms.

At the CRBRP, the fuel assemblies containing SNM will normally be located in either the core or the fuel storage facilities except for periods of fuel transfer or inspection and preparation for shipment in the fuel handling cell. The storage facility for both new and spent fuel will consist of a 26 ft by 50 ft deep concrete vault. The fuel will be stored in a vessel, within the vault, which is filled with sodium. The top of the vessel will be provided with a cover plate and a 20-inch thick steel shield. The movement of fuel at the CRBRP will require the use of highly sophisticated handling equipment. And in the case of irradiated fuel, massive shipping casks will be required for protection against the high radiation levels. The above, together with the security system and physical protection program planned for CRBRP, establishes the plant site as one of the least vulnerable locations in the fuel cycle with respect to the theft or diversion of SNM.

7.3.3 Safeguards Costs at CRBRP

The capital and operating costs associated with the safeguards measures necessary to protect the CRBRP against acts of industrial sabotage and diversion of SNM will not significantly impact upon the cost-benefit balance. The staff has estimated that the incremental capital and annual operating costs for providing an adequate safeguards program at the CRBRP should not exceed $2 million and $1 million, respectively. These costs are over and above those items required in the construction and operation of the plant which would normally be provided for the routine operation, safety, and conventional security of such a facility.

7.3.4 Other Safeguards Costs Relative to CRBRP

As indicated in Appendix E (Sec. 7) to this statement, the use of existing plutonium fuel facilities for the production of CRBRP fuel should not give rise to significant additional fixed-site safeguards. Since the transport of fuel assemblies is likely to be done by a contractor, there would be no capital cost to the project for safeguards measures related to transport; however, the annual cost of these measures should not exceed $890,000.

8. NEED FOR THE PROPOSED FACILITY

8.1 THE LMFBR PROGRAM

The breeder concept has been the subject of worldwide interest for almost two decades because of the view that breeders have the potential for greatly extending effective energy resources. One concept, the liquid metal fast breeder reactor (LMFBR), has been studied since the early 1950s. In a 1962 report to the President (USAEC, 1962), the AEC recommended intensive development and, later, demonstration of the breeder concept. In the mid-1960s, greater emphasis was given to the LMFBR program and several industrial groups, in cooperation with utilities, conducted studies of demonstration concepts.

These efforts continued to the point where the AEC was authorized (on July 11, 1969) to conduct the project definition phase (PDP) of an LMFBR demonstration project. The PDP was the first step of a two-phase approach and was intended to lead to a "definitive contractual arrangement for the design, supporting R&D, construction and operation of a specific plant" (USAEC, 1969). Three reactor manufacturers, Atomics International Division of North American Rockwell Corporation, General Electric Company and Westinghouse Electric Corporation, participated in the PDP under cooperatively funded contracts with the AEC and about 90 utilities While the program was underway, the AEC was authorized on June 2, 1972, to enter into a cooperative arrangement with industry for the development, design, construction and operation of an LMFBR demonstration plant.

In April 1971, the AEC established advisory committees (Senior Utility Steering Committee and Senior Utility Technical Advisory Panel) consisting of management and engineering executives from the electric utility industry, as well as senior AEC representatives, to review and evaluate plans for the LMFBR Demonstration Plant Program. Their deliberations (which are recorded in WASH-1201) and their determinations ultimately led to the AEC's selection of the CE/TVA proposal and the Clinch River Breeder Reactor Plant.

Although the decision to proceed with an LMFBR demonstration project preceded NEPA, in 1972 the AEC issued an environmental statement identifying the project objectives and providing information on options and alternatives regarding the plant (WASH-1509). In 1973, the AEC initiated preparation of an environmental statement on the overall LMFBR Program (WASH-1535). The draft statement was issued in March 1974, and a proposed final environmental statement (PFES) was issued in February 1975.

The PFES was prepared by the AEC to comply with the decision of the U. S. Court of Appeals, District of Columbia Circuit, in Scientists Institute for Public Information, Inc., vs. Atomic Energy Commission et al., 481 F. 2d 1079 (June 12, 1973). The Court held that the AEC was required by the National Environmental Policy Act of 1969 (NEPA) to issue a statement on the environmental impact of the LMFBR Program as a whole, including ramifications of commercial deployment and alternative courses of action.

Since the formation of the NRC and ERDA in January 1975, further actions on the NEPA review of the LMFBR Program have been the responsibility of the Energy Research and Development Administration (ERDA). A public hearing on the PFES was held on May 27-28, 1975. On June 30, 1975, the ERDA Administrator issued his findings that "(t)he PFES amply demonstrates the need to continue research, development and demonstration of the LMFBR concept." He indicated also a need for examination of the current developmental program and consideration of alternative methods of conducting the program "to be sure that:

(a) the research, development and demonstration activities are properly directed to resolve the remaining technical, environmental, and economic issues in a definitive and timely way;

(b) these issues are resolved before a final decision concerning the acceptability of commercial deployment is made; and

(c) test and demonstration facilities that are needed in the LMFBR program are conservatively designed to protect the health and safety of the public and to provide useful information for subsequent environmental economic, and technical assessments," (ERDA, 1975).

The PFES has been supplemented and amended to provide the results of the reviews called for by the Administrator. The resulting documentation constitutes ERDA's Final Environmental Statement

(FES). The statement summarizes the LMFBR Program, of which the CRBRP is one element. As indicated in the Administrator's findings and Section I of the FES, ERDA concludes that there is a need to continue research, development and demonstration of the LMFBR concept and there is no presently available or prudent alternative to this course of action. The structure and pace of this effort is described in the Administrator's findings of December 31, 1975 in order "to provide a more dispositive assessment and to resolve areas of uncertainty in a timely manner."

The overall benefits of the LMFBR program are stated by the Administrator (in the FES) as follows:

> "This technology holds the promise of an essentially inexhaustible source of energy to satisfy a significant share of this Nation's energy needs in the next century. While LMFBR technology is not the only technology which may be able to satisfy this objective, significant uncertainties concerning timely availability of the other major candidates, which are solar electric and fusion energy, make it risky and imprudent to discard the LMFBR Program on the basis of what we presently know. It is simply too soon to confirm with sufficient reliability that these alternate technologies will be available on time and in adequate quantity. It is speculative at this time that these options would be environmentally preferable to the LMFBR technology. Moreover, while I do not adopt any particular growth projection, including those postulated in the PFES, I cannot now discount the possibility that contributions from all three technologies will be desirable or needed to meet future energy demands. The possible needs are such, and the promise of energy from inexhaustible sources so great, that all three technologies must be pursued on a priority basis." (ERDA 1975)

The Administrator subsequently concluded in his findings of December 31, 1975 that:

> "On the basis of the material set forth in the FES, I find that if the reference plan and its supporting programmatic efforts are vigorously pursued, sufficient information would be available as early as 1986 to resolve the major uncertainties affecting widespread LMFBR technology deployment and therefore to permit an ERDA decision on commercialization of that technology. It should be emphasized that availability of the necessary decisional data by 1986 requires the successful and timely completion of a large number of interrelated and parallel efforts. Delay in any of the aforementioned controlling elements will result in a delay of the decision date."
>
> "In conclusion, it must be emphasized that at this stage of LMFBR technology development we do not have all the answers necessary to determine the environmental acceptability, technical feasibility and economic competitiveness of LMFBR technology for widespread commercial deployment. It is to find these answers that ERDA is continuing the research, development, and demonstration program."

8.2 ROLE OF THE CRBRP

As noted in the Administrator's Findings and the FES, licensing of the CRBRP for research, development and demonstration purposes does not constitute a commitment of resources to the future widespread commercial use of breeder reactors. The CRBRP project is designed to provide information regarding the licensing, construction and operating experience which will be considered by ERDA at some future milestone regarding the commercialization of LMFBR technology. The ERDA Administrator has stated that "the current planning schedule calls for preparation and consideration of such a programmatic statement in 1986." Various options, which included schedular considerations for CRBRP, were considered by the ERDA Administrator with the conclusion that "in my judgement, the CRBRP offers the most timely and cost-effective construction, licensing and operating experience essential to the successful completion of the LMFBR Program." (Findings, December 31, 1975.) The identified role of the CRBRP was stated in the PFES as follows: It is a key element in both the engineering and manufacturing phase and the utility commitment phase. In its role as an LMFBR demonstration plant, the principal objectives of the CRBRP are to:

a) Demonstrate safe, clean and reliable operation with high availability in a utility environment.

b) Focus the development of systems and components.

c) Develop industrial and utility capabilities to design, control, operate and maintain an LMFBR.

d) Demonstrate the licensability of LMFBRs.

The CRBRP is the point at which utility companies become deeply involved in the implementation of the LMFBR concept. Utility participation allows utility requirements to be factored into the design and provides the opportunity for utilities to develop the capabilities to maintain and operate LMFBRs. Design and manufacture of the CRBRP will broaden the industrial base for LMFBRs and will provide for utility/vendor interaction with the new technology." (ERDA-1535, Section 1.3B.2)

The specific purposes of the CRBRP, as enumerated in the applicant's ER, are to:

1) Demonstrate that the necessary technology is available to scale up and successfully construct and operate commercial-sized LMFBRs,

2) Provide a technical basis for extending the technology to future commercial plants where improvements in fuel life, plant capacity and thermal efficiency will be made for economic reasons,

3) Develop operating data on the environmental impact of the LMFBR before large numbers of commercialized LMFBRs are constructed,

4) Provide a demonstration of the nuclear parameters necessary for commercial development,

5) Demonstrate the minimal impact from disposal of radioactive waste materials,

6) Demonstrate the equipment on a large scale, and

7) Demonstrate the breeder concept in an industrial environment (ER, p. 1.3-2).

The concept of a demonstration reactor appears to be a sound one, judging from the LWR experience and the fact that nations involved in this technological area are proposing or have constructed LMFBR demonstration reactors. The staff, moreover, does conclude that the identified role of the CRBRP is consistent with the general approach of the LMFBR program. [It is premature at this time to judge whether or not the CRBRP, through its role as a Section 104(b) R&D facility, will operate successfully and thus contribute towards the attainment of the goals outlined above.] There are at present, however, a number of sodium-cooled fast breeder reactors which are operating successfully and thus provide some measure of confidence that successful operation of the CRBRP is a feasible objective. If the CRBRP does operate successfully, the staff concludes that substantial benefits would accrue to the overall attainment of the goals of the LMFBR program.

The Administrator has noted in his findings of December 31, 1975:

> "On balance, I find that the issue of plant operation in a utility environment is best addressed by the program plan entitled reference plan. This plan contemplates construction and operation of the CRBRP, a Prototype Large Breeder Reactor (PLBR), and a Commercial Breeder Reactor (CBR-1) on a schedule which calls for operation for three years of a Nuclear Regulatory Commission - licensed CRBRP and completion of the design, procurement, component fabrication and testing phases for, and issuance by the Nuclear Regulatory Commission of a construction permit, for the PLBR prior to a commitment to construct the CBR-1. In my judgement, this schedule should provide sufficient experience in design, procurement, component fabrication and testing, licensing and plant construction and operation from CRBR and PLBR taken together to enable ERDA to predict with confidence the successful construction and operation of the CBR-1."

Current plans for the CRBRP are for a 5-year formal demonstration period, during which the degree of success of the above stated goals would presumably be assessed. As noted in the Program FES Summary: "In the case of plant experience it is believed that three years of operation after criticality of either the Clinch River Breeder Reactor Plant (CRBRP) or a larger LMFBR is necessary to develop the necessary confidence in the safety, reliability, and maintainability of a breeder reactor system."

Subsequent to the formal 5-year demonstration period, during which CRBRP would be operated in a manner similar to a commercial power plant, the applicant presently anticipates the CRBRP would be used for a number of specific experimental and operational tests (ER, Am 1, Part III, Q5). The continued output of engineering, maintenance and operational data was cited as an input to the design and operation of prototypic commercial LMFBR components and systems (relative to all the specific purposes identified above).

8.3 UTILIZATION OF GENERATED ELECTRICITY

The principal benefit of a commercial nuclear power reactor is the generation of electricity. In this instance, however, electricity generated would be a secondary benefit.

The need for power in the region served by TVA was recently addressed in connection with applications to construct nuclear power reactors in that area (NUREG-75-039). Scheduled additions from June 30, 1974 to the end of 1982 are a total of 18,394 MWe. The electricity generated by the CRBRP would constitute less than 1% of the total system generation during the period of its operation. Therefore, while the CRBRP will assist in meeting projected demand, the need for its generating capacity is concluded to be of secondary importance to the stated objectives of the project.

8.4 SUMMARY AND CONCLUSION

The overall objective of the LMFBR program is to "establish a broad technical and engineering base sufficient to permit industrial involvement required for a commercial breeder industry." ERDA identified the CRBRP as an important element in attaining this objective (ERDA-1535, Section I.B.1). The ERDA Administrator's Findings of December 31, 1975 support this statement and specifically reject those options involving rapid acceleration of the program because of the "lack of any demonstration plant or large plant experience...". Similarly, delays or omission of the CRBRP from the program are stated to be unacceptable (ERDA-1535). The staff concludes that the applicant's discussions of the need for the CRBRP are consistent with existing and prior determinations by ERDA (AEC) arising from the NEPA review of the LMFBR Program. If realized, the benefits deriving from the Program would be of major national significance. The CRBRP, as a key element in the program, can therefore provide a benefit significantly greater than that which might be attributed to the generation of electricity in a generating station of its size.

9. ALTERNATIVES

9.1 ENERGY SOURCES

Alternative energy sources were discussed and analyzed in the Proposed Final Environmental Statement on the LMFBR Program (WASH-1535). They are not considered in this statement because none were considered by ERDA to be capable of fulfilling the general objectives and specific purposes of the CRBRP (Chapter 8).

9.2 SITES

9.2.1 Background

Several sites were proposed to the AEC by reactor manufacturers and utilities during the LMFBR Demonstration Plant Project Definition Phase which ended in 1971. These included the General Public utilities site near Scottsville, Pennsylvania; the ESADA (Empire State Atomic Development Associates) site in New York next to the St. Lawrence River; a site on the Hanford reservation near Richland, Washington; and a site at Savannah River, South Carolina. All of these locations were considered likely to be acceptable (WASH-1201, p 36). However, in the subsequent implementation of plans for the demonstration plant, the AEC and its advisors decided to invite proposals from utilities or groups of utilities which were willing to become the owner-operator of the plant. The proposals received identified only one of the previously proposed locations - the ESADA site in New York. A group of utilities in the northeast suggested a site on the New England Power Company system near Rowe, Massachusetts (WASH-1201, p 459). Commonwealth Edison Company (CE) and the Tennessee Valley Authority (TVA) jointly proposed the location of TVA'a John Sevier Plant near Rogersville, Tennessee, where steam from the reactor would be used to drive existing turbines at the plant (WASH-1201, p 404). An alternative in the CE/TVA proposal was to locate the CRBRP on a new site on the Clinch River at Oak Ridge, Tennessee. The CE/TVA proposal was accepted by the AEC with the understanding that the demonstration plant would be constructed on a suitable site within the TVA power service area (WASH-1201, p 415). TVA's service area encompasses the major waterways in Tennessee and parts of Kentucky, Alabama and Georgia.

9.2.2 Site Selection Criteria

The AEC's advisors had recognized that the considerations applying to LWR site selection should also apply to fast breeder site selection (WASH-1201, p 36). It had therefore been determined that any potential site must not require unusual design features or special licensing considerations and should permit the construction of a plant that would conform with applicable environmental standards. In recognition of the developmental nature of the LMFBR concept, however, an important factor in selecting the site was to assure that the demonstration plant would not have an adverse effect on TVA's ability to provide an adequate supply to the region it serves. The siting criteria used by TVA are summarized (ER, p 9.2-3) as follows:

1. The demonstration plant size will be in the 300 to 500 MWe range;
2. The site must meet physical and environmental requirements;
3. A hook-on plant is preferable to a new plant provided adequate incentives exist;
4. Concerning the hook-on criteria:
    a. The project should not adversely affect TVA's power system operation of system reliability and should permit the use of existing boilers during periods when the LMFBR NSSS is not available for operation; and
    b. Steam conditions and unit sizes of existing steam plant should closely match requirements of the LMFBR demonstration plant;
5. Concerning new site criteria:
    a. The site should be available immediately; and
    b. The site should be one which is not expected to be used for a commercial generating plant in the near future.

The NRC staff considers the above siting criteria appropriate for its own review of the proposed project, with the exception of criterion 5b. While it is understandable that TVA does not wish to commit a site which is usable for large nuclear units, such a site would likely be suitable for the demonstration plant. For this reason, the staff has included several of these sites in its review (Section 9.2.4).

9.2.3 Candidate Plant - Site Alternatives for Hook-On Option

The applicant reviewed all TVA plants that would be operational on a schedule consistent with the demonstration plant to determine their suitability for operation of existing turbines with steam from the LMFBR. These plants and the initial factors used in evaluating them are shown in Table 9.1 (ER, Tab 9.2-1). As indicated, five of the plants appear to be suitable hook-on candidates. However, Colbert, Gallatin and Kingston all were operating and are expected to operate at capacity factors greater than 60%. Due to the relatively high utilization of these plants in meeting system load, TVA believed it prudent to exclude them from further consideration provided Widows Creek units 1-4 or John Sevier units 1-4, which had capacity factors of 50.8% and 54.8%, were suitable for use with the demonstration plant. The NRC staff concurs with this judgment since the average availability of the reactor is unlikely to exceed 55% during the initial 5-year demonstration period (ER, Am I, p A1-73). The extent to which a plant with a normally higher capacity factor is not utilized would represent an undue economic penalty to the TVA system.

TABLE 9.1 TVA Steam Plant Characteristics for Demonstration Plant Siting Adaptability[a]

Plant	Units	Unit Nameplate Capacity-MWe	Throttle Steam Pressure lb/in^2 gage	Throttle/ Reheat Steam Temp. °F	Meets Size Criteria	Acceptable Seismology	Candidate Site
Allen	3	330.00	2400	1050	Yes	No	
Browns Ferry[b]	3	1152.00	950	540	No	--	
Bull Run	1	950.00	3500	1000/1000	No	--	
Colbert	1&2	200.00	1800	1050/1050	Yes		
	2-4	223.25	1800	1050/1050	Yes	Yes	Yes
	5	550.00	2400	1050/1000	No	--	
Cumberland	1&2	1300.00	3500	1000/1000	No	--	
Gallatin	1&2	300.00	2000	1050/1050	Yes	Yes	Yes
	3&4	327.60	2000	1050/1050	Yes		
John Sevier	1	223.25	1800	1050/1050	Yes	Yes	Yes
	2-4	200.00	1800	1050/1050	Yes		
Johnsonville	1-4	125.00	1450	1000	Yes		
	5-6	147.00	1450	1000	Yes	No	
	7-10	172.80	2000	1050/1000	Yes		
Kingston	1-4	175.00	1800	1000/1000	Yes		
	5-9	200.00	1800	1050/1050	Yes	Yes	Yes
Paradise	1-2	704.00	2400	1050/1000	No	--	
	3	1150.20	3500	1000/1000	No	--	
Sequoyah[b]	1-2	1220.58	765	515	No	--	
Shawnee	1-10	175.00	1800	1000/1000	Yes	No	
Watts Bar	1-4	60.00	850	900	No	--	
Watts Bar Nuclear Plant	1-2	1269.90			No	--	
Widows Creek	1-4	140.63	1450	1000	Yes	Yes	Yes
	5-6	140.63	1800	1000/1000	No	--	
	7	575.01	2400	1050/1000	No	--	
	8	550.00	2400	1050/1000	No	--	
X-14 & X-15[b]	1-2	1332.00			No	--	

(a) ER, Table 9.2-1
(b) Nuclear Plants

At John Sevier, units 3 and 4 were selected to accommodate the hook-on arrangement since adequate space is available adjacent to these units for the reactor and other components of the nuclear steam supply system (NSSS). These units have normal steam conditions of 1800 psig at 1050°F, with 1050°F reheated steam; whereas the steam from the reactor would be delivered to the turbine at about 900°F. A separate oil-fired reheater would be added to provide 900°F reheated steam, which would increase the complexity of the project and possibly compromise its demonstration data. The oil-fired reheater would involve added capital and operating costs, and the lower steam temperature would result in a 36 MWe reduction in plant capacity. Nevertheless, a hook-on arrangement at the John Sevier Plant would be feasible, and the NRC staff knows of no reason why it would not be environmentally acceptable.

The normal steam conditions of 1450 psig - 1000°F at Widows Creek units 1-4 are better matched to design objectives of the NSSS and no reheat cycle would be required. Steam from the NSSS would have a higher moisture content which would accelerate the turbine blade erosion somewhat, but not enough to make the arrangement infeasible. Reducing the steam temperature to 900°F would also reduce the plant capacity by 27 MWe. Vacant land near the existing units is sufficient for addition of the NSSS. However, the staff noticed during a recent site visit that a 1000-ft smoke stack is being erected between these units and the river. In view of the accident potential of a toppled stack of this size, a reevaluation of the position of a breeder reactor on this site, and possibly its design, would be necessary if this alternative is considered further.

9.2.4 Candidate Plant - Site Alternatives for New Sites

Eleven new sites, including Clinch River, were studied for the demonstration plant. Their locations are shown in Figure 9.1 (ER, Am I, Part 1, p 340.1). The sites were evaluated by the applicant on the basis of population, seismology, geology, transportation access, nearness to transmission lines, hydrology, and ecology. Some of these factors are shown in Table 9.2. The Spring Creek, Caney Creek, Buck Hollow, and Lee Valley sites were eliminated because of less favorable geologic characteristics. Reasons given for elimination of other sites were:

Murphy Hill - has potential for future commercial power production.

Blythe Ferry - would require construction of 20 mi of new railroad line and 6 bridges.

Taylor Bend - would block access to the tip of the peninsula, or require purchase of an unneeded additional 3030 acres.

Phipps Bend - has potential for future commercial power production.

Hartsville - is being developed for commercial power production.

Rieves Bend - availability of adequate cooling water is questionable.

All of the six sites listed above, except for Rieves Bend, would probably be as acceptable as the Clinch River site from an environmental standpoint. However, the Blythe Ferry and Taylor Bend sites would be more costly or less desirable to develop for the reasons given.

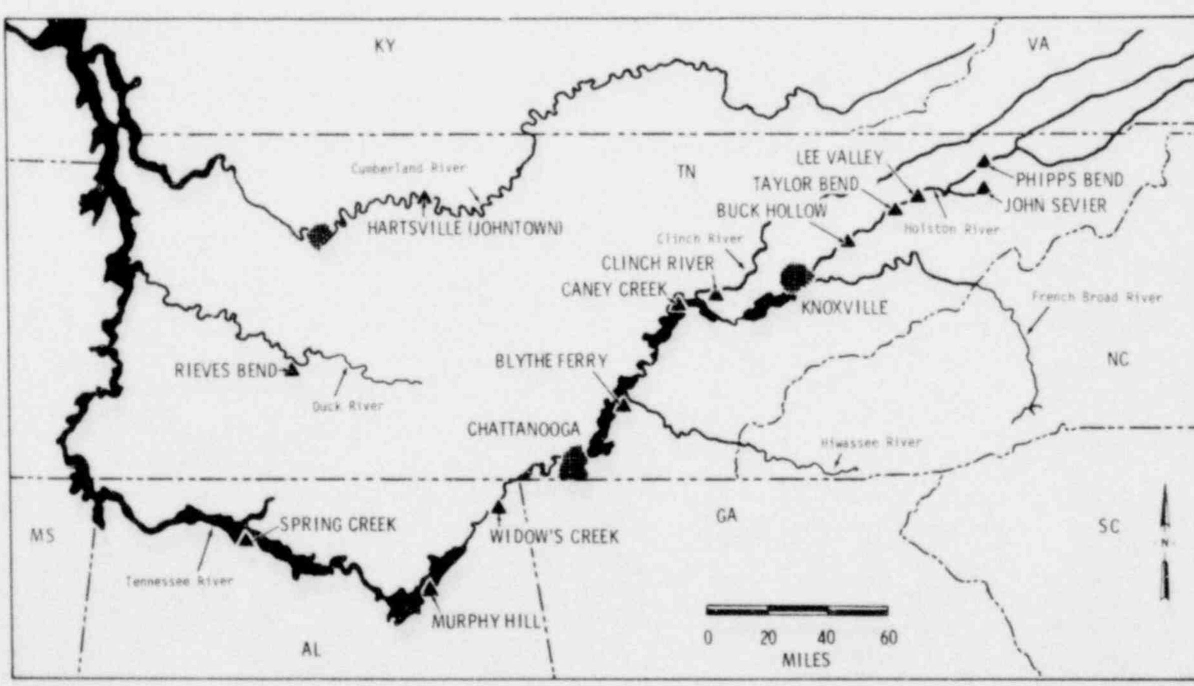

FIGURE 9.1 General Location - Alternative Sites

TABLE 9.2 Site Data for Candidate Sites - New

NO.	SITE	RIV MI	PLT GR EL	MAX POSS FL EL	CONDENSER COOLING	ACCESS FACILITIES HWY	RAIL	BARGE	FOUNDATION CONDITIONS	DIST FROM POPULATED AREAS	TRANS LINES 161 KV
1.	TENN RIVER Spring Creek (Wheeler Res)	283L	580	573	Auxiliary Cooling Req'd	7±mi (Ala20)	7±mi (SOU)	Yes	Not investigated not suitable	18±mi to Athens Ala (pop 14,000±) 19±mi to Decatur Ala (pop 37,800±)	1-3 mi SW
2.	Murphy Hill (Guntersville Res)	370L	618	618	Auxiliary Cooling Req'd	16±mi (US431)	27±mi (L&N)	Yes	Core drilling indicates top of rock 21 to 61 ft below general site grade	11±mi to Guntersville Ala (pop 6,500±) 15±mi to Scottsboro Ala (pop 9,300±)	1-Just across reservoir. Proposed line and substation 3 mi S
3.	Blythe Ferry (Chickamauga Res)	499L	730	725	Auxiliary Cooling Req'd	0.3±mi Tenn 80	22±mi (SOU)	Yes	Seismic determinations indicate top of rock at favorable depth below plant grade	6±mi to Dayton Tenn. (pop 4,400±)	1-6 mi SE
4.	Caney Creek (Watts Bar Res)	562R	820	775	Auxiliary Cooling Req'd	1.5±mi (US70 & 27)	6±mi (L&N)	Yes	Not investigated	4.5±mi to Rockwood Tenn (pop 5,300±) 5.5 mi to Kingston Tenn (pop 4,200±)	1±mi NW 1-4 mi SE across reservoir
5.	CLINCH RIVER Clinch River (Watts Bar Res)	16R	800	785	Auxiliary Cooling Req'd	2±mi (Oak Ridge Turnpike)	2±mi Spur of SOU	Yes	Core drilling indicates lime stone and silt stone underlies site Geologists believe adequate foundation is available	8±mi to Kingston Tenn (pop 4,200±) 10 mi to Oak Ridge Tenn (pop 28,000±)	1-passes through site 1±mi N
6.	FR. BROAD RIVER Taylor Bend (Douglas Res)	64R	1055	1016	Auxiliary Cooling Req'd	2±mi (US 25E)	4±mi (SOU)	No	Currently under investigation	7±mi to Newport Tenn (pop 7,300±) 12±mi to Morristown Tenn (pop 20,300±)	1-6±mi N 2-9±mi N
7.	HOLSTON RIVER Buck Hollow	39L	1050	950	Auxiliary Cooling Req'd	4±mi (US 11E)	4±mi (SOU)	No	Currently under investigation	5±mi to Jefferson City (pop 5,100±)	1-passes through site 1-2±mi S
8.	Lee Valley (Cherokee Res)	88L	112[illegible]	1089	Auxiliary Cooling Req'd	2±mi (Tn 66A)	6±mi (SOU)	No	Geologists say site is underlain by limestone and shale	10±mi to Rogersville Tenn (pop 4,000±) 11±mi to Morristown Tenn (pop 20,300±)	3-passes just north of the site
9.	Phipps Bend	122R	1195	1152	Auxiliary Cooling Req'd	2±mi (US 11 W)	1.5±mi (SOU)	No	Currently under investigation	11.5±mi to Rogersville Tenn (pop 4,000±) 16±mi to Kingston Tenn (pop 32,000±)	2-9±mi SW
10.	CUMBERLAND RIVER Johntown (Old Hickory Res)	285R	536	514	Auxiliary Cooling Req'd	1±mi (Tn 25)	5.5±mi (L&N)	Yes	Extensive core drilling indicates satisfactory foundation available	8±mi to Harrisville Tenn (pop 2,200±) 18±mi to Carthage Tenn (pop 2,500±)	2-5±mi S
11.	DUCK RIVER Rieves Bend (Proposed Columbia Res)	146L	700	644	Auxiliary Cooling Req'd	3±mi (Tn 50)	4±mi (L&N)	No	Core drilling indicates satisfactory foundation available	5±mi to Columbia Tenn (pop 21,500±)	1-10±mi S

A 4-unit nuclear plant is planned for the Hartsville site and consideration of TVA's application for construction permits is well along in the NRC licensing process. Assuming space is available on this site for the LMFBR demonstration plant as well, the staff's opinion is that constructing it there during the same time period would present conflicts that should be avoided.

Murphy Hill and Phipps Bend are also potential sites for LWR commercial power plants and were therefore rejected by TVA for the demonstration plant in accordance with its siting criteria (Section 9.2.2). An application for permits to construct two units at Phipps Bend was recently docketed by NRC; however, consideration of the application is not far enough along to anticipate that construction conflicts would occur if the LMFBR were placed there. Based on a review of information provided by the applicant and a visit to both sites, the staff concluded that either one would be suitable for the demonstration plant.

9.2.5 Comparison of Alternative Sites

The selection process described in the foregoing sections resulted in the applicant's eliminating all but three sites: The John Sevier and Widows Creek hook-on sites; and the new site at Clinch River. To this list the staff added the Phipps Bend and Murphy Hill new sites. A comparison of all five sites is given in Table 9.3. The data reveal numerous differences in site characteristics, but none which indicate that location of the LMFBR demonstration plant at any one of the five sites would not be feasible.

Although atmospheric dispersion conditions over the southern Appalachians are, in general, not so favorable as those in other areas of the country, the atmospheric dispersion conditions at the Clinch River site are better than at many other sites in the Tennessee River Valley area of eastern Tennessee. The applicant has noted, as indicated in Table 9.3, that meteorological conditions are slightly better at John Sevier than at Clinch River. From data collected onsite at the Phipps Bend, Clinch River and Bellefonte sites (Bellefonte is in the general vicinity of Widows Creek and Murphy Hill), long-term atmospheric dispersion conditions were found by the staff to be more favorable at Clinch River than at Phipps Bend or Bellefonte. Annual average relative atmospheric dispersion (χ/Q) values, calculated with at least one full year of onsite meteorological data from each site, were used by the staff in making the comparisons.

In August 1972, the applicant made a cost comparison of locating the demonstration plant at John Sevier, Widows Creek and Clinch River (Table 9.4). The comparison showed that adding the nuclear facility to the Widows Creek plant would be $54.1 million less expensive than construction and five-years' operation of an entirely new plant at the proposed Clinch River site; adding the nuclear facility at John Sevier would be $41.3 million less expensive than the CRBRP. The savings at the two hook-on sites come mainly in lower site development costs and avoiding the purchase of a turbine-generator and other balance-of-plant facilities. These savings would be partially offset by the expense of the hook-on conversion, though not enough to make them economically unattractive.

An important, though unquantifiable, economic factor in favor of an entirely new plant is its potential value to TVA, which will have the option to purchase and continue to operate the plant at the conclusion of the initial 5-year period. The CRBRP, with its own turbine-generator, probably would have value sufficient to justify continued operation as a power producer. However, the hook-on plants cannot be assigned a value as capacity since they would not represent an increase in power system capacity; they would actually incur a 27-MWe reduction of the present capacity at Widows Creek, or a 36-MWe reduction at John Sevier, due to the off-design steam conditions which would result from the reactor. The ages of the turbines at Widows Creek (about 30 years) and at John Sevier (about 25 years) at the conclusion of the 5-year demonstration period would also mitigate against continued operation of a hook-on plant.

In view of the above considerations and other potential technical problems with a hook-on arrangement (ER, p 9.2-32), the applicant chose to construct an entirely new plant. The NRC staff concurs with this decision. The staff also agrees with the applicant's choice of the Clinch River site rather than Phipps Bend or Murphy Hill inasmuch as there appear to be no significant environmental benefits to be gained from locating the plant at either of these alternative sites.

TABLE 9.3 A Summary of Comparisons Between the John Sevier, Widows Creek, Clinch River, Phipps Bend and Murphy Hill Sites (ER, Table 9.2-3)

	John Sevier[a]	Widows Creek[a]	Clinch River[a]	Phipps Bend[b]	Murphy Hill[b]
	Based upon a preliminary analysis, each site represents a feasible location to build the plant.				
Foundation Conditions	Good	Several potential problems have been identified. Adequate foundation could be designed.	Similar to TVA's Bull Run Steam Plant. Adequate foundation could be designed.	Adequate	Adequate
Seismology	**Seismology is similar for these sites. No active faults in vicinity of any of the sites and no physical evidence of any recent seismic activity at the sites.**				
Flooding	Site grade lies below maximum possible flood (MPF) level elevation which would require special flooding protection.	Site grade lies below MPF level elevation which would require special flooding protection.	Plant grade can be established above MPF level elevation. Best site from this standpoint.	Marginally acceptable	Site above MPF
Cooling Water	Adequate based on John Sevier Steam plant operations.	Adequate cooling water available.	Will require supplemental cooling.	Mean daily stream-flow is 3600 cfs.	Mean daily stream-flow is 39,360 cfs.
Meteorology	Slightly better than Clinch River site.	Less desirable than Clinch River.	Slightly less desirable than John Sevier site.	Slightly less desirable than the Clinch River site.	Slightly less desirable than the Clinch River site.
Available Land	All five plant sites can accommodate the facilities and an exclusion area radius of 2,000 ft.				
Access	Highway and rail facilities available. Must tie into facilities at the plant.	Highway, rail and barge facilities available. Tie into facilities may require some rerouting of existing lines plus additional track to the NSSS.	Highway, rail and barge facilities can be added. Two miles of rail track and two miles of improving or building of roads is required.	Good road and railroad access, but river is not navigable.	Would need about 16 miles of new roads and 16 miles of new railroads. Barge access is feasible.
Transmission Facilities	No additional offsite transmission lines required with only some tie-in equipment needed.		Some additional offsite transmission lines required. (Section 3.9) Tie-in to 161-kV line and switchyard needed.	Acceptable access to transmission grid.	Acceptable acccess to transmission grid.
Steam Conditions	Degraded from existing conditions. Considered feasible but will have increased turbine erosion and associated maintenance.	Degraded from existing conditions. Considered feasible but moisture may be a problem.	Set by plant design.	Set by plant design.	Set by plant design.
Population					
Total population within 50 miles (1970)	694,295	763,760	678,800	No urban center (>50,000) within 50 miles	914,000
Total population within 10 miles					
1970	18,955	15,105	41,895	18,000	9,600
2010	27,560	24,985	65,089	--	--
Total population within 2 miles	725	359	No significant concentration	No significant concentration	No significant concentration
Land Impact					
Additional land Committed - Acres	None	None	Some (to be determined)	1350 acre total site	1235 acre total site
Land Use Designation	Industrial	Industrial	Industrial	Industrial	Industrial
Proximity to National Monuments or Historic Sites	Andrew Jackson historical site within 25 miles	Russel Cave within 15 miles	Museum of Atomic Energy and ORNL Graphic Reactor within 10 miles	No onsite properties, but there are two National Register properties within 5 miles.	No national properties, but a historic log cabin and a private cemetery are onsite.
Water Impact					
Distance to Nearest Surface Water User	31.4 miles	21.7 miles	1.6 miles	--	--
Potable Water Intake	3.46 MGD	1.19 MGD	2.5 MGD	--	--
Additional Heat Rejection to Reservoir from LMFBR	Essentially none	Essentially none	Small with cooling towers	Small with cooling towers	Small with cooling towers
Air Quality Impact	SO_2 emissions from operation of oil-fired reheater of 1.4 tons/hr. However, operation of LMFBR will decrease SO_2 emission levels when fossil-fired plant would otherwise be required.	Reduces overall system emission levels when LMFBR is in operation. In comparison to John Sevier, these sites have lower emission levels by amount contributed by operation of oil-fired reheater during operation of LMFBR.			

(a) ER, Table 9.2-3
(b) ER, App A

TABLE 9.4 Summary of Economic Comparison of LMFBR Demonstration Plant Alternatives

	(Millions of 1972 Dollars)[a] Clinch River	Widows Creek	John Sevier
A. PLANT COST[b]			
Site Development[c]	20.8	--	--
Nuclear Plant (NSSI)[d]	227.5	227.5	225.8
Turbine Plant	46.2	--	--
Hook-on	--	31.9	37.7
Cooling Facilities	4.5	--	--
Switchyard	2.7	--	--
Subtotal (1972 $)	301.7	259.4	263.5
	Base	(42.3)	(38.2)
B. FIVE-YEAR DEMONSTRATION PERIOD OPERATING COST			
Nuclear Fuel Fabrication[d,e]	47.0	47.0	41.0
Fuel Oil	--	--	12.8
Non-Fuel O&M	27.7	26.5	25.8
Subtotal	74.7	73.5	79.6
Potential Power Credit @ 3.5 Mills	(30.7)	(28.8)	(29.2)
Net Operating Cost (1972 $)	44.0	44.7	50.4
	Base	+0.7	+6.4
C. OTHER PROJECT COST			
Project Management	24.2	Same	Same
Contract Services	17.2	Same	Same
Property Insurance	21.0	Same	Same
Supporting R&D	130.3	Same	Same
Subtotal (1972 $)	192.7+	Same	Same
D. PROJECT COST			
A + B + C (1972 $)	538.4+	496.8+	506.6+
Escalation Allowance @ 30%	161.5	149.0	152.0
	699.9+	645.8+	658.6+
	Base	(54.1)	(41.3)

(a) Updated costs are not presented since hook-on arrangements subsequently were rejected because of potential technical problems, noncost in nature.

(b) Plant cost estimates include normal overhead and appropriate contingencies for each part of the plant estimate, but do not include interest during construction.

(c) Site development costs for John Sevier and Widows Creek are small and included in the hook-on cost estimate.

(d) Based on estimates from proposals submitted to PMC by the reactor manufacturers.

(e) Nuclear fuel fabrication cost does not include the cost of other fuel cycle materials and services that will be provided by ERDA; the difference in cost indicated is due to the smaller reactor size at John Sevier.

9.3 FACILITY SYSTEMS

9.3.1 Cooling System Exclusive of Intake and Discharge

The applicant chose a predominantly "closed-cycle" system employing a mechanical draft wet cooling tower. A linear array would be used that is 55 ft by 60 ft by 400 ft long. The single tower would have a 25°F range and 15°F approach and use 10 cells for cooling. Additional water would be added to the condenser-cooling tower circulation system to replace losses due to cooling tower evaporation, drift and blowdown.

Alternatives considered by the applicant were (ER, Sec 10):

- Open cycle system
- Predominantly "closed-cycle" systems
  - Natural draft wet cooling towers
  - Cooling lake
  - Spray pond
  - Mechanical draft wet cooling towers - circular array
- Combination open-cycle/closed-cycle system
  - Wet-dry mechanical draft cooling towers
- Totally "closed-cycle" systems
  - Dry cooling towers

9.3.1.1 Open-cycle

Due to hypothetical no flow conditions of the Clinch River during certain times of the year, the condenser heat load could not be dissipated adequately in an open-cycle system. Therefore, this alternative was not considered viable.

9.3.1.2 Natural Draft Wet Cooling Towers

Cooling by this alternative would require a single tower 385 ft high with a 310 ft base diameter. The visible plume would extend to a greater distance than under the base case, but the potential for ground fogging and icing would be nonexistent. Compared to the base case, the amount of deposited drift would be reduced, but a 0.3% increase in makeup flow would be required. Except for the aesthetic impact of the higher and longer plumes and the size of the tower itself, this alternative is viable and is included in the benefit-cost analysis.

9.3.1.3 Cooling Lake

Use of a cooling lake to dissipate waste heat would require sufficient land suitable for impoundment. CRBRP would require a 350 to 400 acre lake. Due to the uneven topography and competing land uses, the cooling lake is not a viable alternative.

9.3.1.4 Spray Ponds

The spray pond cooling system considered for the site would require about 8 acres including two rectangular channels each 80 ft wide and 2175 ft long. To dissipate the anticipated heat load, a floating platform spray system consisting of 54 modular cells would be required. A potential for fogging, icing and drift would occur. This alternative is viable and is evaluated in the benefit-cost section.

9.3.1.5 Mechanical Draft Wet Cooling Tower-Circular Array

This alternative is the same as the base case except for tower configuration. With a circular cell configuration, greater plume rise can be obtained, thereby reducing ground fog potential and recirculation of the exhausted air stream. The alternative is evaluated in the benefit-cost section.

9.3.1.6 Combination Open-Cycle/Closed-Cycle System

Two types of open-cycle/closed-cycle systems were considered for the CRBRP, a series wet/dry mechanical tower and a parallel wet/dry tower. Currently, such systems are used for controlling plume formation. The flexibility of the system would allow efficient evaporative cooling in the warmer months, combined with a variable dry heat exchange section for control during colder months. Besides the environmental advantage of plume control, the wet/dry tower would reduce water consumption and drift when compared to all-wet cooling. However, the use of the dry section in the winter results in a warmer blowdown and reduced generating capacity. This alternative is carried forward to the benefit-cost analysis.

9.3.1.7 Dry Cooling Towers

Dry cooling towers are mainly designed for areas of critical water supply that require no makeup from a natural water body. Instead, dry cooling towers remove heat from a circulating fluid through radiation and convection to the air being circulated past the heat exchanger tubes. Because of the poor heat transfer properties of air, tubes are generally finned to increase the heat transfer area. Additionally, since the heat transfer process does not include the latent heat of evaporation, dry cooling towers require both greater air flows and larger air temperature increases in order to dissipate the same amount of heat as a comparable evaporative cooling system. The theoretical lowest temperature that a dry cooling system can achieve is the dry bulb temperature of the air.

Dry tower systems are of three different types:

(1) For small units (up to 300 MWe), steam is ducted from the turbine to the heat exchanger for direct steam condensing.

(2) The direct-contact type can be built in which the cooling water and steam mix in a direct-contact condenser. This type requires a significant increase in water treatment and storage costs, since the entire cooling system uses steam generator quality water (Beck 1972).

(3) Depending on turbine design, conventional surface condensers or multi-pressure (zoned) surface condensers can also be used, with the dry tower replacing the wet tower in a system similar to existing wet tower systems. This system does not require steam generator quality water.

The principal disadvantage of dry cooling towers is economic. Plant capacity can be expected to decrease by about 5 to 15%, depending on ambient temperatures and assuming an optimized turbine design. Busbar energy costs are expected to be on the order of 20% more than a once-through system and 15% more than a wet cooling tower system, assuming 1982 operation. Environmentally, the effects of heat releases from dry cooling towers have not yet been quantified. Some air pollution problems may be encountered; noise generation problems for mechanical draft towers would be equivalent or more severe than those of wet cooling towers; and the aesthetic impact of natural draft towers, despite the probable absence of a visible plume, would remain. The system would produce no fogging or icing and might, under appropriate meteorological conditions, reduce local natural fogging effects by ventilation. Dry cooling towers now being used for European and African fossil plants are limited to plants in the 200 MWe or smaller category.

Because of the small electrical output of the plant, this alternative is considered in the benefit-cost analysis.

9.3.2 Intake Systems

Based on the balancing of economic and environmental benefits and costs the applicant has chosen a perforated pipe system as the preferred intake for the CRBRP. In this system, two large double wall perforated pipes would be submerged 70 ft from shore and parallel to stream flow. The 3/8-in. perforations would result in a 40% open structure in the 4 ft diameter outer pipe and a 7% open structure in the 3 ft diameter inner pipe, minimizing entrapment and impingement of fish.

Placing the pipes parallel to the river would allow natural water currents to facilitate the passage of debris and aquatic biota past the pipes. The system has these advantages, which in combination, should help reduce fish entrapment and impingement: 1) low intake velocities (0.3 fps through the perforations when both pipes are operating or 0.5 fps when only one pipe is operating) with uniform velocities due to internal sleeving of pipes; 2) clear escape pathways in all directions except directly into the perforations [9.5 mm (3.8 in.) in diameter]; 3) low approach velocities (0.12 fps at 0.75 in. from the pipe); and 4) elimination of need for trash racks or vertical traveling screens.

Other intake systems considered by the applicant are:

- Conventional traveling screens
- Traveling screens mounted at angle to flow
- Single entry-double exit traveling screens
- Horizontal screens
- Louver system
- Electric screens
- Bubble, sound and light barriers, and
- Infiltration bed

9.3.2.1 Conventional Traveling Screens

A conventional vertical traveling screen, flush mounted with the supporting wall (to minimize entrapment in dead water areas) and with fish escape ports on the side walls (to minimize impingement), was considered by the applicant (Figure 9.2)(ER, Sec 10.2). Fish escape passages are not likely to be completely effective because the passages would also draw water into the intake structure, creating a current flow which must be overcome by the entrained fish.

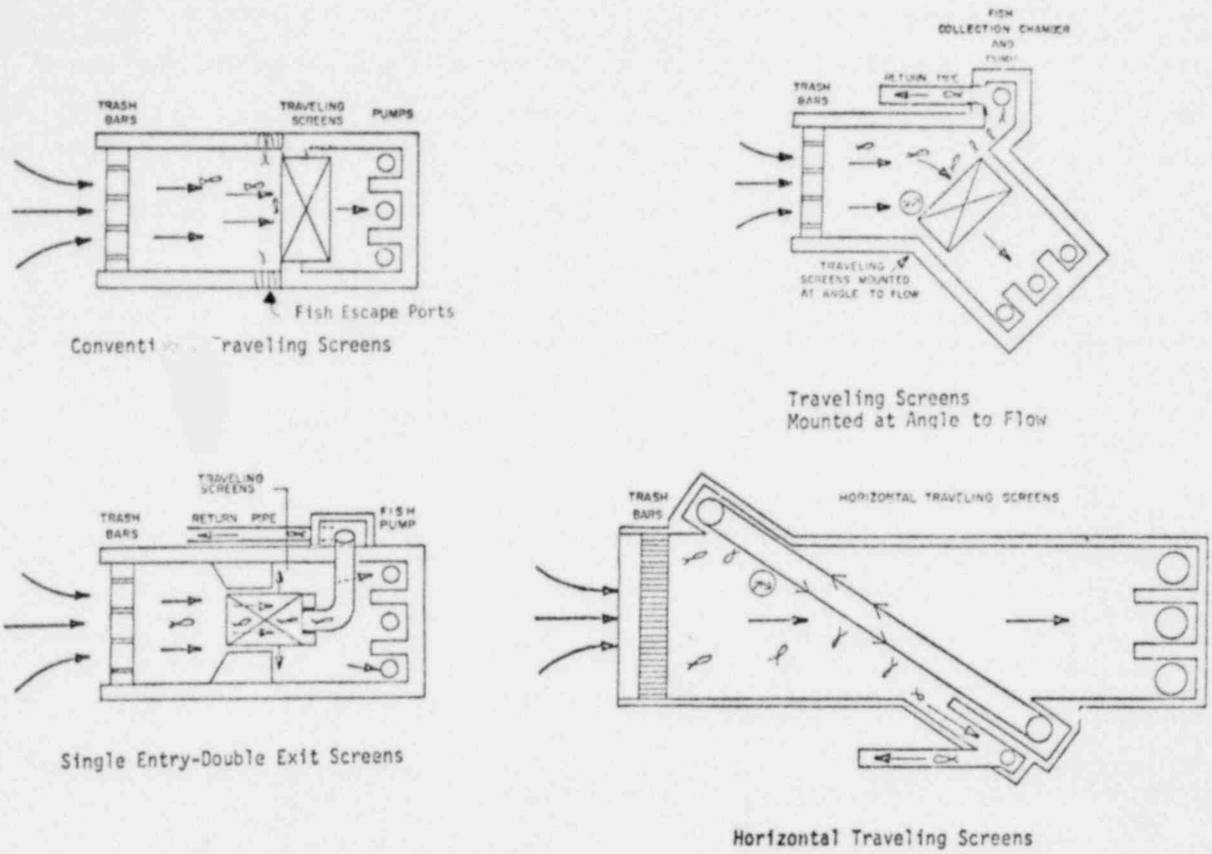

FIGURE 9.2 Fish Protection Features of Traveling Screens Intake Alternatives

The design screen approach velocity is 0.5 fps (Section 5.3.1.1), considered as an upper permissible limit to reduce impingement losses. With traveling screen alternatives, however, there is a wide distribution of velocities across the face of the screens, possibly exceeding 0.5 fps.

Shoreline intake structures of this type are large structures, presenting more of an aesthetic impact than submerged intakes with smaller pumphouses.

In spite of the disadvantages discussed above, traveling screen intake systems have been successfully used at many stations and are considered as a viable alternative to the submerged perforated pipe system proposed for the CRBRP. Further consideration of this system is given in the benefit-cost section.

9.3.2.2 Traveling Screens Mounted at Angle to Flow

This system is a variation on the conventional traveling screen system accomplished by positioning the traveling screens at a 45°-60° angle to the incoming flow instead of normal to the incoming flow as shown in Figure 9.2. This offset permits use of a fish escape port at one end (outside corner angle) of the screen, which is outfitted with a fish pump to create a positive flow in that direction. Escape is further aided by a natural flow vector in that direction as a result of the water's meeting the screen at an angle. Further consideration of this viable alternative is given in the benefit-cost section.

9.3.2.3 Single Entry-Double Exit (Passavant) Screens

In this variation of the traveling screen concept, the screen surfaces are placed parallel to the intake flow. The water passes from the inside to the outside (both surfaces) of the traveling screen, making a right angle flow path. Fish pass straight on through to an escape passage beyond the screen, and their progress is aided by the natural flow vector in that direction augmented by a fish pump beyond the screen (Figure 9.2). The major advantage is that fish do not need to change direction to make an escape; therefore, lethargic fish may be drawn to safety more easily. Further consideration of this alternative is given in the benefit-cost section.

9.3.2.4 Horizontal Traveling Screens

A horizontal traveling screen (Figure 9.2), when mounted at an angle to the water flow and operated at high rotational speeds, can produce a large velocity component parallel to the screen face and thus assist fish to escape. In the experimental stage, this is an attractive scheme but it has the basic disadvantage of not being able to accommodate the large water level fluctuations such as found at the site. The staff concludes that this is not a viable alternative.

9.3.2.5 Louver Screens

Louver screens are placed in the water upstream of the intake and deflect fish into a by-pass channel away from the main stream flow. The optimum size and spacing of the louver panels are determined by the flow in the stream. In the case of the Clinch River, where flows can range from 0 to 22,000 cfs, and in winter the water level can fluctuate daily by as much as 8 ft, a louver system that would be effective at all times could not be designed. The staff concludes that a louver system is not a viable alternative.

9.3.2.6 Electric Screens

Fish are known to be repelled by high voltage pulses, forming a fish barrier in front of an intake structure. The most effective barrier voltage is determined by the size and species of fish to be repelled. In a stream with the natural species variety of the Clinch River, designing an electric screen completely effective for all species would not be possible. Furthermore, fish that are momentarily stunned by the voltage would be drawn into the intake and impinged since the water flow is in that direction. Electric screens are more suitable as barriers to upstream migrating species, where temporarily stunned fish are swept back downstream and can recover. The staff concludes that an electric screen is not a viable alternative.

9.3.2.7 Bubble, Light, and Sound Barriers

A curtain of air bubbles, generated by passing compressed air through a perforated pipe, is an effective barrier to most fish. However, when fish are in a lethargic state (at low water temperature) their response to an air bubble curtain is not as acute, and they may drift through it.

An intense light sometimes can be used to repel fish and keep them from entering an intake structure, but this is temporary. Fish become acclimated to light and then will pass through it.

Multi-frequency pulsating sound will also act as a barrier to fish movement, but the fish response is dependent on the species. In a species diverse stream, such as the Clinch River, this would not be very effective for driving fish away from an intake structure.

In the opinion of the staff, none of those methods is a viable alternative for repelling fish from the proposed intake structure.

9.3.2.8 Infiltration Beds

In this system, the intake pipe is buried in a porous media beneath the water supply. This can be the stream bed itself or an underlying aquifer. The large area from which the water is drawn results in very low approach velocities, with a resulting negligible impingement loss. The natural geology of the CRBRP site precludes the use of this type of filtration system unless constructed with an artificial filtration media. To do this would disturb a large part of the river bottom, which would be harmful to the benthic life. The artificial beds are also prone to clogging which could occur in the Clinch River. For example, during the March 1974 collecting period, the turbidity of the Clinch River exceeded the recommended maximum value of 50 Jackson turbidity units for discharge into warmwater bodies of water set forth by the FWPCA in 1968. The turbidity values for that period were 70-80 JTUs, indicating that clogging would be a potential problem for this type of intake. The staff concludes that this is not a viable alternative for the CRBRP intake system.

9.3.3 Discharge Systems

All liquid effluents from the CRBRP are discharged to the Clinch River with the cooling water blowdown. The discharge structure selected by the applicant is a high momentum, submerged single-port system. The system was selected because of its superior mixing characteristics and reduced thermal and chemical plume. Alternatives considered were low momentum, surface discharge and high-momentum, submerged multiport discharge.

9.3.3.1 Surface Discharge

This alternative consists of releasing the discharge at a shallow angle to the surface of the river and floating the discharge out onto the cooler surface of the river. Mixing with river water is avoided and the primary method of dispersing the heat is through an air-water exchange. In the particular manifestation of this alternative for the CRBRP site, the discharge actually would be a submerged discharge during the summer months when the river level is normally about 6 ft above the discharge trough. Under summer conditions, therefore, there is partial mixing with the river water, but not so much as for the high velocity submerged discharge alternatives.

Although this alternative results in a larger body of water being affected by the thermal plume than with the reference method, the impact is not considered severe enough to rule out its use. Further consideration of this alternative is given in the benefit-cost section.

9.3.3.2 Submerged Multi-Port Discharge

In this system, the cooling tower blowdown is discharged at high velocity through a multiplicity of nozzles located 4 ft below the minimum water level. This alternative achieves the greatest initial plume entrainment and greatest reduction in plume excess temperature in the near field mixing zone of all the systems considered for the CRBRP. This alternative is considered by the staff to be environmentally acceptable and is treated further in the benefit-cost section.

9.3.4 Chemical Waste Treatment

Methods selected for treating chemical waste at CRBRP are described in Section 3.6. These include neutralization and separation of suspended matter. Excluding cooling tower blowdown, which contains material withdrawn with the water taken from the river, the principal waste discharges from the plant would be sludges and dissolved salts. Alternatives considered for the waste discharges were:

- Mechanical dewatering of sludges.
- Reverse osmosis pretreatment of demineralizer feedwater.
- Zero discharge of surge and neutralizing tank effluent.

9.3.4.1 Mechanical Dewatering of Sludges

Mechanical dewatering of sludges is an alternative to the proposed drying beds for producing a more compact and drier sludge. The environmental advantages include reduction in solid waste volume and a slight increase in recyclable water. The mechanical dewatering processes considered were centrifugation and vacuum filtration. The major reasons for rejecting the alternative were: 1) available commercial equipment is too large for processing the relatively small quantity of sludge produced and 2) continuous operator attention would be required during equipment operation. Other disadvantages include higher noise levels, increased energy consumption, the need for weather-proof housing and the possible need for sludge conditioning chemicals.

9.3.4.2 Reverse Osmosis Pretreatment of Demineralizer Feedwater

Addition of a reverse osmosis system to the high purity makeup water treatment system was considered as a means of reducing the frequency of the demineralizer regenerations, thus reducing the quantity of regenerant chemical waste discharged. Reverse osmosis would be used as a pretreatment step to the ion exchange beds to remove the bulk of the dissolved salts by ultrafiltration. This pretreatment step generates product water, or a partially demineralized water stream, and a reject or brine stream. The former would be routed to the ion exchange demineralizers for further reduction in salt content while the latter would be discharged to the plant effluent stream. This alternative was rejected on the basis of the questionable reliability of the reverse osmosis system for the designated purpose and the fact that the demineralized waste is not eliminated but only reduced in frequency of generation. The size of the ion exchange demineralizers and the attendant waste treatment facilities cannot be reduced by this pretreatment step.

9.3.4.3 Zero Discharge of Surge and Neutralizing Tank Effluent

Three alternatives were considered for treating this waste stream to accomplish zero discharge: 1) offsite treatment, 2) percolation ponds, and 3) evaporation. Offsite treatment was rejected because the area has no treatment plants capable of handling the quantity and type of waste produced. Percolation ponds were not considered feasible because of the area's soil characteristics. Evaporation of this waste stream to produce purified water for recycle in the plant was rejected on the basis of high cost and only marginal improvement in the quality of the product water.

9.3.5 Biocide Systems

In order to prevent colonization of algae, bacteria, and fungi in the cooling water system, the applicant proposes to inject chlorine continuously at the intake water pumps at a level of about 1 ppm. Intermittent slug feeding (3 ppm for 15 min every 8 hr) also would be used to control slime deposits. Alternative biocide systems considered were:

- Organic biocides
- Ozone
- Mechanical cleaning systems

9.3.5.1 Organic Biocides

Several organic chemicals are effective in controlling growths of microorganisms in circulating water systems. Some of the more effective ones are acrolein (an unsaturated aldehyde), DE 508 (2, 2, dibromo-3 nitrilopropionamide), and quaternary ammonia compounds. Like chlorine, the substances are also toxic to many fish species. Unlike chlorine, however, they do not spontaneously decay in toxicity by exposure to sunlight, so they must be chemically detoxified before discharge. This is usually done by the addition of sodium sulfite. The addition of sodium sulfite to the receiving waters is not desirable if it can be avoided because it represents an additional COD load to the stream. Furthermore, many of these organic chemicals are applied as solutions, with the solvent (such as ethylene glycol) capable of being toxic itself and not neutralizable by the sodium sulfite. The staff concludes that the use of organic biocides is not a viable alternative to the chlorine injection system selected by the applicant.

9.3.5.2 Ozone

Ozone, prepared onsite by the passage of cold air (or oxygen) past charged plates, is receiving increasing attention as a biocide in circulating water systems. It dissipates even more quickly than chlorine, so there is no residual activity problem. Its specific biocidal effect is not so well known as is the effect of chlorine on the Asiatic clam, a prevalent infestation in the Clinch River. Therefore, more research would be needed before an ozone system could be properly designed for the CRBRP. Also, a byproduct of ozone degradation is oxygen, which could cause supersaturation at times and would be harmful to fish. For these reasons, ozone is not a viable alternative biocide for this application.

9.3.5.3 Mechanical Cleaning Systems

Condenser tubes can be kept free of biological fouling by periodic passage of sponge rubber balls or plastic brushes, but the systems have not gained widespread acceptance by the industry. The materials mechanically scrub the inside surface of the condenser tubes and remove biological growths. Such mechanical systems would not altogether eliminate the need for a chemical biocide. They would not result in a major reduction in released biocide residuals.

The applicant has elected not to use a mechanical cleaning system in conjunction with chlorination, and the staff concurs in this decision. The level of residual chlorine to be discharged (0.2 ppm) is so low that it is not expected to create any harmful effects in the Clinch River. Therefore, further reduction is unnecessary.

9.3.6 Sanitary Waste System

A sanitary waste treatment system would be needed to provide treatment of a maximum of 8000 gpd of sewage generated during operation with the 210 man peak staff. The applicant plans on a packaged aeration/filtration/chlorination facility with a liquid effluent discharge to the Clinch River to meet this need. Alternatives considered were:

- Tap-in to existing facility
- Ground discharge
- Incineration
- Activated sludge/membrane filtration
- Clarification/filtration/carbon adsorption.

9.3.6.1 Tap-In to Existing Facility

This alternative involves pumping the sanitary waste to an existing treatment plant having sufficient excess capacity to handle an additional 8000 gpd. Neither of the two closest processing plants (one at the Oak Ridge Gaseous Diffusion Plant and the other at the Clinch River Industrial Park) have the capacity necessary to handle the CRBRP sanitary waste. The Oak Ridge municipal sewage treatment plant is 15 miles away, too far to be practical. The tap-in alternative, therefore, is not considered a viable sanitary waste treatment system.

9.3.6.2 Ground Discharge

In the ground discharge alternative the sanitary waste would be discharged directly to the ground (by way of a tile field, percolation pond, or spraying) and be filtered and neutralized by the natural assimilative capacity of the soil. This system has the advantages of eliminating any discharge to the river and of not requiring very much energy. At the site, however, the top 20 to 30 ft of earth is clay and not suitable for a ground discharge sanitary waste system. The staff does not consider this to be a viable alternative sanitary waste discharge system.

9.3.6.3 Incineration

It is possible to dewater raw sewage and incinerate the residual sludge to produce an ash which is disposed of as a solid. This system has very high capital and operating costs, and consumes large amounts of energy (typically, the burner is fired with No. 2 oil). For these reasons, the staff does not consider incineration to be a reasonable alternative for sanitary waste disposal.

9.3.6.4 Activated Sludge/Membrane Filtration

In this alternative, a biological decomposition process is used on the sanitary waste, and suspended solids are removed by membrane filtration. This results in a higher quality effluent than the reference process and eliminates any chlorine discharge to the receiving waters. This alternative is given further consideration in the benefit-cost section.

9.3.6.5 Clarification/Filtration/Carbon Adsorption

This process involves clarification of the waste stream by flocculation, as a secondary level treatment process, to reduce suspended solids. Filtration through sand (as in the reference process) further removes solids before the final effluent is passed through activated charcoal. The charcoal adsorbs organic matter, resulting in a final effluent with a lower BOD than the reference system. There would probably be no need to chlorinate the effluent. Further consideration is given to this alternative in the benefit-cost section.

9.3.7 Transmission System

The alternate transmission line route is shown along with the proposed route in the ER (Fig 10.9-1). The alternate route is 0.2 mile longer (3.4 miles compared to 3.2 miles) and would require clearing 8.7 more acres of forest. The composition of forest to be cleared is similar to the proposed route except that the alternate route would disturb 8 more acres of pine, 11.7 more acres of unforested land (old fields), and 12.1 fewer acres of hardwood. Thus the impact to biota would be slightly different for the two routes, with the preferred route removing a few more acres of hardwood which is preferred by squirrels and many bird species. However, both routes would present favorable habitat for deer, rabbits and upland game birds after construction and revegetation. Soil erosion potential would be about the same for both routes, but the alternate route would have a slightly greater potential impact from heavy equipment and a slightly less favorable revegetation potential than the proposed route. The alternate route would be visible for one mile at Bethel Valley Road. Neither route would cross highways, railroads, or historical or archaeological sites. Neither route would require new access roads.

The proposed route is preferred because it is shorter, lacks major visual impact, affects fewer forested acres and presents less construction impact than the alternate route. Therefore, the staff does not consider the alternative route to be a preferable alternative.

9.4 BENEFIT-COST COMPARISON

9.4.1 Cooling System

The costs and benefits of the viable cooling system alternatives are summarized in Table 9.5.

TABLE 9.5 Summary of Environmental and Economic Costs for the Alternative Cooling Systems

	Unit of Measure	Mechanical Draft Wet Tower: Linear Array	Mechanical Draft Wet Tower: Circular Array	Natural Draft Wet Tower	Spray Pond	Mechanical Draft Wet/Dry Tower: 30% Plume Severity	Mechanical Draft Wet/Dry Tower: 0% Plume Severity	Mechanical Draft Dry Tower
Environmental Costs								
Plume Formation								
Ground Fog Potential	Hrs/yr (all directions)	146	146	0	NA	138	138	0
Visible Plume Extent	Mean length in miles (95% R.H., C stability)	1.8	1.9	2.9	NA	1.5	1.6	-
Drift Deposition	lbs/acre/mo	89	74	3	~90	44	37	-
Water Use								
Entrainment	Percent/yr[a]	0.33	0.33	0.33	0.33	0.30	0.30	0
Impingement	Qualitative	Same	Same	Same	Same	Same	Same	0
Water Consumption	Percent of Melton Hill Dam releases[b]	0.20	0.20	0.20	0.20	0.19	0.19	0
Heat Rejection	Heat load to river in winter as percent of total plant heat duty	0.048	0.048	0.049	0.052	0.055	0.055	0
Initial Temperature Difference	Blowdown temperature minus river ambient (in winter), °F	30	30	31	36	48	43	-
Effect of Chemicals	Qualitative	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	None
Land Use	Acres	0.5	1.0	1.7	8	2.1	3.3	4.3
Visual Impact		Negligible	Negligible	Severe	Negligible	Negligible	Negligible	Negligible
Economic Costs								
Plant Net Output	MWe differential	Base	Base	0.2	(2.9)	(2.2)	(1.4)	(13.6)
Total System Cost	Present worth in millions of $	Base	0.50	2.19	2.52	2.06	2.19	15.49

(a) Makeup flow as a percentage of annual releases, density of entrainable organisms assumed uniform
(b) Evaporation and drift losses as percentage of annual releases

With a natural draft cooling tower, there is a marked reduction in ground level fogging and icing and in drift deposition, but this is offset by a more visible plume at higher elevations. The natural draft tower presents the most notable visual impact of all the cooling alternatives. The 385 ft high tower would be visible from many populated areas, including Gallaher Bridge, Interstate 40, ORNL, and Melton Hill Dam. The natural draft tower does not offer enough environmental advantages over the reference mechanical draft tower to offset the added cost of $2.19 million. The staff concurs in its rejection.

The spray pond alternative would be an acceptable alternative cooling system from an environmental standpoint. Its effect on water resources and aquatic ecology would be comparable to the reference system except the slight disadvantage of requiring more land (8 acres). The present worth cost differential is $2.52 million. Because the system does not offer any real environmental advantage and because it is more expensive than the reference system, the applicant chose to reject it for the CRBRP. The staff concurs in that decision.

The circular array mechanical cooling tower system has a slight environmental advantage over the linear array system in that a higher loft is generated. This results in slightly reduced ground level effects (drift, fog, ice) at the expense of a larger plume. The marginal advantages of the circular array are not judged to be significant enough by the staff to warrant the estimated added cost of $0.5 million for the circular array.

The totally closed cycle system (dry cooling tower) is judged by the staff to be an acceptable choice. However, it imposes an added power penalty of 13.6 MWe and an added equivalent investment cost of $15.49 million. Since the environmental impact of the reference cooling system would be negligible (see Section 5.3.3), the staff concludes that the marginal improvement of the dry cooling tower system would not be justified at this higher cost.

The advantages and penalties of the mechanical draft wet cooling tower can be averaged with those of the mechanical draft dry cooling tower by using a combination system, operated in either or both modes. The staff concludes that there are no significant environmental advantages to be gained by such averaging in this application. Since the economic penalty is greater than $2 million, this alternative was rejected.

9.4.2 Intake Systems

The monetary and environmental costs of the most viable alternative intake systems are summarized in Table 9.6. The most sensitive environmental factor influencing the choice of intake system is impingement loss, with construction effects and aesthetic factors being weighted less heavily. The perforated pipe and Passavant screen systems afford the greatest protection from impingement losses. The perforated pipe system has a lower water velocity at the screens, and the velocity distribution is more uniform. Furthermore, it affords clear escape pathways in all directions except directly into the perforations. Trash racks and vertical traveling screens are unnecessary with the perforated pipe. It is also the least expensive of the viable systems. For those reasons the applicant has selected the perforated pipe system, and the staff concurs in this selection.

TABLE 9.6 Summary of Monetary and Environmental Costs of Alternative Intake Systems

	Proposed Perforated Pipe	Conventional Traveling Screens	Angle-Mounted Traveling Screens	Passavant Screens
A. Monetary Costs				
1. Capital Cost Differential	Base	$127,000	$141,000	$216,000
2. Equivalent Investment Operating-Cost Differential	Base	1,000	1,000	1,000
3. Total Differential Cost	Base	$128,000	$142,000	$217,000
B. Environmental Costs				
1. Entrainment	Complete	Complete	Complete	Complete
2. Impingement				
a. Fish escape passages	Good	Fair	Good	Good
b. Water velocity at screens	0.2 fps @ 0.75 inch[a]	0.5 fps @ 1.0 inch	0.5 fps @ 1.0 inch	0.5 fps @ 1.0 inch
c. Velocity distribution	Excellent	Poor	Poor	Poor
3. Construction Effects	Little shore-line disturbance Some off-shore dredging	Shore-line disturbance	Shore-line disturbance	Shore-line disturbance
4. Aesthetic Impact	Small Pumphouse	Large structure	Large structure	Large structure

(a) With both pipes operating

9.4.3 Discharge Systems

The monetary and environmental costs of the alternative discharge systems are summarized in Table 9.7 (ER Table 9.5.3-1). The total differential costs for the various alternatives are very small in the context of the absolute cost of the discharge system. Thus, cost is not considered by the staff as a determinant in the selection of the discharge system alternative.

The staff concludes that for the small quantities of water being discharged from the CRBRP relative to the receiving body, the submerged single-port diffuser is quite adequate for promoting mixing and for ensuring protection of the aquatic resources. Mixing in the river would be slower with surface discharge. In Chapter 5 the staff discussed the probable impacts of discharges of chemicals and heated water to the Clinch River. The conclusion was that the reference system would have no significant effect on phytoplankton, zooplankton, drift invertebrates, benthic invertebrates, ichthyoplankton, or fish. The staff concurs in the selection of the submerged single-port discharge.

TABLE 9.7 Summary of Environmental and Economic Costs for the Discharge Alternatives

Environmental Costs	Submerged Single-Port	Surface Discharge	Submerged Multiport
Mixing Effectiveness			
Thermal:			
- Typical Case - Winter	Excellent	--	Good
- Typical Case - Summer	Good	--	Good
- Extreme Case - February	Good	Poor	Good
- Extreme Case - July	Very Good	Fair	Good
Chemical:			
- Typical Case - Winter	Good	--	Good
- Typical Case - Summer	Good	--	Good
- Extreme Case - February	Good	Fair	Good
- Extreme Case - July	Good	Fair	Good
Navigation Effects	Slight	None	Slight
Aquatic Life Effects	Less	Some	Less
Construction Effects	Slight	Very Slight	Slight
Aesthetic Effects	None	Some	None
Economic Costs			
Capital Cost:			
- Material Costs	Base	($1,000)	$1,000
- Installation Costs	Base	($5,000)	$3,000
- Total Differential Capital Costs	Base	($6,000)	$4,000

9.4.4 Sanitary Waste Systems

The effluent water quality parameters of the reference system and the two alternative systems selected for the benefit-cost analysis are compared with various standards in Table 9.8. All three systems would discharge an effluent well within the standards; therefore, marginal differences between them are not considered to be significant. The applicant selected the extended aeration/filtration/chlorination system based on its proven technology, reliability and overall system cost while producing a discharge within applicable standards and not having any harmful effect on the receiving waters. The staff concurs with the selection.

TABLE 9.8 Effluent Quality of Sanitary System Alternatives[(a)]

	EPA Guidelines	Tennessee Standards	Extended Aeration/ Filtration/ Chlorination (Proposed System)	Activated Sludge/ Membrane Filtration	Clarification/ Filtration Carbon Adsorption
BOD	30 mg/l	30 mg/l	10 mg/l	10 mg/l	5 mg/l
Suspended Solids	50 mg/l	40 mg/l	5 mg/l	1 mg/l	5 mg/l
Residual Chlorine	--	0.5-2.0 mg/l	1.0 mg/l	0	NA[(b)]
Ammonia Nitrogen	--	5.0 mg/l	0.5 mg/l	NA[(b)]	NA[(b)]
pH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0
Estimated Total Monetary Cost of Treatment System			$1.50/1000 gal[(c)]	$1.90/1000 gal[(d)]	$6.75/1000 gal[(e)]

(a) Monthly averages
(b) Not available
(c) ER, Section 10.6.5
(d) Reference: Blecker, H.G., and T. M. Nichols "Capital and Operating Costs of Pollution Control Equipment Modules," Vol II Data Manual PB-224 536, ICARUS Corp., Report prepared for EPA, July 1973.
(e) Does not include cost of sludge disposal.

10. EVALUATION OF THE PROPOSED ACTION

10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

10.1.1 Abiotic Effects

10.1.1.1 Land

Site preparation and construction activities related to the CRBRP would disturb about 228 acres of land which is largely forest including 58 acres for transmission line right-of-way. Approximately 73 acres of this amount would be dedicated on a long-term basis to plant structures (4 acres), graded areas around the plant structures (30 acres), access roads and railroad (20 acres on-site, 4 acres off-site), impounding ponds (8 acres), barge unloading area (2.5 acres) and other facilities. All of the transmission tower bases would occupy less than one additional acre. (Sects. 3.8 and 4.2.1)

Erosion would result from construction and subsequent rainfall, but the control practices and revegetation planned by the applicant would minimize this effect (Sect. 4.3).

Construction traffic would add to congestion on local roads, particularly on State Road 58 at shift change times (Sect. 4.5.1). This congestion could be alleviated somewhat by staggering work schedules (Sect. 4.6.2).

Fog resulting from cooling tower operation could be a minor nuisance on nearby roads, but this should occur only a few hours per year. The visible plume would usually extend no more than 1.5 miles, but it could be as long as six miles 6% of the time the plant is operating (Sect. 5.3.3).

The plant and some transmission line structures would be visible from Gallaher Bridge and several residences south of the river. Ridges and hills would otherwise provide natural screening (Sect. 5.1).

10.1.1.2 Water

Water consumed by the project would be a maximum of 35 gpm for construction purposes and an average of 10 cfs (4500 gpm) during plant operation. These quantities are about 0.002% and 0.2%, respectively, of the annual average river flow (Sects. 4.3 and 5.2).

Minor amounts of silt will be added to the river due to construction activities, but these will be minimized by erosion control. The applicant will be required not to exceed 50 mg/ℓ of suspended solids in water discharged from settling basins (Sect. 4.3).

Plant operation would add dissolved residual chlorine to the river at a continuous 6 cfs rate in concentrations up to 0.2 mg/ℓ free residual chlorine (Sect. 5.4.1).

Plant operation would increase the river's copper concentration to 0.06 mg/ℓ and iron to 0.7 mg/ℓ 200 ft downstream. Insignificant adverse effects are expected because the area of potentially toxic concentrations would not exceed 0.1 acre except for the no-flow condition, which would be avoided by appropriate water releases from Melton Hill Dam (Sect. 5.4.1).

10.1.1.3 Air

Construction noise would be noticed by a few residents south of the site. Dust would not have a significantly adverse effect (Sect. 4.5.4).

Noise during plant operation would not likely be noticeable beyond the site boundary (Sect. 5.1).

The plant would discharge heat to the atmosphere at a rate of 2.73×10^9 Btu/hr (Sect. 3.4.1).

About 57 lb/yr of pollutants would be released to the atmosphere as a result of operating the emergency diesel generators (Sect. 3.7.2).

10.1.1.4 Other

Tax receipts would not compensate for the increased public services needed by the additional work force associated with the CRBRP, particularly during construction (Sects. 4.5 and 5.6).

Historic and archeological resources on site should not be affected if borrow pit activity is restricted as planned (Sect. 4.2.1). However, access would be subject to plant security requirements (Sect. 5.1).

10.1.2 Biotic Effects

10.1.2.1 Terrestrial

Construction would result in harvesting some timber and destruction of other plant and animal life on the 228 acres disturbed. All but 73 acres would be revegetated after completion of the CRBRP (Sect. 4.4.1).

At most, 1000 lb/acre/yr of dissolved solids from the cooling tower would be deposited on surrounding land and foliage. No significantly adverse impact is expected (Sect. 5.3.3).

10.1.2.2. Aquatic

The thermal, chemical, and mechanical effects are treated together and consist of the following:

° Excavation - Approximately 40,000 m^2 of river bank and bottom temporarily would be lost during construction as a habitat for benthic organisms (Sect. 4.4.2).

° Impingement - 0.5% susceptible fish passing the perforated pipe intake may be killed (Sect. 5.3.1.1).

° Entrainment - Phytoplankton, zooplankton, drift invertebrates and ichthyoplankton all would suffer the same losses based on the fraction of total river flow withdrawn by the plant. Losses at the average riverflow of 4800 cfs would be 0.46%; maximum loss occurring at the low river flow of 1000 cfs would be 2.2 (Sect. 5.3.2.2).

° Thermal discharge - Potential 8% maximum loss of phytoplankton, zooplankton, drift invertebrates, benthic macroinvertebrates, ichthyoplankton, fish, and other organisms during the winter season; less than 1% during all other seasons (Sect. 5.3.2.2).

° Cold shock - Estimated effects would be insignificant due to the small sizes of the 2.5°C (4.5°F) isotherm (< 8% of river cross-sectional area and 0.01 surface acre of water) (Sect. 5.3.2.3).

° Chemical and sanitary discharge - Copper, iron, and suspended solids potentially could result in adverse effects upon aquatic life in less than 8% of the river's cross-sectional area under worst-case conditions of no-flow and high ambient concentrations. Other chemicals would be diluted to concentrations below those reported to be toxic (Sect. 5.4).

10.1.3 Radiological Effects

The average annual dose to an individual living, playing, and working at the site boundary and eating fish, beef, and milk exposed to plant effluents by various pathways would be 1.6 mrem/yr. This value, which is less than 2% of the natural background exposure of 100 mrem/yr, is below the normal variation in background dose, and represents no radiological impact. The average dose from the plant effluents to other individuals among the population would be significantly less than 1.6 mrem/yr.

A total dose of about 0.24 man-rem/yr would be received by the estimated 2010 population of 987,000 living in unrestricted areas within a 50-mi radius of the plant. By comparison, an annual total of about 9.9×10^4 man-rem would be delivered to the same population as a result of the average natural background dose. The 1000 man-rem estimated as occupational onsite exposure is about 1% of this annual total background dose (Sect. 5.7.3).

Most of the 17 man-rem annual dose from transport of radioactive materials to and from the CRBRP and probably all of the 1.4 man-rem annual dose from its supporting fuel cycle facilities would be received outside the 50-mi radius of the plant. These are also insignificant fractions of the dose from natural background radiation (Sect. 5.7.3).

The risks associated with accidental radiation exposure would be very low (Chapter 7).

10.2 SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

10.2.1 Scope

This section sets forth the relatively short-term uses of the environment for construction and operation of the breeder demonstration facility and the actions that could maintain and enhance the long-term productivity. Based on its analysis in the previous sections of this statement, the staff concluded that the resources committed to the proposed CRBRP represent an acceptable balancing of near-term usage and long-term productivity.

10.2.2 Enhancement of productivity

The major result from the project would be a demonstration of the LMFBR parameters necessary to its development for commercial size power plants. If the demonstration is successful and it leads to large-scale use of such plants, available reserves of uranium fuel would be extended. The degree to which the reserves would be extended depends upon the fuel doubling time that the reactor demonstrates and on future growth in the country's demand for electric power.

Electrical energy that would be produced is estimated to be an average of two billion kWH/yr over a 30-year operating life. The electricity would be distributed through the TVA system.

10.2.3 Uses Adverse to Productivity

10.2.3.1 Land Usage

The site has been owned by the U.S. Government and in the custody of the TVA for many years. It has been restricted from public use since the 1940s and designated for industrial development, but the land is presently idle, unsettled, and uncleared. The property contains nc resources not found in the surrounding area except for some items of historic and archeological interest that would be preserved. In the opinion of the staff, use of the land for the CRBRP would be consistent with long range development plans for the property.

New transmission lines for the proposed facility would parallel existing ERDA and TVA lines. The staff concluded that the transmission lines would have no important effect on alternative productive uses of the land (Section 5.5).

10.2.3.2 Water Usage

Since the average consumptive use of 10 cfs of river water would be only about 0.2% of Melton Hill Dam releases, the plant would have no effect on the availability of the river for recreational, municipal, agricultural or commercial uses.

10.2.4 Decommissioning

Sufficient experience is available from the decommissioning of licensed power reactors and demonstration nuclear power plants to indicate that decommissioning of the CRBRP would introduce no new or unknown technical problems of a safety or environmental nature. The Fermi 1 reactor was decommissioned by removing the fuel, the depleted uranium blanket and the sodium from the reactor and decontaminating accessible areas. The fuel was shipped to a reprocessing facility and the blanket material to a retrievable waste storage facility. The sodium was removed from the reactor primary and secondary systems and is now stored in tanks and drums at the Fermi 1 site. The sodium will be held there until it is shipped to the CRBRP for reuse.

The Fermi 1 facility remains in a protective storage status with access to the facility controlled by security guards. Radiation surveys are done quarterly to assess the containment of residual radioactivity within the facility. Decommissioning of the Fermi 1 reactor is quite applicable to CRBRP decommissioning as Fermi 1 was also a sodium cooled breeder reactor (PRDC, 1974).

The Southwest Experimental Fast Oxide Reactor (SEFOR), a sodium-cooled reactor with mixed-oxide fuel, was placed in protective storage when decomissioned. All fuel and sodium were removed and accessible areas were decontaminated.

Another sodium cooled reactor, the Hallam Nuclear Power Facility, was decommissioned by entombing all radioactive structures below ground level after removing the above ground structures.

Experience in complete dismantlement and removal of all radioactive components was obtained at Elk River, MN, site of a water cooled demonstration nuclear power plant.

A total of 9 civilian nuclear power facilities were or are in the process of being decommissioned. In addition to Fermi 1, Hallam and Elk River discussed above, decommissioning experience has been obtained at 6 other facilities: Carolina Virgina Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua Reactor, Valicitos Boiling Water Reactor (VBWR) and the Peach Bottom Unit No. 1.

No specific plan for decommissioning the CRBRP has been developed at this time, consistent with NRC's current regulations which contemplate detailed consideration of decommissioning near the end of a reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan that is submitted to the NRC for review. The licensee would be required to comply with regulations then in effect and decommissioning of the facility could not commence without authorization from the NRC.

Estimated costs of decommissioning of a 1000 MWe nuclear plant at the lowest level (protective storage) are about $1 million plus an annual maintenance cost of about $100,000 (AECH). Estimates vary from case to case, the variction largely arising from differing assumptions as to level of site restoration. For example, complete restoration, including regrading, has been estimated to cost $70 million (Pacific, 1972).

The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and scrap versus the complete demolition and removal of the complex. The operation would be controlled by the Commission's current rules and regulations to protect the health and safety of the public and the environment.

10.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

10.3.1 Scope

Irreversible commitments generally concern changes set in motion by the proposed action which at some later time could not be altered so as to restore the present ord r of environmental resources. Irretrievable commitments are generally the use or consumption of resources neither renewable nor recoverable for later use. Commitments inherent in environmental impacts are identified in this section, while the main discussions of the impacts are in Chapters 4 and 5. Commitments that involve local long-term effects on productivity are discussed in Section 10.2.

10.3.2 Commitments Considered

Types of resources of concern in this case can be identified as: 1) material resources--materials of construction, renewable resource material consumed in operation, and depletable resources consumed; and 2) nonmaterial resources, including a range of beneficial use of the environment.

Resources that, generally, may be irreversibly commited by the plant are: 1) biological species destroyed in the vicinity; 2) construction materials that cannot be recovered and recycled with present technology; 3) materials that are rendered radioactive but cannot be decontaminated; 4) materials consumed or reduced to unrecoverable forms of waste, including ^{235}U, ^{238}U and ^{239}Pu; 5) the atmosphere and water bodies used for disposal of heat and certain waste effluents, to the extent that other beneficial uses are curtailed, and 6) land areas rendered unfit for other uses.

10.3.3 Biotic Resources

Certain life stages of various aquatic organisms normally found in the vicinity of the intake and discharge would be entrained in the plant cooling water, entrapped within the intake, passed through the plant and/or entrained in the discharge plume. Organisms so exposed would suffer from a combination of mechanical, chemical, and thermal stress. An insignificant fraction would be lost to the total river ecosystem. The losses of both aquatic organisms and terrestrial biota are not judged to be irreversible resource commitments.

10.3.4 Material Resources

10.3.4.1 Materials of Construction

Materials of construction would be almost entirely of the depletable category of resources. Concrete and steel would constitute the bulk of those materials, but numerous other mineral resources would be incorporated in the plant. No commitments have been made on whether they would be recycled when their proposed use would have terminated. Materials not incorporated in the plant such as transmission line conductors and tower metal would be recyclable with only a minor penalty.

10.3.4.2 Replaceable Components and Consumable Materials

Some materials are of such value that economics clearly promotes recycling. Plant operation would contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed to reclaim and recycle the constituents. Some parts of the plant would become radioactive by neutron activation. Radiation shielding around the reactor and around other components inside the primary neutron shield constitute the major materials in that category, for which separating the activation products from the base materials would not be feasible. Components that come in contact with reactor coolant or with radioactive wastes would sustain variable degrees of surface contamination, some of which would be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry. Estimated quantities of materials used in a 1000 MWe liquid metal fast breeder reactor plant, about three times the size of the CRBRP, are shown in Table 10.1, including field construction materials consumed. Although the data were developed for a light water power reactor plant, the staff's opinion is that the material requirements would be about the same for a similar-sized fast breeder plant, and significantly less for the CRBRP with its maximum output of 379 MWe net.

TABLE 10.1 Estimated Quantities of Composite Materials Contained in a 1000 MWe LMFBR Power Plant, Including Field Construction Materials Consumed[(a)]

Material	Total Estimated Quantity
Aluminum, metric tons	18
Babbitt metal, metric tons	<1
Brass, metric tons	10
Carbon steel, metric tons	32,731
Concrete, yd^3	98,130
Copper, metric tons	694
Galvanized iron, metric tons	1,257
Inconel, metric tons	124
Insulation (thermal), metric tons	922
Lead, metric tons	46
Nickel, metric tons	1
Paint, gal	17,500
Silver, metric tons	<1
Stainless steel, metric tons	2,080
Wood, bd ft	4.8×10^6

(a) AEC, Estimated Quantities of Materials Contained in a 1000-MW(e) PWR Power Plant, ORNL-TM-4515, Oak Ridge National Laboratory, Oak Ridge, TN, June 1974.

Precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of those valuable depletable resources as is practicable would depend on need. Materials consumed during plant operation would be reactor control elements, other replaceable reactor core components, chemicals used in the laboratory and in processes such as reactor cooling and water treatment, and minor quantities of materials used in maintenance and miscellaneous operations. In the opinion of the staff, consuming those materials would have negligible effect on their reserves. About 1000 MT of sodium would be consumed, but it is one of the most abundant elements known.

The extent of fuel consumption over the plant's 30-yr life cannot be accurately predicted. The total requirement could be 20 metric tons (MT) of plutonium and 210 MT of uranium, although the breeder capability is expected to establish much lower requirements. Under ideal recycling, the plant's lifetime uranium requirement would be 56.6 MT with 39.4 MT recoverable at the time of plant decommissioning. The applicant estimates that over the plant's 30-yr life, 2.06 MT of

^{239}Pu would be required and the same amount would be produced; 0.04 MT of ^{235}U would be consumed, and 17.65 MT of ^{238}U would be consumed. A supply of depleted uranium would be available as spent fuel from light water reactor power plants. About 410 MT of fuel cladding would become contaminated with radioactive material, making it irretrievable since recycling is uneconomical (ER, pp 3.8-2, 5.8-4, and 5.8-4; and Am I, Part II, G6).

10.3.5 Water and Air Resources

Air and water would be used as carriers for chemical and radioactive materials released by the plant. The 10 cfs consumptive use of river water would not likely curtail downstream uses, even during extremely low flow; furthermore, the commitment would be neither irreversible nor irretrievable.

10.3.6 Land Resources

Thirty of the 34 acres committed to plant use could be restored for other purposes, with a moderate decommissioning effort. The 4 acres for principal plant buildings and the 2.5 acres for the barge unloading facility could be restored only at very high costs.

10.4 BENEFIT-COST

10.4.1 Benefits

10.4.1.1 LMFBR Concept Demonstration

The principal benefit of the proposed facility would be to demonstrate the liquid metal fast breeder nuclear reactor concept for commercial use in generating electrical power. If the applicability can be demonstrated, the useable energy in our uranium resources would be extended.

10.4.1.2 Power Produced

The electricity generated by the plant would be a secondary benefit. If it operates at the 68.5% average capacity factor estimated by the applicant (ER, p. A1-73) over the 30-yr plant life, a total of 6.2×10^7 MWh would be produced. An equivalent amount of electricity supplied by burning coal in a steam generator would consume about 800,000 tons of coal per year (based on 2.54×10^6 tons of coal to produce 6.57×10^9 kWh (WASH-1535)).

10.4.1.3 Research

The applicant has proposed an extensive preoperational monitoring program to characterize the environment prior to construction, and a similar operational phase monitoring program to determine any adverse effects due to plant construction or operation. Surface and groundwaters, local meteorology, terrestrial and aquatic ecology, and radiological surveys would be conducted (Chapter 6).

The ERDA has undertaken a large research program in support of the LMFBR concept. Research and development (R&D) by ERDA in support of the CRBRP is expected to total $314 million between 1975 and 2020 with an additional $891 million for safety related R&D applicable to the total LMFBR program (WASH-1535, Table 11.2-3).

10.4.1.4 Environmental Enhancement

The results of onsite archaeological investigations by the University of Tennessee will be made available to the public.

10.4.1.5 Employment and Payroll

The primary and secondary work force and associated payrolls were discussed in previous sections. The data are summarized in Table 10.2.

The direct payroll of $245 million during the construction period is expected to induce a secondary payroll of $39.6 million through creation of local demand for goods and services. In a similar fashion, during the operational period, the $40.6 million direct payroll is expected to induce a secondary payroll of $7.2 million.

TABLE 10.2 Summary of Employment Benefits

Item	Construction Period (1976-1983)	Demonstration Period (1984-1988)
Direct Employment[a]	1,180	275
Induced Employment[a]	670	210
Direct Payroll[b]	\$245,200,000	\$40,600,000
Induced Payroll[b]	\$ 39,600,000	\$ 7,210,000

(a) Annual average based on Table 4.1
(b) See Table 4.8

10.4.1.6 Taxes

State and local sales taxes generated from payroll spending would be the principal source of public funds generated by the project for use in the project area. The staff estimate of the value of tax revenues is summarized in Table 10.3. These revenues would be generated principally in the counties of Anderson, Knox, Loudon, and Roane.

TABLE 10.3 Tax Revenues from CRBRP Payroll Spending[a]

Period	State Sales Tax (3.5%)	Local Sales Tax (1.5% max)	Total
Construction (1976-1983)	\$4,200,000	\$1,800,000	\$6,000,000
Demonstration (1984-1988)	688,000	295,000	983,000
Total (1976-1988)	\$4,888,000	\$2,095,000	\$6,983,000

(a) All dollar values are present valued (8% discount rate) after escalation (8% rate) for inflation.

In the absence of local authority to tax the CRBRP project directly through property taxes, or sales and use taxes on materials and supplies used in construction, the in-lieu-of-tax payment becomes an important factor. In the opinion of the staff, the local public costs arising as a result of the project would not be covered unless in-lieu-of-tax payments are made (Table 5.9).

10.4.2 Cost Description of the Proposed Facility

10.4.2.1 Environmental Costs

Environmental costs discussed in Chapters 4 and 5 are summarized in Table 10.4.

10.4.2.2 Monetary Costs

The estimated cost of the CRBRP has undergone several revisions since the project was first proposed. For the purposes of this statement, the staff reviewed the September 1974 estimate of \$1.736 billion for construction and operation for a 5-yr demonstration period. The breakdown of that estimate is given in Table 10.5.

In the table, base cost elements are in 1974 dollars. Escalation is handled as a separate line item, applying a 8%/yr escalation rate to the various components. For example, associated with the \$47 million revenue for electricity sold to TVA is a \$65 million credit included in the total \$498 million escalation item.

TABLE 10.4 Summary of Environmental Costs, CRBRP

Effect	Reference Section	Summary Description
Land Use		
Construction Activities	4.2.1	About 170 acres disturbed during construction of the plant and support facilities.
Long-Term Dedication	4.2.1	About 73 acres permanently dedicated, including 24 acres for access roads and railroad.
Transmission Lines	5.5	A total of 3.2 miles of right-of-way would be widened, causing a disturbance of about 58 acres. Two streams and several intermittent streams would be crossed.
Water Use		
Construction	4.3	50,000 gpd (35 gpm) maximum rate.
Operation	5.2	10 cfs (4500 gpm) water consumptively used during operation.
Thermal Effects	3.4.1	Cooling water would be heated 25°F by passage through the condensers.
	3.4.1	Maximum outfall temperature would be 94.5°F (July).
Intake Velocities	3.4.2	Intake velocity is expected to be about 0.4 fps.
Discharge Volume	3.4.3	Minimum rate of 2,500 gpm; maximum rate of 3,470 gpm.
Chemical and Sanitary Waste	5.4	Rapidly diluted to harmless concentrations under flowing river conditions.
Siltation	4.3	Removal 40,000 m^3 of material for construction of intake and barge slip and suspended solids in site runoff would have minor, temporary effects.
Terrestrial Ecological Effects		
Rare and Endangered Species	2.7.1.2.2	The Southern Bald Eagle, a threatened species, has been observed on the site.
	4.2.1	Rare wild flower collection [illegible] on the site would not be disturbed.
Vegetation and Animal Life	4.4.1	Some timber would be harvested but other vegetation and some animals on land disturbed by construction would be lost.
Cooling Tower Drift	5.3.3	Worst case deposition would be 90 lb/acre/mo of salts; no adverse effect is expected.
Aquatic Ecological Effects		
Benthic Losses		
a. During Construction	4.4.2	Benthic organisms lost as a result of dredging would be easily reestablished.
b. During Operation	5.3.2.4	The maximum scour area around the discharge would be 10 m^2 and produce a permanent loss of benthos in that area.
Impingment	5.3.1.1	A maximum of 0.5% of fish passing the intake could be impinged.
Entrapment	5.3.1.1	Negligible
Entrainment	5.3.1.2	An average loss of 0.46% and a maximum loss of 2.2% of phytoplankton, zooplankton, drift invertebrates and ichtyoplanton is estimated.

TABLE 10.4 Summary of Environmental Costs, CRBRP (Cont'd)

Thermal Effects	5.3.2.2	No significant change on the ecosystem is expected as a result of drift or passage of aquatic species through the thermal plume.
Cold Shock	5.3.2.3	Fish loss is unlikely from any interruption of heated effluents.
Trace Chemicals	5.4.1	Iron and cooper concentrations would not exceed established discharge limits or toxicity levels, assuming Melton Hill Dam regulation meeting CRBRP needs.
Sanitary Waste	5.4.2	Negligible
Radiological Releases		
Individual Dose	5.7.3	1.6 mrem/yr average annual dose to an individual at site boundary, less than 2% of 100 mrem/yr natural background dose.
Cumulative Dose	5.7.3	0.24 man-rem/yr to total 987,000 population within 50 miles in year 2010, insignificant compared to 9.9×10^4 man-rem/yr from natural background.
Occupational Dose	5.7.3	1000 man-rem/yr conservatively estimated, 1% of 50 mi population natural background dose.
Transportation Dose	5.7.2.6	17 man-rem/yr total to transport workers and population along entire shipping routes.
Accidental Dose	7.1, 7.2	The risks associated with accidental radiation exposure are very low.
Community Effects		
Archaeological Sites	5.1	None of the several archaeological sites on the property would be disturbed by construction activities. Access to Hensley Cemetery would be allowed.
Visual Impact	5.1	The structures would be partly visible from the Gallaher Bridge and scattered residences south of the river.
	5.3.3	It would be possible to have a 6 mile long plume 6% of the time during plant operation. Fog could be a minor nuisance on nearby roads a few hours per year.
New Population	5.6	275 employees during operational phase would generate a total new population of 1200 persons.
Payroll	4.5.2	During the life of the project a $286 million payroll should generate a secondary payroll of $47 million.
Public Services	5.6.1	No firm provisions have been made for funds to provide public sector services.
Traffic	4.6.2 5.3.3.1	Excessive traffic congestion on Route 58 in Roane County during construction could be mitigated by staggered shift schedules. Fog would be only an aesthetic distraction.
Physical Resources		
Uranium	10.3.4.2	Less than 210 metric tons
Plutonium	10.3.4.2	Less than 20 metric tons

TABLE 10.5 Cost of Construction and Operation of CRBRP[a]

Element	Cost (000,000 omitted)	% of Base Cost
Plant Equipment	$ 284	28.0%
Engineering	293	28.9
Construction	213	21.0
Core Fabrication	75	7.4
Operation & Maintenance	49	4.8
Special Nuclear Material	10	1.0
PMC Staff & Services	32	3.2
Equipment Development	88	8.7
Insurance	5	.5
Safety-related Design Changes	11	1.1
Revenue from Operation	(47)	(4.6)
Subtotal, base cost	$1,013	100.0%
Contingency	225	22.2
Escalation	498	49.2
Total project cost	$1,736	171.4%

(a) Cost and Schedule Estimate for the Nation's First Liquid Metal Fast Breeder Reactor Demonstration Plants, RED-75-358, May 22, 1975, General Accounting Office.

A capital cost of $2 million and annual operating costs not exceeding $1,890,000 have been estimated by the staff for safeguards measures necessary to protect the CRBRP and the related fuel cycle facilities and transport of radioactive materials from acts of sabotage, theft or diversion (Sect. 7.3.3). These additional costs would not significantly affect the cost/balance relative to the project.

10.4.3 Benefit-Cost Summary

The staff reviewed the applicant's proposed plant (Chapter 3) and made an independent evaluation of the environmental effects of its construction and operation (Chapters 4 and 5) at the proposed site (Chapter 2). Further consideration was given to the environmental and monetary factors associated with alternative plant-site combinations and plant system alternatives (Chapter 9).

On the basis of its evaluations the staff concludes that 1) constructing and operating the CRBRP at the proposed location would be possible without causing any significant impact on the physical environment of the area, 2) locating the project at an alternative TVA site using the hook-on arrangement would be less expensive but attendant technological risks could jeopardize the ability of the project to meet its intended objectives, and 3) local costs for additional public services needed by project personnel and their families may exceed the local benefits from the project and therefore should be assessed by the applicants to determine the need for offsetting in-lieu-of-tax payments. The staff further concludes that the CRBRP, as a demonstration plant, is a key element in the evaluation and development of the LMFBR concept.

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APPENDIX A

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT BY AGENCIES AND INTERESTED PARTIES

(Reserved for comments)

APPENDIX B

TENNESSEE WILDLIFE RESOURCES COMMISSION
PROCLAMATION
ENDANGERED OR THREATENED SPECIES

APPENDIX B

TENNESSEE WILDLIFE RESOURCES COMMISSION
PROCLAMATION
ENDANGERED OR THREATENED SPECIES

Pursuant to the authority granted by Tennessee Code Annotated, Sections 51-905 and 51-907, the Tennessee Wildlife Resources Commission does hereby declare the following species to be endangered or threatened species subject to the regulations as herein provided. Said regulations shall become effective sixty days from this date.

SECTION I. ENDANGERED OR THREATENED SPECIES

FISH

ENDANGERED

Lake Sturgeon	*Acipenser fulvescens*
Ohio River Muskellunge (in Morgan, Cumberland, Fentress & Scott Counties)	*Esox masquinongy ohioensis*
Barren's Topminnow	*Fundulus sp. (cf. F. albolineatus)*
Spotfin Chub	*Hybopsis monacha*
Yellowfin Madtom	*Noturus flavipinnis*
Snail Darter	*Percina (Imostoma) sp.*

THREATENED

Silverjaw Minnow	*Ericymba bucatta*
Slender Chub	*Hybopsis cahni*
Blue Sucker	*Cycleptus elongatus*
______ Madtom	*Noturus sp. (cf. N. hildebrandi)*
Frecklebelly Madtom	*N. munitus*
Slackwater Darter	*Etheostoma boschungi*
Coldwater Darter	*E. ditrema*
Trispot Darter	*E. trisella*
Duskytail Darter	*E. (Catonotus) sp.*
Coppercheek Darter	*E. sp. (cf. E. maculatum)*
Longhead Darter	*Percina macrocephala*
Amber Darter	*P. (Imostoma) sp.*
Reticulate Logperch	*P. sp. (cf. P. caprodes)*

AMPHIBIANS

THREATENED

Tennessee Cave Salamander	*Gyrinophilus palleucus*

SECTION I. ENDANGERED OR THREATENED SPECIES (Continued)

REPTILES

THREATENED

Northern Pine Snake	*Pituophis m. melanoleucus*
Western Pigmy Rattlesnake	*Sistrurus miliarius streckeri*

BIRDS

ENDANGERED

Mississippi Kite	*Ictinea misisippiensis*
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Duck Hawk	*Falco peregrinus*
Red-cockaded Woodpecker	*Dendrocopos borealis*
Raven	*Corvus corax*
Bachman's Sparrow	*Aimophila aestivalis bachmanii*

THREATENED

Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*A. cooperi*
Marsh Hawk	*Circus cyaneus hudsonius*
Bewick's Wren	*Thyromanes bewickii*
Grasshopper Sparrow	*Ammodramus savannarum*

MAMMALS

ENDANGERED

Indiana Myotis	*Myotis sodalis*
Gray Myotis	*Myotis grisescens*

THREATENED

River Otter	*Lutra canadensis*

SECTION II. REGULATIONS

Except as provided for in Tennessee Code Annotated, Section 51-906 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 51-905 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna.

TENNESSEE WILDLIFE RESOURCES COMMISSION

Dr. P. H. Clayton Jr.

Chairman

I certify that this is an accurate and complete copy of rules lawfully promulgated and adopted by the Tennessee Wildlife Resources Commission on the 12th day of June, 1975.

Harvey Bray

Secretary

Subscribed and sworn to before me this the 18th day of June, 1975.

Bobby L. Stratton

Notary Public

My commission expires on the 18th day of December, 1976.

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE CORPORATION
NUCLEAR DIVISION

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37830

February 20, 1975

Ms. Betty Keppler
Ecosystems Department
Battelle-Northwest Labs.
Richland, WA 99352

Dear Betty:

Here are the acreages for the whole Reservation:

	Acres	% of Total
Hardwood	10,876	37
Pine Plantation	5,002	17
Natural Pine	4,888	16
Cedar & Pine	478	2
Hardwood-Cedar	1,660	5
Hardwood-Pine	5,959	20
Hardwood-Cedar-Pine	589	3
	29,443	100

Tom Kitchings
Tom Kitchings
Environmental Sciences Division
Building 3017

TK/clh

APPENDIX C

LETTERS FROM STATE OF TENNESSEE REGARDING ARCHEOLOGICAL AND HISTORIC RESOURCES

APPENDIX C

FROM, ER, AM I, PART II, G2

GOVERNOR
GRANVILLE HINTON
COMMISSIONER
PENN S. FOREMAN
ASSISTANT COMMISSIONER
TONY KOELLA
ASSISTANT COMMISSIONER

TENNESSEE DEPARTMENT OF **Conservation**

Division of Archaeology

5103 EDMONDSON PIKE • NASHVILLE, TENNESSEE 37211

March 12, 1975

Mr. E. H. Lesesne
Director, Water Control Planning Division
Tennessee Valley Authority
448 Evans Building
Knoxville, TN 37902

Dear Mr. Lesesne:

I have reviewed the report submitted by Dr. Gerald F. Schroedl relating to the archaeological work done in the area of the Clinch River Liquid Metal Fast Breeder Reactor Facility and consider this work to be of excellent quality.

Dr. Schroedl's survey, judging by his report, was very through and brought to light many interesting archaeological and historic sites. His proposal to test the village area near the mound and the shell midden should provide valuable information on the Woodland and Archaic culture periods in the Clinch River area.

The Tennessee Valley Authority is to be commended for its interest and excellent support of the above archaeological research.

T.V.A. has properly considered all archaeological resources and has in my estimation asserted the proper mitigation. The results of the report and studies have shown that there are no sites worthy for nomination to the National Registry.

If you should have further questions or would like additional comments, please do not hesitate to call me.

Sincerely yours,

Joseph L. Benthall

Joseph L. Benthall
Director and State
Archaeologist

LMFBR PROJECT SECTION
MAR 17 1975
2

STATE OF TENNESSEE
TENNESSEE HISTORICAL COMMISSION
170 SECOND AVENUE, NORTH
NASHVILLE, TENNESSEE 37201
TELEPHONE (615) 741-2371

LAWRENCE C. HENRY, Executive Director
State Historic Preservation Officer

May 1, 1975

Mr. Edward H. Lesesne
Director of Water Control Planning
Tennessee Valley Authority
448 Evans Building
Knoxville, Tennessee 37902

Dear Mr. Lesesne:

This will acknowledge receipt of the report submitted by Dr. Gerald F. Schroedl on Historic Sites Reconnaissance in the Clinch River Breeder Reactor Plant Area.

We have reviewed this report and based on the information contained therein conclude that no structures of historical significance remain in the area. It is obvious that exhaustive efforts were put forth to make the report as complete as possible, and the results reveal that no properties eligible for entry in the National Register of Historic Places exist.

If I can be of further help, please let me know.

Sincerely,

Lawrence C. Henry

LCH/HLH/11

APPENDIX D

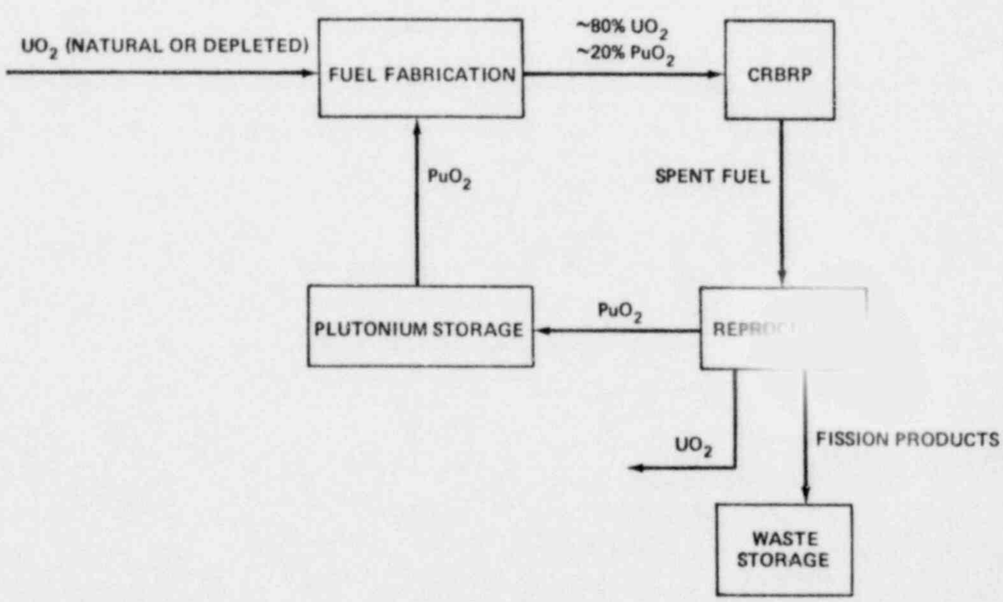
ENVIRONMENTAL EFFECTS OF THE CRBRP FUEL CYCLE AND TRANSPORTATION OF RADIOACTIVE MATERIALS

1. INTRODUCTION

In contrast to light water reactors (LWRs), a fast breeder reactor produces fissile fuel from fertile fuel at a rate higher than the original fissile fuel is expended in the production of thermal energy. The fissile fuel thus produced can be used in a reactor after it is separated from the discharged spent fuel and appropriately processed. The various fuel cycle steps involved are described in detail for a generic LMFBR in the Proposed Final Environmental Statement on the LMFBR Program.[1] A simplified schematic diagram of the fuel cycle for the proposed LMFBR demonstration plant is shown in Figure 1.

The initial feed materials would consist of plutonium (obtained from the reprocessing of light water reactor fuels) and depleted uranium (which is a by-product from the enrichment of the U-235 content of natural uranium). The plutonium would be converted to an oxide (PuO_2) at a reprocessing plant while the uranium, as the hexafluoride (UF_6), would be converted to an oxide (UO_2) at a fuel fabrication plant. Subsequently, at the fuel fabrication plant, plutonium dioxide and uranium dioxide would be combined and fabricated into fast breeder mixed-oxide fuel for seed assembly core components and uranium dioxide would be fabricated into assemblies for axial and radial blanket components of the reactor.

After exposure in the reactor, the irradiated fuel and blanket components would be stored at the reactor for a specified time. This permits decay of the shorter-lived fission products and reduces the component's decay-heat generation rates. Subsequently, they would be shipped in shielded casks to a reprocessing plant where the plutonium, uranium and



CRBRP FUEL CYCLE

Figure 1

fission products would be chemically separated. The separated fission products would be shipped to a Federal waste-storage facility, and the plutonium recycled as fuel. The recovered uranium would either be stored or recycled into the mixed oxide or blanket UO_2. Depleted uranium from enrichment facilities would be used as make-up for the uranium that is either converted to plutonium in the reactor, lost as scrap in the fuel cycle process steps, or stored for later disposition.

An analysis of the predicted environmental impact from the fuel cycle associated with the CRBRP and the transport of radioactive materials between the supporting facilities is provided in the following discussion. This analysis is based on the quantities of materials required in a fuel cycle to maintain the CRBRP's operation.

The initial core loading will consist of approximately 6.5 metric tons (MT) of uranium and plutonium in the form of sintered mixed-oxide pellets of PuO_2 and UO_2 encapsulated in sealed stainless steel tubing (rods) which are formed into assemblies. Each of the 198 fuel subassemblies in the reactor core (108 inner core zone assemblies and 90 outer core zone assemblies) will contain 217 fuel rods. Plutonium enrichment will be 18.7 weight percent in the inner core zone and 27.1 weight percent in the outer zone of the first core. In future cores, the plutonium enrichment will be 22 weight percent in the inner core zone and 32 weight percent in the outer zones. With equilibrium loading, the reactor core would contain 1.7 MT of plutonium, and 4.8 MT of uranium.

An additional 21.7 MT of depleted uranium will be committed in the radial and axial blankets. The radial blankets, consisting of 150 assemblies each containing 61 rods, will contain 16.3 MT of depleted uranium. The two blankets, which are an integral part of the fuel core, will each contain 2.7 MT of depleted uranium.

During operation of the reactor, the irradiated fuel will become poisoned with fission products and require fresh (unirradiated) fuel. An estimated 2,300 fuel assemblies and 850 radial blanket assemblies would be used during the 30-year life of the plant. The total requirements of the plant during its life could be as high as 20 MT of plutonium and 210 MT of uranium.

The applicant stated in the Environmental Report (ER Sect. 3.8) that the first five years of plant operation would be carried out in a pre-equilibrium mode, while the balance of the plant operating life (25 years) would be carried out in an equilibrium mode. Notable differences between the two operational modes are indicated in Table 1. The quantities of materials and the material shipments for the CRBRP fuel cycle would be maximal during pre-equilibrium operation; therefore, the staff has focused its evaluation on the annual environmental impact associated with the pre-equilibrium mode of operation.

TABLE 1

NOTABLE DIFFERENCES BETWEEN CRBRP OPERATIONAL MODES

	Pre-equilibrium (5 years)	Equilibrium (25 years)
New Fuel Assemblies replaced/yr	102	66
Weight of Assemblies (tons)	26.3	17.0
Number of Fuel Assembly Shipments/yr	51	33
Number of Spent Fuel Assembly Shipments/yr	25.5	8
Number of Radial Blanket Assembly Shipments/yr	1.4	4

Mining and milling operations for the CRBRP fuel cycle are unnecessary since the feed materials employed would be by-products of the existing LWR fuel cycle. Otherwise, the related transportation steps are similar to those encountered in the LWR fuel cycle.(2) These include shipments of fuel feed materials (such as UF_6 and UO_2) and irradiated material (such as spent fuel, PuO_2 recovered in reprocessing spent fuel, and wastes from fuel fabrication, the reactor and reprocessing plants). Such shipments will normally be made by truck with appropriate restrictions regarding shipping conditions.(3) Where heavy packages are involved (e.g., a spent fuel cask weighing about 75 tons), shipments will be made by rail. Since transportation has no intrinsic capacity factor in the same sense as a fixed facility, the transportation requirements in support of the CRBRP fuel cycle are discussed in terms of the annual pre-equilibrium fuel requirements.

2. ENVIRONMENTAL CONSIDERATIONS

a. Fuel Cycle Impacts

The environmental impact from the fuel cycle facilities supporting the CRBRP was established by utilizing information and data on fuel cycle impacts presented in references 1 through 5. A general analysis of the predicted environmental impacts resulting from the utilization and related shipments of materials in an annual fuel cycle for one 1000-MWe LMFBR is discussed in the latter references. This analysis is based on the quantities of materials required to maintain the CRBRP in operation annually, as reported in the ER. Where necessary, the values reported for the generic model LMFBR were scaled to the CRBRP requirements to ascertain their associated impacts. These impacts are summarized in Table 2.

The amount of land and water utilized by the supporting fuel cycle facilities is inconsequential when compared to the requirements of the power plant. The 11.7 acres of land committed for the fuel cycle facilities are less than 1% of the land committed for the power plant. The daily water discharge of 7.23×10^3 gallons via the air and 1.64×10^3 gallons to water bodies for the fuel cycle amount to approximately 0.1% of the water released from the power plant heat dissipation systems.

Fossil fuel requirements, in the form of electrical energy or equivalent coal in support of the CRBRP fuel cycle are 3.97×10^3 MW-hr/yr or 1.71×10^3 MT/yr, respectively. These values are equivalent to 0.2% of the CRBRP output or to the use of 0.7 MWe by a coal-fired power plant.

Liquid and airborne non-radiological chemical effluent releases from the discharge systems during routine operation of the fuel cycle facilities should result in concentrations that are only a fraction of the state and Federal standards.

The annual estimated doses from ionizing radiation resulting from normal operation of the CRBRP fuel cycle facilities supporting the plant are given in Tables 3 and 4. Average doses from natural background radiation, fallout from weapons testing (based on 1970 data), and medical uses (based on average 1970 diagnostic use) are included for perspective. The data show that yearly population doses* due to operation of these facilities should add very little to the impact of existing natural background and medical doses. Based on these data, the staff concludes that the resulting doses from the radiation fields due to fuel cycle facilities supporting the CRBRP would be well below maximum permissible concentrations (MPC's) as outlined in 10 CFR Part 20, Appendix B, well within Federal Radiation Council guidelines, and not significant.

b. Transportation of Radioactive Materials in the Fuel Cycle

An analysis of the quantities of radioactive material and their transport requirements to maintain the CRBRP during operation in the pre-equilibrium period was performed by the staff. The materials considered in this analysis were divided into three categories: unirradiated fuel, materials and assemblies; irradiated fuel; and irradiated waste. Table 5 summarizes the estimated material quantities that would be generated and the number of shipments made in the operation of the CRBRP fuel cycle.

Shipments of incoming and outgoing radioactive materials to and from the CRBRP will be carried out by commercial trucks and railroads. As shown in Table 6, the staff estimates that approximately 58 incoming shipments and 46 outgoing shipments would be made annually during pre-equilibrium phase of operation. During equilibrium operation, the estimated number of shipments would decrease to approximately 48 incoming and 36 outgoing shipments annually.

Protection of the public and transport workers from radiation during shipment of lading control. Primary reliance for safety in transport of radioactive material is placed on the packaging.[3,9] The packaging must meet applicable Federal and state regulatory standards which provide that the packaging shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear

*See Table 4, footnote C

TABLE 2

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR THE CRBRP FUEL CYCLE

Natural Resource Use	Fuel Fabrication Mixed Oxide (Core Fuel)	Fuel Fabrication Uranium Dioxide (Blanket)	Reprocessing	Waste Management	Transportation	Total
Land (acres)						
Temporarily Committed	1.7	3.4	5.1	--	--	10.2
Undisturbed Area	1.4	2.9	4.8	--	--	9.1
Disturbed Area	0.3	0.5	0.3	--	--	1.5
Permanently Committed	--	--	0.2	1.3	--	1.5
Total Land	1.7	3.4	5.3	1.3	--	11.7
Water (gallons/day)						
Discharged to air	2.19×10^2	1.19×10^3	5.82×10^3	--	--	7.23×10^3
Discharged to water bodies	1.65×10^2	1.47×10^3	--	--	--	1.64×10^3
Discharged to ground	--	--	--	--	--	--
Total Water	3.84×10^2	2.66×10^3	5.82×10^3	--	--	8.87×10^3
Fossil Fuel						
Electrical Energy (MW-hr/yr)	1.50×10^2	8.15×10^2	3.0×10^3	--	--	3.97×10^3
Equivalent Coal (MT/yr)	5.4×10^1	3.60×10^2	1.3×10^3	--	--	1.71×10^3
Effluents-Chemicals						
Atmospheric* (MT/yr)						
SO_x	2.0	13.3	48.0	--	--	63.3
NO_x	0.52	3.5	12.7	--	--	16.7
Hydrocarbons	5.2×10^{-3}	3.5×10^{-2}	0.13	--	--	0.17
CO	1.3×10^{-2}	8.7×10^{-2}	0.31	--	--	0.41
Particulates	$5.x \times 10^{-1}$	3.5	12.7	--	--	16.7
HF	--	2.36×10^3	--	--	--	2.36×10^3
NH_3	--	7.08×10^3	--	--	--	7.08×10^3

TABLE 2 (Continued)

Effluents	Fuel Fabrication: Mixed Oxide (Core fuel)	Fuel Fabrication: Uranium Dioxide (Blanket)	Reprocessing	Waste Management	Transportation	Total
Chemicals						
Liquid (grams/yr)						
H_2SO_4	1.38×10^2	--	--	--	--	1.38×10^2
HNO_3	59.0	--	--	--	--	59.0
HCl	39.0	--	--	--	--	39.0
$NaNO_3$	8.3×10^3	--	--	--	--	8.3×10^3
NaOH	1.2×10^3	--	--	--	--	1.2×10^3
NH_4OH	--	1.85×10^7	--	--	--	1.85×10^7
$Ca(OH)_2$	--	1.09×10^6	--	--	--	1.09×10^6
CaF_2	--	4.80×10^2	--	--	--	4.80×10^2
PO_4^{3-}	1.78×10^3	9.70×10^3	--	--	--	1.15×10^4
PO_4^{3-}(after degrading)	1.78×10^2	9.70×10^2	--	--	--	1.15×10^3
Total solids	6.71×10^3	3.66×10^4	--	--	--	4.33×10^4
PO_4^{3-} (in cooling tower drift)	96.0	5.47×10^2	--	--	--	6.43×10^2
Radiological (Curies/yr)						
Atmospheric						
Pu-236	7.4×10^{-6}	--	--	--	--	7.40×10^{-6}
Pu-238	8.3×10^{-8}	--	7.2×10^{-5}	--	--	7.2×10^{-5}
Pu-239	1.7×10^{-8}	--	1.5×10^{-5}	--	--	1.5×10^{-5}
Pu-240	2.3×10^{-8}	--	2.0×10^{-5}	--	--	2.0×10^{-5}
Pu-241	2.4×10^{-6}	--	2.2×10^{-3}	--	--	2.2×10^{-3}
Pu-242	6.4×10^{-7}	--	--	--	--	6.4×10^{-7}
U-232	2.6×10^{-3}	--	--	--	--	2.6×10^{-3}
U-234	6.3×10^{-5}	--	4.1×10^{-9}	--	--	6.3×10^{-5}
U-235	--	--	4.1×10^{-11}	--	--	4.1×10^{-11}

TABLE 2 (Continued)

Effluents	Fuel Fabrication: Mixed Oxide (Core fuel)	Fuel Fabrication: Uranium Dioxide (Blanket)	Reprocessing	Waste Management	Transportation	Total
Radiological (Curies/yr)						
Atmospheric						
U-236	--	1.2×10^{-7}	1.3×10^{-10}	--	--	1.2×10^{-7}
U-238	6.8×10^{-5}	7.3×10^{-6}	4.4×10^{-9}	--	--	7.5×10^{-5}
Th-228	6.9×10^{-13}	--	--	--	--	6.9×10^{-13}
Th-231	--	9.9×10^{-8}	--	--	--	9.9×10^{-8}
Th-234	--	7.3×10^{-6}	--	--	--	7.3×10^{-6}
Am-241	4.0×10^{-9}	--	--	--	--	4.0×10^{-9}
Np-237	6.6×10^{-16}	--	--	--	--	6.6×10^{-16}
Pa-234	--	7.3×10^{-16}	--	--	--	7.3×10^{-6}
H-3	--	--	7.8×10^{2}	--	--	7.8×10^{2}
Kr-85	--	--	6.2×10^{2}	--	--	6.2×10^{2}
I-129	--	--	3.0×10^{-5}	--	--	3.0×10^{-5}
I-131	--	--	2.4×10^{-11}	--	--	2.4×10^{-11}
Ru-103	--	--	3.2×10^{-5}	--	--	3.2×10^{-5}
Ru-106	--	--	5.3×10^{-3}	--	--	5.3×10^{-3}
Particulate fission products	--	--	2.5×10^{-3}	--	--	2.5×10^{-3}
Liquid						
Pu-236	8.1×10^{-10}	--	--	--	--	8.1×10^{-10}
Pu-238	6.9×10^{-6}	--	--	--	--	6.9×10^{-6}
Pu-239	1.5×10^{-6}	--	--	--	--	1.5×10^{-6}
Pu-240	1.9×10^{-6}	--	--	--	--	1.9×10^{-6}
Pu-241	2.1×10^{-4}	--	--	--	--	2.1×10^{-4}
Pu-242	5.2×10^{-9}	--	--	--	--	5.2×10^{-9}
U-232	2.2×10^{-11}	--	--	--	--	2.2×10^{-11}
U-234	5.2×10^{-11}	2.1×10^{-4}	--	--	--	2.1×10^{-4}
U-235	--	2.5×10^{-5}	--	--	--	2.5×10^{-5}

TABLE 2 (Continued)

Effluents	Fuel Fabrication: Mixed Oxide (Core fuel)	Fuel Fabrication: Uranium Dioxide (Blanket)	Reprocessing	Waste Management	Transportation	Total
Radiological (Curies/yr)						
Liquid						
U-236	--	3.2×10^{-5}	--	--	--	3.2×10^{-5}
U-238	5.8×10^{-11}	1.9×10^{-3}	--	--	--	1.9×10^{-3}
Th-228	5.8×10^{-12}	--	--	--	--	5.8×10^{-12}
Th-231	--	2.5×10^{-5}	--	--	--	2.5×10^{-5}
Th-234	--	1.9×10^{-3}	--	--	--	1.9×10^{-3}
Am-241	3.5×10^{-7}	--	--	--	--	3.5×10^{-7}
Np-237	5.5×10^{-13}	--	--	--	--	5.5×10^{-13}
Pa-234	--	1.9×10^{-3}	--	--	--	1.9×10^{-3}
Solids (Curies/yr)						
Other than high level						
Alpha	1.4×10^{2}	2.8×10^{2}	--	--	--	4.2×10^{2}
Beta-Gamma	2.4×10^{-3}	4.9×10^{-3}	--	--	--	7.3×10^{-3}
Thermal (Btu/yr)	2.2×10^{7}	4.6×10^{7}	7.2×10^{8}	--	5.0×10^{6}	7.9×10^{8}

*Based upon combustion of equivalent coal for power generation

TABLE 3

COMPARISON OF MAXIMUM INDIVIDUAL DOSES DUE TO NORMAL EFFLUENTS FROM THE CRBRP SUPPORTING FUEL CYCLE WITH OTHER SOURCES(6,7)

Radiation Source	Dose (millirems/year)[a]
Fuel Fabrication Plant	0.00008[b]
Fuel Reprocessing Plant	0.001[c]
Transportation (other than to and from the CRBRP)	4.10[b]
Storage of Radioactive Waste	negligible
Other Sources of Radiation	
Natural Background	100[d]
Fallout	4[e]
Medical Use (diagnostic only)	72[e]
Television	0.1[e]
CRBRP	1.6[f]

a. Normalized for the CRBRP supporting fuel cycle facilities for one year.

b. Total-body dose; value for transportation assumes maximum exposure for 12 minutes @ 50 mrem/hr.

c. G.I. tract dose.

d. External natural background for Eastern Tennessee.

e. 1970 average doses from reference 8.

f. From Section 5.7.3, NRC's Draft Environmental Statement for CRBRP.

TABLE 4

ANNUAL POPULATION DOSES DUE TO THE NORMAL EFFLUENTS FROM THE CRBRP SUPPORTING FUEL CYCLE.(6,7)

Radiation Source	Annual Dose (man-rems)[a,c]
Fuel Fabrication Plant	0.08
Fuel Reprocessing Plant	0.99
Transportation (other than to and from the CRBRP)	0.30
Storage of Radioactive Waste	negligible
TOTAL	1.37
Other Sources of Radiation[b]	
Natural Background	98,730
Fallout	3,950
Medical Use (diagnostic only)	72,685
Television	99
CRBRP	0.24[d]

a. Normalized for the CRBRP supporting fuel cycle; includes gaseous and liquid effluents and direct radiation.

b. 1970 average doses taken from reference 8 for a projected population of 987,300 people within 50 miles of the site.

c. The man-rem population dose is the summation of individual doses among the population and reflects dose impact as a whole. The natural background dose of 98,730 man-rem, for example, is accrued by 987,730 persons if each receives a background dose of 0.10 rem per year (987,300 x 0.10 = 98,730).

d. From Section 5.7.3, NRC's Draft Environmental Statement for CRBRP.

TABLE 5 - A SUMMARY OF MATERIALS AND QUANTITIES SHIPPED FOR THE CRBRP

Type of Shipment	Mode of Transport	Quantity Shipped Per year[a] (kg)	Quantity Shipped Per Package[a] (kg)	No. of Packages Per Vehicle	Heat Generation Rate Per Package (W)	Est. Activity Per Package (Ci)	Avg. No. of Shipments Per Year	Est. Avg. Shipping Distance[g,h] (miles)	Shipment Destination[i]
				Unirradiated Material					
UF_6	Truck	12,437	8,604	1		3.21	1.45	750	FP
UO_2	Truck	11,514	97	64	2.6×10^{-3}	1.60	1.85	750	FP
PuO_2	Truck	1,250	9	64	81	1.04×10^{5}	2.17	750	FP
Fresh Core Assembly	Truck	20,502	201	2	218	2.8×10^{5}	51	750	PS
Fresh Blanket Assembly	Truck	3,107	239	2	6.3×10^{-3}	3.78	6.5	750	PS
				Irradiated Material					
Spent Core Assembly	Rail	20,502	804	1	24×10^{3}	2.17×10^{6}	25.5	750	RP
Spent Blanket Assembly	Rail	3,107	2,151	1	15.8×10^{3}	6.78×10^{5}	1.44	750	RP
Radial Shield Assembly	Rail	8,160	3,060	1	3.06×10^{3}		2.67	750	RP
Control Rod Assembly	Rail	2,591	864	1			3	750	RP

Type of Shipment	Mode of Transport	Quantity Shipped Per Year (ft3)	Quantity Shipped Per Package (ft3)	No. of Packages Per Year	No. of Packages Per Vehicle	Heat Generation Rate Per Shipment (W)	Est. Activity Per Shipment (Ci)	Avg. No. of Shipments Per Year	Est. Avg. Shipping Distance[g,h] (miles)	Shipment Destination[i]
				Waste From Fuel Preparation and Fabrication Plants						
α Waste	Rail	3,587[b]	c	c	c	22.5	2.79×10^{4}	3.6	1000	FR/BG
Low Level β - γ Waste	Truck	15,057[b]	7.4	2035	64	2×10^{-3}	0.475	31	500	BG
				Solid Waste From CRBRP						
Low-Level β-γ Waste										
Compactible	Truck	200	7.4	28	64		10	.44	500	BG
Non-Compactible	Truck	1187	7.4	182	64		9.6	2.84	500	BG
Solidified liq Radwaste	Truck	1000	7.4	136	15		103.7	9.7	1000	FR/BG
Metallic Sodium	Truck	42	7	6	15		9	.4	1000	FR/BG
Sodium Bearing Solids	Truck	235	TBD[j]	TBD	TBD		TBD	TBD	1000	FR/BG

(CONTINUED)

TABLE 5 (CONT'D) A SUMMARY OF MATERIALS AND QUANTITIES SHIPPED FOR THE CRBRP

Type of Shipment	Mode of Transport	Quantity Shipped Per Year (ft3)	Quantity Shipped Per Package (ft3)	No. of Packages Per Year	No. of Packages Per Vehicle	Heat Generation Rate Per Shipment (W)	Est. Activity Per Shipment (Ci)	Avg. No. of Shipments Per Year	Est. Avg. Shipping Distance[g,h] (miles)	Shipment Destination[i]
					Solid Waste From Reprocessing Plants					
α Waste	Rail	267[b]	c	c	c	22.5	2.79×10^4	0.27	1000	FR/BG
α-β-γ Waste	Rail	694[b]	25	28	3	1.12	500	10	1000	FR/BG
Low-Level-β -γ Waste	Truck	1041[b]	7.4	141	64	2×10^{-3}	0.475	2.2	500	BG
Cladding Hulls	Rail	58[d]	3.5	17	36	10.3×10^3	1.46×10^6	.47	1000	FR/BG
High-Level Waste	Rail	19	6.28	3.04	12	2.5×10^4	7.8×10^6	.25	1500	RSSF
Noble Gases	Truck	0.6[e]	0.6[f]	1	6	1.47×10^3	9.0×10^5	0.167	1500	NGSF
Iodine	Truck	0.027	0.16	0.17	64	1.0×10^{-3}	1.46	0.0026	1000	FR/BG

[a]All quantities of materials shipped are given in kilograms of heavy metal.

[b]Compacted a factor of 10 from original volume generated.

[c]Alpha waste is packaged in 55-gal (7.4-ft^3) drums and large boxes; each rail car contains 1000 ft^3 of waste.

[d]Hulls compacted to 8.8 ft^3 per ton of fuel.

[e]Compressed gas at 2,200 psi.

[f]Standard gas cylinder.

[g]Estimated distance to one-of-a-kind repository, 1500 mi; between facilities, 750 mi; to multiple burial ground sites, 500 mi.

[h]Distance of 1000 mi is a compromise between 1500 mi to one-of-a-kind repository and 500 mi to multiple burial ground sites.

[i]FP: fabrication plant; PS: power station; RP: reprocessing plant; FR: Federal repository; BG: burial ground; RSSF: retrievable surface storage facility; NGSF: noble gas storage facility.

[j]TBD: To be determined.

TABLE 6 - TRANSPORTATION OF RADIOACTIVE MATERIALS TO AND FROM THE CRBRP

	Number of shipments/yr (first 5 years)	Number of shipments/yr (after 5 years)	Probable mode of transportation
A. Incoming Shipments			
New Fuel Elements			
Core Assemblies	51	33	truck
Radial Blanket Assemblies	6.5	15	truck
TOTAL	57.5	48	
B. Outgoing Shipments			
Irradiated Fuel Elements			
Core Assemblies	25.5	8	rail
Radial Blanket Assemblies	1.44	4	rail
Replacement In-vessel Components			
Control Rod Assemblies & Drive Lines	3	3	rail
Radial Shield Assemblies	2.67	5.5	rail
Solid Radwaste			
Compactible Solids	0.44	0.25	truck
Non-Compactible Solids	2.84	5.5	truck
Solidified Liquid Radwaste	9.7	9.7	truck
Metallic Sodium	0.4	0.4	truck
TOTAL	45.99	36.35	

criticality safety and provide adequate heat dissipation under both normal conditions of transport and specified damage test conditions (i.e., the design basis accident). The contents of the package must also be controlled so that the standards for external radiation levels, temperature, pressure and containment are met.(8,10)

c. Environmental Effects of Transportation to and from the CRBRP

1. Heat Load
The heat load per shipping container for all unirradiated materials (Table 5) is expected to have essentially no impact on the environment. The temperature of the outer surfaces of these packages would be no higher than 5°F above the average ambient air temperature.

The rate of release of heat to the air from casks designed to transport irradiated materials would be about 13 kW, or about 45,000 BTU/hr. This rate can be compared with the rate at which waste heat is released from a 100-hp truck engine operating at full power, about 50 kW or 180,000 BTU/hr.(2) With the cask coolant system operating normally, the temperature of the cask surface would be less than 50°F above ambient temperature; in any case, the temperature of accessible cask surface would not exceed 180°F in accordance with regulations.(11) Because the amount of heat would be small and would be released over the entire transportation route, no appreciable effect on the environment would result.

2. Traffic Density
The projected number of annual shipments of each type of package is tabulated in Table 6. The traffic would be over public roads via truck for unirradiated shipments and the number of these shipments would be very small compared with normally expected traffic density. Irradiated material shipments by rail would require an average of about 33 railroad car shipments per year. The empty casks would be returned to the CRBRP. The weight of the spent fuel in the loaded cask would constitute only about 2% of the total weight of the loaded casks. Because the cask being returned empty weighs almost as much as the cask loaded with irradiated assemblies, the weight and number of shipments of empty casks must be considered in assessing the impact on the environment of the shipping of irradiated fuel. Shipping irradiated assemblies would therefore, involve about 66 rail-car shipments, including return shipments of the cask. Thus, the total number of shipments would be too small to have any measurable effect on the environment as a result of increase in traffic density.

3. Radiation Exposure
Specific estimates of the doses to transport workers and the general population from the shipment of incoming and outgoing radioactive material to and from the CRBRP cannot be made since the supplier and reprocessor of the assemblies and the burial site(s) for the radioactive waste have not been established. However, estimates have been made for a 1000-MWe model LMFBR.(1) Using similar assumptions, based on average, realistic model conditions as to radiation fields outside of packages, shipping distance, exposure times and number of people exposed, the radiological doses from the transportation of radioactive materials for the CRBRP were derived. These are compared with the values for the model LMFBR in Table 7. As noted in the table, the cumulative radiation dose to transport workers and the general population is approximately 17 man-rem per year for the CRBRP and 10 man-rem for the model LMFBR. The difference is attributable to the higher number of shipments performed during the pre-equilibrium operational mode. This dose would be uniformly distributed along the route among approximately 750,000 people.(3) Due to average normal background radiation (about 130 mrem per person per year), these same people receive about 975,000 man-rem per year.

Based on the above analysis, the staff concludes the doses to transport workers and the general population associated with the shipment of radioactive material to and from the CRBRP would be negligible, for they would be indistinguishable from the doses attributable to natural sources.

TABLE 7

ESTIMATED TOTAL-BODY DOSES TO TRANSPORT WORKERS AND THE GENERAL PUBLIC FROM SHIPMENT OF RADIOACTIVE MATERIALS TO AND FROM A 1000-MWe MODEL LMFBR AND THE CRBRP

	MAN-REM RECEIVED PER YEAR			
	1000 MWe Model LMFBR		CRBRP	
	Transport Workers	General Population	Transport Workers	General Population
A. Incoming Shipments				
New Fuel Elements				
Core Assemblies	2.40	0.56	7.1	1.65
Radial Blanket Assemblies	0.038	0.0093	0.084	0.021
B. Outgoing Shipments				
Irradiated Fuel Elements				
Core Assemblies	5.10	0.73	5.7	0.82
Radial Blanket Assemblies	0.92	0.13	0.95	0.13
Solid Radwaste	0.048	0.0117	0.21	0.07
TOTAL	8,45	1.43	14.04	2.69

REFERENCES

1. Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program, Volume II, Section 4.5, U.S. Atomic Energy Commission, WASH-1535, December 1974.

2. Environmental Survey of the Uranium Fuel Cycle, Section H, U.S. Atomic Energy Commission, WASH 1248, April 1974.

3. Environmental Survey of Transportation of Radioactive Materials to and from the Nuclear Power Plants, U.S. Atomic Energy Commission, WASH-1238, December 1972; Docket No. 71-9026, LMFBR Spent Fuel Shipping Cask Model I-(182)-1, Aeroject General Manufacturing Company.

4. Draft Environmental Statement, Generic Environmental Statement for Mixed Oxide, Volume 3, Chapter IV, Section G, U.S. Atomic Energy Commission, WASH-1327, August 1974.

5. "Recycle Fuels Plant Environmental Report," Westinghouse Electric Corporation, July 1973, Docket No. 70-1432.

6. Clinch River Breeder Reactor Environmental Report, Volume 2, Section 5.3, Project Management Corporation, April 7, 1974, Docket No. 50-537.

7. Reference 1, Volume I, Section 1.4.2, Table 1.4-1.

8. The Safety of Nuclear Power Reactors and Related Facilities, U.S. Atomic Energy Commission, WASH-1250, July 1973.

9. 10 CFR Part 71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions.

10. 49 CFR 170-179 (for classification, packaging, labeling and carriage by rail or truck.

11. 49 CFR 173.393(e). Shipping: General Packing Requirements.

APPENDIX E

SAFEGUARDS RELATED TO THE TRANSPORTATION OF RADIOACTIVE MATERIALS AND CRBRP FUEL CYCLE

1. INTRODUCTION

Certain nuclear materials involved in the operation of the CRBRP must be considered as possible targets for diversion or theft and subsequent use in the fabrication of nuclear explosive devices or use in dispersal devices to create radiological incidents. The possibility of sabotage of nuclear facilities and transport vehicles resulting in radiological incidents must also be considered.

The Nuclear Regulatory Commission (NRC) has the authority and responsibility for establishing requirements for the protection of special nuclear material (SNM)* against theft or diversion and for the protection of nuclear facilities and SNM against acts of sabotage which could be inimical to the national security or to the public health and safety. The body of procedural and physical controls utilized to carry out this responsibility is the NRC's safeguards program. Plutonium and the radioactive fission products resulting from reactor operation are the materials of primary concern in considering the safeguards implications of the CRBRP.

This discussion is concerned primarily with the safeguards aspect of the transportation of nuclear materials to and from the plant site. Fuel cycle activities in support of the CRBRP are also addressed and a general discussion of the anticipated effects of CRBRP operation on fuel cycle safeguards is provided. The exact nature of the safeguards system for protecting these activities is not fully known at this time. However, the system will be patterned after present safeguards requirements as modified by the experience gained in safeguarding present-day nuclear power plant activities. The plant will be subject to NRC safeguards requirements, licensing review, and inspection.

2. SAFEGUARDS PURPOSES AND PROGRAM ELEMENTS

A system of safeguards must include measures to deter, prevent or respond to the unauthorized possession or use of significant quantities of nuclear materials through theft or diversion and to sabotage of nuclear materials and facilities. These measures must provide multiple opportunities to interrupt adversary action sequences, including all of the following features: (1) obvious physical security and employee awareness/motivation measures that serve to deter adversaries; (2) the capability to detect any attempt to breach physcial security barriers; (3) an effective internal material control program; (4) arrangements for external assistance; and (5) contingency plans for recovery of nuclear materials.

The following functional elements should be considered to assure effective implementation of a safeguards program:

(1) definition of the nature and dimensions of the threat;

(2) development and imposition on the nuclear industry of safeguards requirements directed toward countering the threat;

(3) licensing activities, including review of safeguards procedures proposed by nuclear industry applicants, as required by regulations;

(4) inspection of safeguards implementation to ensure adequacy;

(5) enforcement of requirements through administrative, civil, or criminal penalties;

*Special nuclear material is defined as plutonium, uranium-233, or uranium enriched in the isotope 235.

(6) administrative and technical support for response and recovery;

(7) development and testing of methods, techniques, and equipment necessary to the effective implementation of safeguards;

(8) continuous program review in the light of industrial/technical or social/political changes to assure that any needed changes are made in these elements.

3. NATURE OF THE THREAT

An adversary group could attempt an act upon one or more domestic nuclear facilities or material shipments. The threat remains the same regardless of the motivation or origin of the group.

In an environment of general civil order, a large adversary group would be highly unlikely due to its susceptibility to detection by law enforcement agencies. The most serious credible threat would come from a small group of dedicated, well-armed and trained individuals This threat could be exclusively external in nature or it could involve assistance from within the organization that is charged with protecting the facility or material.

There is no way to predict from historical data the exact form the threat would take or the means that would be used by an adversary group. The safeguards system must therefore be based on the assumption that the possibility of a serious threat exists and the system must be designed to make its effectiveness as independent as practicable of the exact nature of the threat.

4. CURRENT NRC SAFEGUARDS PROGRAM

Title 10 of the Code of Federal Regulations (10 CFR 70) provides that, with certain limited exceptions, no person may receive title to, own, acquire, deliver, receive, possess, use, transport, import, or export special nuclear material without a license. NRC publishes specific safeguards requirements for materials and plant protection in 10 CFR Parts 70 and 73 and carries out the following activities to assure effective compliance with the requirements: (1) prelicensing evaluation of a license applicant's proposed nuclear activities, including safeguards procedures; (2) issuance of a license to authorize approved activities subject to specific safeguards requirements; and (3) inspection and enforcement to assure that applicable safeguards requirements are met by implementation of approved procedures. The establishment of a reasonable state of preparedness for coping with emergency situations, particularly those involving radiological hazards, is an additional requirement which must be met by licensees.

4.1 Licensing Activities

The prelicensing review addresses information submitted by the applicant to the NRC for approval--including the applicant's technical qualifications; a description of the process, equipment, and facilities to be used; the material control and accounting program, including measurement performance capability; and a physical security plan. Details of the material control and accounting program and the physical security plan are withheld from public disclosure as provided in 10 CFR Part 2 (10 CFR 2).

The prelicensing review includes consideration of other regulatory aspects of the facility design and operation. Account is taken of the interrelated effects of safety requirements and of the inherent features of the facility that contribute to the protection afforded by the safeguards system. For example, the requirements that SNM be safely contained during normal operation, operational accidents, and natural phenomena, such as earthquakes and tornadoes, also provide significant physical protection. Similarly, the requirements for shielding and safe shutdown in the event of maloperation, and special personnel access control during such emergencies, in themselves enhance safeguards.

Each licensee must confine possession and use of SNM to the purposes and locations authorized in the license and may transfer nuclear materials only to an authorized recipient. The licensee must also comply with the detailed accountability and physical protection requirements (fixed-site and in-transit) incorporated into the license pursuant to the regulations. The current safeguards requirements for special nuclear materials at fixed sites and in transit are summarized in Annex A of this Appendix.

4.2 Inspection and Enforcement

The licensee is required to afford the NRC the opportunity, at all reasonable times, to inspect SNM and the premises and facilities where SNM is used, produced, or stored, and to review the procedures for, and observe, the offsite movement of SNM. In addition, each licensee is required to make available for inspection any relevant records and to perform, or to permit the NRC to perform, any tests deemed necessary for the administration of the NRC regulations.

Following each safeguards inspection, a letter setting forth the inspection findings is prepared and sent to the licensee. Where items of noncompliance or deficiencies are found, licensees are directed to take prompt corrective action and to inform the NRC of the results. In addition, the NRC can take one or more of the following steps: assess a civil penalty; suspend a license; revoke a license; or modify a license.

4.3 Emergency Preparedness

Appendix E to 10 CFR Part 50 sets forth requirements which must be met by nuclear power plant and fuel reprocessing licensees to cope with emergencies. Currently, nuclear fuel processing and fuel fabrication licensees develop emergency plans on a case-by-case basis from requirements established by the NRC Office of Nuclear Material Safety and Safeguards. In June 1975, proposed amendments to 10 CFR Part 70 were published which would require applications for fuel processing or fuel fabrication licenses to contain information similar to that required in 10 CFR Part 50.

Much of the required emergency planning is associated with measures to provide protection for onsite persons. Also required, however, are procedures for notifying local, State, and Federal officials and agencies, for the early warning of the public, and for public evacuation or other protective measures should such actions become necessary or desirable. These agencies, as well as licensees, have responsible roles to play in both the planning and the implementation of emergency preparedness procedures. This recognizes that each has the necessary authority to implement emergency measures in its respective jurisdiction. At the Federal level, prompt assistance is available throughout the United States from regional coordinating offices of the Energy Research and Development Administration (ERDA). This takes the form of Radiological Emergency Assistance Teams utilizing personnel and physical resources of ERDA-owned facilities. The assistance of other Federal agencies is available through an Interagency Radiological Assistance Plan (IRAP) which was formally developed in 1961.

The NRC is presently revising its plans and procedures for responding to peacetime nuclear emergencies. These action plans are directed toward the response to peacetime emergencies affecting NRC-licensed facilities and material, such as radiological accidents and incidents, security threats, and terrorist acts and threats. As an associated task, the NRC is establishing an "Incident Management Center," a communications center from which the response to peacetime incidents and emergencies can be managed. Under consideration by the NRC is an option of expanding the concept of the center to include its use as a focal point for all emergency communications that directly affect the NRC and require activation of its emergency plans.

5. FUEL CYCLE SAFEGUARDS IMPACTS

Fuel cycle activities in support of the CRBRP are expected to be carried out in conjunction with the commercial fuel cycle(s) in use during the plant's operating life and with ERDA LMFBR demonstration programs. At the present time the supplier of the fuel for the CRBRP has not been established nor has it been determined where the spent fuel will be processed.

The safeguards-related environmental impact of other fuel cycle activities stemming from the operation of the CRBRP will be substantially dependent upon the exact nature of the activities and their relationship to the CRBRP fuel cycle. Although a detailed assessment of this impact is precluded by the present and future uncertainties associated with the supporting fuel cycle activities, it should be recognized that the safeguards policies and techniques utilized to protect strategic special nuclear materials (SSNM)* in one facility or shipment are applicable to protection of the same kind of nuclear materials in other facilities or shipments. The safeguards measures being studied for application to existing nuclear facilities and to new fuel cycles will be directly applicable or readily adapted to the CRBRP fuel c· le activities. This section provides a general discussion of the anticipated effects of CRBRP operation on fuel cycle safeguards.

5.1 CRBRP Fuel Cycle Activities

The nature of the safeguards problem is closely related to the characteristics of the nuclear materials present in a fuel cycle and of the forms and locations in which they appear. Plutonium and the radioactive fission products resulting from reactor operation are the materials of primary concern in considering the safeguards implications of the CRBRP.

Figure 1 of Appendix D in this environmental statement presents a simplified schematic diagram of the CRBRP fuel cycle. The initial core loading of the reactor would consist of approximately 6.5 metric tons (MT) of uranium and plutonium. Fuel would be in the form of sintered mixed-oxide pellets of PuO_2 and UO_2 encapsulated in stainless steel tubing (rods). The PuO_2 makes up approximately 20% of the fuel and provides the fissile material for power generation. The UO_2 would contain either depleted or normal uranium concentration. Plutonium enrichment would be 18.7 weight percent in the inner core zone and 27.1 weight percent in the outer zone of the first core. In future cores, the plutonium enrichment would be 22 weight percent in the inner core zone and 32 weight percent in the outer zones. With equilibrium loading, the reactor core would contain 1.7 MT of plutonium and 4.8 MT of uranium. An additional 21.7 MT of depleted uranium would be committed in the radial and axial blankets. Average isotopic composition of the plutonium metal in the core and blanket would be approximately 71% Pu-239, 19% Pu-240, 7% Pu-241 and 2% Pu-242.

After its period of use in a reactor, the irradiated fuel becomes poisoned with fission products and must be replaced with fresh fuel. An estimated 2,300 fuel assemblies and 850 radial blanket assemblies would be committed during the 30-year life of the CRBRP. The total requirements of the plant during its life could be as high as 20 MT of plutonium and 210 MT of uranium.

Spent fuel elements would be transported in massive shielded casks (following a cooling period at the plant site) to a reprocessing plant where the fission products would be separated, solidified, and transported to high-level waste storage. The recovered plutonium would be transported to storage (or directly to the fuel fabrication facility for recycle) as PuO_2. Unused uranium would be separated as uranyl nitrate and, after conversion to uranium oxide or uranium hexafluoride, would be transported to storage or recycled directly to the fuel fabrication facility.

5.2 Related LWR Fuel Cycle Activities

The CRBRP fuel may be supplied by existing plutonium fuel facilities or by future facilities that would come into existence as a result of a favorable decision on wide-scale plutonium recycle.

With regard to existing licensed plutonium fuel facilities, the NRC has determined that the safe, rds framework of existing and proposed regulations discussed in its statement of Novemb. 14, 1975** is adequate to enable the Commission to carry out its responsibilitie o protect the public health and safety and the common defense and security. While e ience and continuing study may indicate areas where revisions to the Commiss s regulations applicable to these facilities should be made, the production of CRBRP mixed oxide fuel in conjunction with these existing activities should not involve substantially different safeguards issues or costs.

*Strategic special nuclear material is defined as plutonium, uranium-233, or uranium enriched to greater than 20% in the isotope 235.

**40 FR 53056.

The safeguards measures employed to protect existing nuclear materials and plants are described in detail in Annex A and Reference 1. A supplement to Reference 1 is in preparation by the NRC staff which will discuss alternative safeguards measures for protecting wide-scale use of mixed oxide (recycle plutonium) fuel. The production of CRBRP fuel in either of these cycles should not necessitate any significant changes in the fixed site safeguards.

5.3 ERDA Demonstration Programs

The Energy Reorganization Act transferred the licensing and inspection operations for privately-owned nuclear facilities from the regulatory arm of AEC to the NRC. Responsibility for promulgation of safeguards requirements and inspection of AEC-owned nuclear facilities was transferred from the AEC to ERDA (except for new demonstration nuclear reactors and facilities for the receipt and storage of high-level radioactive waste, which are subject to NRC licensing and inspection). ERDA is charged to develop and to demonstrate the effectiveness of safeguards for new fuel cycles. NRC is to conduct confirmatory research and to determine whether the safeguards plan submitted to NRC by ERDA for facilities subject to NRC licensing, and plans submitted by private facilities, satisfy NRC criteria.

Facilities operated by ERDA in the course of the development and demonstration program for the LMFBR and its fuel cycle are another possible alternative source of fuel fabrication and reprocessing operations in support of the CRBRP. The safeguards measures being formulated for use at these facilities are themselves part of the LMFBR program. The ERDA safeguards program includes the development of a capability to make improved threat predictions and system effectiveness evaluation, and the design and demonstration of balanced, flexible safeguards systems for application to future fuel cycles.

While the regulatory responsibilities of NRC and the developmental responsibilities of ERDA must be clearly separated, the activities of the two agencies toward improved safeguards will be coordinated. In view of the safeguards development programs which will be underway at the ERDA LMFBR demonstration facilities, it is expected that the CRBRP activities will not give rise to substantially different safeguards issues at these facilities.

5.4 Commercial LMFBR Fuel Cycle Activities

The development of a program for safeguarding the commercial LMFBR fuel cycle is discussed in Reference 2. The safeguards implications of the postulated future LMFBR mode of electric power generation are examined therein, taking into account that the LMFBR fuel cycle would be only one of several commercial fission reactor fuel cycles requiring safeguards.

Prior to wide commercial use of the LMFBR, safeguards system demonstrations can be expected to be carried out as a means of providing continuing assurance that nothing has been overlooked. Operation of the CRBRP in conjunction with the proposed future LMFBR industry would have a minimal safeguards impact on the related fuel cycle activities.

6.0 CRBRP NUCLEAR MATERIAL IN TRANSIT

6.1 Shipments of Unirradiated Fuel Assemblies, Radioactive Wastes, and Irradiated Fuel Assemblies

6.1.1 Unirradiated (Fresh) Fuel Assemblies

During annual refueling, approximately one-third of core fuel assemblies would be replaced. New fuel assemblies would be shipped to the site in NRC-approved shipping containers. Each container holds one fuel assembly and is approximately 3.5 feet wide by 4 feet high by 19 feet long. Two containers would be shipped on a single truck. The total weight of the two fuel assemblies (not including containers) would be approximately 900 pounds. The loaded weight of each container would be on the order of 2,000 pounds.

During the first five years of plant operation (pre-equilibrium mode) there would be an average of 51 truck shipments of two fuel assemblies per truck each year to the CRBRP.

The plutonium enrichment of the fresh fuel varies from 18.7 to 32.0 weight percent. The total weight of heavy metal in each fuel assembly would be approximately 33 kg, with the plutonium content ranging from 6 kg to 10 kg per assembly (12 kg to 20 kg per shipment).

6.1.2 Radioactive Wastes

Each year the CRBRP would ship approximately 220,000 pounds of radioactive waste having a combined activity of 4.5 x 10^4 curies. All packaged radioactive waste would be shipped to a licensed burial site for disposal. As yet, the location of this site has not been determined.

6.1.3 Irradiated (Spent) Fuel Assemblies

Irradiated fuel assemblies would be transported and protected in a cask approximately 8 feet in diameter by 21 feet in length. Irradiated fuel assemblies would be inserted in a removable canister inserted in the cask. The canister capacity is nine fuel assemblies. The approximate weight of the cask is 77 tons and is designed for transportation on a 100-ton capacity railroad flatcar. The cask and car combination is designed in accordance with NRC and DOT regulations. It is provided with crash protection and passive cooling capability. The actual number of fuel assemblies per cask shipped will be determined on the basis of economic considerations and a heat load limit of 27 kW per cask.

It is estimated that the number of spent fuel assemblies removed from the reactor would require eight shipments per year during equilibrium cycle and 26 shipments per year during the pre-equilibrium cycle mode of operation.

6.2 Theft or Diversion of CRBRP Nuclear Material in Transit

6.2.1 Unirradiated Fuel Assemblies

Based on the considerations listed below, the transport process might be perceived as the most attractive and vulnerable segment in the entire fuel cycle.

- The fuel could be SSNM grade material.

- The material, already packaged, would be safe to handle, transfer, transport and store.

- A single shipment could contain a strategic quantity.

- Material on the open road could appear to be less defensible than material behind barriers or in valuts at a fuel site.

The mixed oxide fuel assemblies consisting of depleted uranium combined with 18.7 to 32 weight percent plutonium must be considered a potential target for theft or diversion. Published reports* have stated that such material could be used directly as a fissile explosive. In addition, the dissolution and separation of the PuO_2 from the mixture is not considered to require rare or unique skills.

Consequently, the physical security measures employed to protect the fresh fuel assemblies in transit must be selected and implemented with the greatest care. The issue of transport security is presently being studied by the NRC on a generic basis. Many alternatives are being examined and compared for effectiveness. It is expected that the development and use of new protection techniques in conjunction with the general NRC safeguards program will be a continuous process.

Proposed safeguards measures for in transit security that are being considered include:

- Use of specially designed vehicles with penetration resistant cargo compartments and immobilization capability.

- Use of convoys with massive defensive forces and equipment.

*See for example: M. Willrich and T. B. Taylor, Nuclear Theft: Risks and Safeguards, Ballinger Pub. Co., Cambridge, Mass., 1974.

- Transport by air from secure base to secure base.
- Combinations of above elements.

Given the relatively small number of yearly shipments (51 the first five years, less if combined into convoys), it would be possible to amass and apply resources to counter any conceivable threat. There are no known technical, logistic or societal impediments to producing a transit protection system that would be essentially undefeatable.

6.2.2 Radioactive Wastes

Because of the low concentration of plutonium and uranium in the waste and the relatively low radioactivity per unit weight, waste is not considered to be either attractive or useful to terrorists.

6.2.3 Irradiated Fuel Assemblies

Irradiated fuel is not considered to be an attractive target for theft by malevolent groups. The extreme radioactivity, requiring the use of massive gamma and neutron shields in the shipping container, prohibits removal of the fuel from the container without special equipment and procedures. In addition, the contained plutonium cannot be easily separated from the fission products.

6.2.4 Consequences of Theft

A complete review of the safeguards problem must include consideration of the potential consequences of safeguards failures. A successful theft could lead to the use of explosives or radiological weapons. These potential consequences are discussed in Sections 6.2.4.1 and 6.2.4.2.

6.2.4.1 Fabrication of a Nuclear Explosive by Amateurs

The debate on whether or not construction of a nuclear explosive device is easy revolves around matters of degree. There appears to be general agreement that, given the availability of the requisite nuclear material, the construction of an illicit explosive device requires a certain level and range of skills and resources. Disagreement arises with respect to the way the level of required skills and resources is characterized.

A theoretical knowledge of nuclear physics and the unclassified literature on how nuclear weapons work are not a sufficient basis for the confident design of a practical nuclear explosive. The critical knowledge required for designing and fabricating a reasonably reliable nuclear explosive is not theory; it is the practical experience in design, fabrication and testing of actual nuclear devices -- the experience of having tried and experimentally determined what will and will not work and why. This kind of knowledge is not widespread.

The assembly of a workable weapon is complex and laden with many obstacles, any one of which could prevent the accomplishment of the adversary's first goal -- the availability of a workable explosive device. The attempted detonation of even high-grade material is more likely to result in a low tonnage yield or a disassembling, non-nuclear explosion than a substantial yield explosion unless the fabrication and assembly have been carried out by highly trained and experienced technicians.

Considering the sequence of goals that must be attained by the adversary, the overall probability of any successful explosion of an illicit weapon is low. That such a weapon would be in the multi-kiloton range is doubtful. Nevertheless, the potential consequences arising from any nuclear explosive are so serious as to warrant the utmost vigilance, however low the probabilities may be. With time, simple "recipes" for crude nuclear explosives that might just work could pass into the public domain from the minds of experienced weapon makers. Thus, it is essential that nuclear materials be safeguarded so as to prevent unauthorized access to or acquisition of any significant quantities of nuclear materials that could be employed in the fabrication of a nuclear explosive.

The physical effects of a nuclear blast can be determined from the published literature. A summary of these physical effects is given by Willrich and Taylor. The damage radii for various effects of nuclear explosions as functions of yield are shown in Table 1 of this section.

Examples are given by Willrich and Taylor to illustrate the effects of nuclear explosions in a football stadium, a residential area, or a basement parking lot. While the examples given are speculative and are based on an assumption of complete success by the adversary, they do illustrate the extremely severe consequences of a nuclear explosion.

Clearly, if a workable illicit device of even modest yield were cleverly placed and detonated, thousands of people could be killed and millions of dollars worth of property could be destroyed. For reasons stated earlier, the probability that any of these events would actually take place, while not specifically quantifiable, is considered to be extremely low. It should be further noted that the adversary who has succeeded in fabricating a workable weapon, despite the obstacles cited above, faces further serious obstacles if his goal is to cause a high number of casualties and great damage. The selection of appropriate emplacement areas is finite; the safeguards response capability, alerted by the theft or diversion, would have brought its search and detection techniques to bear; and law enforcement agencies would be watchful for suspicious actions, especially in congested urban areas, at public gatherings, at key governmental facilities, and in areas of technological vulnerability.

6.2.4.2 Dispersal Weapons

The treatment of the consequences of radiological (dispersal) weapons is more speculative than that for nuclear explosions because of the greater extent of uncertainty involved. Detailed discussions of the subject of dispersal of plutonium are contained in References 1 and 2 (WASH-1327 and WASH-1535). In summary, it can be said that the possibility exists that plutonium could be dispersed into buildings or the atmosphere (as could most any chemical, radiological or biolgical agent).

Although the potential consequences could be significant, they would not approach the severity of a nuclear explosive. The use of radiological weapons does not appear to be consistent with the observed behavior of terrorists or extortionists.*

*Willrich and Taylor.

TABLE 1

DAMAGE RADII FOR VARIOUS EFFECTS OF NUCLEAR EXPLOSIONS AS FUNCTIONS OF YIELD[a]

Yield (high explosive equivalent)	Radius for Indicated Effect (Meters)						
	500-rem Prompt Gamma Radiation	500-rem Neutrons	Fallout (500-rem Total Dose)[b]	Severe Blast Damage (10 psi)	Moderate Blast Damage (3 psi)	Crater Radius (surface burst)	Crater Radius (underground burst)
1 ton	45	120	30-100	33	65	3.4	6.7
10 tons	100	230	100-300	71	140	6.8	13.3
100 tons	300	450	300-1,000	150	300	13.6	26.5
1 kiloton	680	730	1,000-3,000	330	650	27	53
10 kilotons	1,150	1,050	3,000-10,000	710	1,400	54	104
100 kilotons	1,600	1,450	10,000-30,000	1,500	3,000	108	208
1 megaton	2,400	2,000	30,000-100,000	3,250	6,500	216	416

[a] M. Willrich and T. B. Taylor, Nuclear Theft: Risks and Safeguards, Ballinger Pub. Co., Cambridge, Mass., 1974.
[b] Assuming 1-hr exposure to fallout region, for yields less than 1 kiloton, increasing to 12 hr for 1 megaton.

6.3 Sabotage of CRBRP Nuclear Material in Transit

Shipments of certain nuclear materials to and from the CRBRP must be considered as possible targets for acts of sabotage which could result in radiological hazards outside of the plant boundary. Of the three categories of nuclear material transported to and from the site (fresh fuel, spent fuel, and waste) only fresh fuel (unirradiated) assemblies and spent (irradiated) fuel assemblies are likely to be considered as attractive targets for acts of sabotage (See Section 6.22 regarding the unattractiveness of radioactive waste).

6.3.1 Unirradiated Fuel Assemblies

The possible consequences of acts of sabotage directed at shipments of fresh fuel assemblies do not constitute a significant radiological hazard. There is substantial probability that no material would be released in an attack. Although the inner and outer containers may be ruptured, it is likely that the fuel cladding would remain intact following a credible sabotage attack. Should any material escape to the environment, it would likely produce only localized contamination in view of the high density ceramic form of the fresh fuel.

Safeguards measures which will be applied to guard shipments of fresh fuel assemblies against theft (cf. Annex A and Section 6.2.1) will also provide assurance that the shipments will be protected from attack by saboteurs. This protection further decreases the likelihood of an act of sabotage causing a radiological hazard involving unirradiated fuel.

6.3.2 Irradiated Fuel Assemblies

Acts of sabotage directed toward shipping casks containing irradiated fuel might be attempted with the intent of creating a radiological incident. The design features that enable the shipping cask to withstand severe transportation accidents (e.g., multiplicity of heavy steel shells, a thick, dense gamma shield, a liquid jacket, and sacrificial impact absorbers) also enable the casks to withstand attack by small arms fire and explosives. It would require extraordinary skills and uncommon materials to breach the inner vessel.

Historically, spent fuel shipments have not been protected in a manner similar to the protection of shipments of unirradiated SSNM. The high radiation levels and the undesirable fission product inventory of the spent fuel make it a highly unattractive target for theft. In addition, the package design features have been relied upon as providing adequate protection against saboteurs. In the course of the continuing appraisal of safeguards adequacy in response to perceived changes in the nature of the threat, the possibility exists that spent fuel shipments may be the subject of upgraded safeguards measures.

A massive rupture of the cask is considered to be an incredible event. However, a possibility exists that a small bore penetration into the inner vessel could be made. An assessment of the consequences of such an action follows:

For casks utilizing liquid as the primary coolant, a sabotage-induced breach to ambient of the inner vessel would cause loss of primary coolant and an increase in the temperature of the fuel rods. If this condition continued for several hours, 100% of the rods in a rail cask might reach perforation temperature, releasing the entire gaseous and volatile inventory. For a four-element cask, the radioactivity released might be as much as 1.3×10^{3} Ci of Kr-85, 2.9×10^{-3} Ci of I-129, and 33.5 Ci of gross fission products. The whole-body dose for an individual 50 meters downwind from and on the centerline of a ground level release is calculated to be 0.74 rems. The highest population whole-body dose within an area roughly equivalent to a 22.5° sector extending from 50 meters to 20 miles (assumed population density of 300 persons/sq mi) is calculated to be about 2 man-rems. Pasquill weather type "F" blowing constantly in the same direction was used in the analysis. There are believed to be no significant clinical effects from whole-body short-term radiation doses of less than 50 rems.* For casks utilitzing gas as the primary coolant, loss of the outer shield water and a breach to ambient of the inner vessel would result in a comparable radioactive release.

*See Ref. 3 (Table 9.3) and Ref. 4.

During the past 25 years several thousand packages of irradiated fuel have been transported within the United States; to NRC's knowledge there has never been a criminal act or sabotage attack directed toward release of or diversion of any shipment of spent fuel. This past experience provides basis for the belief that the future probability of criminal acts or sabotage of a spent fuel shipment is very small. It is the staff's opinion that, for quick, lethal action, a saboteur is more likely to choose any one of a large number of other, much more readily available types of hazardous shipments -- such as explosives and chemical agents -- to accomplish his purpose. The dispersion of the radioactive material contained in spent fuel shipping casks using the scenarios discussed above is inefficient, costly, dangerous to the criminal or saboteur, requires a high degree of technical and scientific knowlege, is uncertain in its consequences, and, because of the delayed action of radioactive effects, is less than feasible for an immediate threat to life.

A release of solid, non-volatile radioactive materials, were it to occur, would contaminate the vehicle and nearby ground. The resulting hazard, although dangerous and long lived would be restricted to the immediate vicinity of the transport vehicle. The results of recent destructive tests conducted on obsolete casks indicate than an expert, dedicated effort would be required to release any radioactive material in excess of the gaseous and volatile fission products. As stated previously, a massive rupture of the cask is considered to be an incredible event.

7. SAFEGUARDS COSTS

7.1 Costs of Transport Security for Fresh Fuel Assemblies

While a cost/benefit analysis assessing the impact of incremental changes can be made for a specific transport system, comparison of one system to another is best performed on a total transport cost basis.

Three systems were selected for cost discussion; two that are under consideration for use in the future and one of the systems now in use.

The following costs (in 1975 dollars) were estimated for the year 1990 and based on shipment of 102 fuel assemblies per year.

System Number	System Description	Protection Afforded
1	Safe, Secure Trailer 3 escort vehicles 10 guards and drivers	Maximum
2	Cargo aircraft from secure terminal to secure terminal, 3 guards or pilots, no escorts	Maximum
3	Armored road vehicle with 2 guards and drivers, no escort vehicles (current option)	Medium

Single Carrier Shipments

System	Per Shipment Unit Cost	No. of Shipments	Annual Cost
1	$12,200	51	$620,000
2	$34,000	26	$890,000
3	$ 8,800	51	$450,000

The costs for System 1 could be reduced approximately 20% by use of convoy shipments.

7.2 Fuel Cycle Safeguards Costs

The use of existing plutonium fuel facilities for the production of CRBRP fuel should not give rise to significant additional fixed-site safeguards costs (cf. Section 5.2).

8. CONCLUSIONS

The CRBRP fuel requirements will have a negligible safeguards impact on whichever fuel cycle supplies the material; e.g., the LWR fuel cycle, the ERDA LMFBR demonstration or the commercial LMFBR fuel cycle.

REFERENCES

1. U. S. Atomic Energy Commission. "Generic Environmental Statement Mixed Oxide Fuel (GESMO)" (Draft). Washington, D.C.: U. S. AEC, August 1974. (WASH-1327)

2. U. S. Atomic Energy Commission. "Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program." Washington, D.C.: U. S. AEC, December 1974 (WASH-1535)

3. Lamarsh, John R. Introduction to Nuclear Engineering, Reading, Mass.: Addison-Wesley, 1975.

4. U. S. Atomic Energy Commission. "The Origin and Significance of Radiation Dose Limits For the Population." Washington, D. C.: U. S. AEC, 1973. (WASH-1336).

ANNEX A TO APPENDIX E

SAFEGUARDS REQUIREMENTS FOR SPECIAL NUCLEAR MATERIALS AT FIXED SITES AND IN TRANSIT

INTRODUCTION

Terrorist activities over the past few years have sparked interest and concern at the highest levels of Government for the safety and security of the Nation's critical resources. Where nuclear materials are concerned, the fear of theft is compounded by the possibilities of internal diversion. NRC's safeguards measures, designed to counter such threats, are contained in 10 CFR Part 70 and 10 CFR Part 73, which outline material accountability requirements and physical protection requirements, respectively. The regulations are supplemented by detailed "regulatory guides" that provide licensees with acceptable methods by which requirements may be satisifed. The objectives, simply stated, are to deny access to unauthorized persons and prevent misuse or diversion by those who are authorized access to nuclear materials. The following are highlights of current requirements for protecting special nuclear materials against theft or diversion and for protecting facilities, where special nuclear materials are used or stored, against acts of sabotage which could be inimical to the national security or to the public health and safety.

PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIAL AT FIXED LOCATIONS

Each persons who is licensed or applies for a license to possess or use at any site or contiguous site uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium alone in any combination in a quantity of 5,000 grams or more computed by the formula, grams = (grams contained U-235) + 2.5 (grams U-235 + grams plutonium), must comply with established physical protection requirements. A physical protection plan must be submitted to the NRC for approval, and must demonstrate how the licensee will satisfy the following regulatory requirements:

Physical Security Organization

The licensee must maintain a physical security organization, including armed guards, to protect his facility against industrial sabotage and the special nuclear material in his possession against theft. At least one supervisor of the security organization must be onsite at all times. The licensee must establish, maintain, and follow written security procedures which document the structure of the security organization and which detail the duties of guards, watchmen, and other individuals responsible for security. All guards or watchmen must be properly trained, equipped, qualified, and requalified at least annually.

Physical Barriers

All "vital equipment," which is defined as any equipment, system, device, or material whose failure, destruction or release could directly or indirectly endanger public health and safety, must be located within a separate structure or barrier designated as a "vital area." All vital areas and material access areas must be located within a larger protected area which is surrounded by a physical barrier. An isolation zone is required around the outer physical barrier and it must be kept clear of obstructions, illuminated and monitored to detect the presence of individuals or vehicles attempting to gain entry to the protected area, and allow response by armed members of the facility security organization to suspicious activity or to the breaching of any physical barrier. Special nuclear material not in process must be stored in a vault or in a vault-type room equipped with an intrusion alarm. Each vault or vault-type room is to be controlled as a separate material access area. Enriched uranium scrap in the form of chips, small pieces, cuttings, solutions, etc., in 30-gallon or larger containers and with a U-235 content of less than 0.25g/ℓ may be stored within a locked, separately-fenced area located within a protected area and no closer than 25 feet to the perimeter of that protected area. When unoccupied, this storage area must be protected by a guard or watchman who must patrol at intervals not to exceed four hours, or by intrusion alarms.

Access Controls

Personnel and vehicle access into a protected area, material access area, or vital area must be controlled. A picture badge identification system must be used and visitors must be registered and escorted. Individuals and packages entering the protected area are required to be searched. Admittance to a vital area or material access area must be controlled and access limited to those persons who require such access to perform their duties. Methods of observing individuals within a material access area to assure that special nuclear material is not being diverted must be provided and used on a continuing basis. All individuals, packages, or vehicles must be searched for concealed nuclear material before exiting from a material access area. Keys, locks, combinations and related equipment are required to be controlled to minimize the possibility of compromise.

Intrusion Alarms

All emergency exits in the protected area, vital areas and material access areas must be alarmed. Each unoccupied material access area must be locked and alarmed. All alarms must annunciate in a continuously manned central alarm station located within the protected area and in at least one other continuously manned station. All alarms must be self-checking and tamper indicating, and inspected and tested for operability and required functional performance at specified intervals not to exceed 7 days.

Communications

Each guard or watchman on duty must be capable of maintaining continuous communications with an individual in a continuously manned central alarm station within the protected area who must be capable of calling for assistance from other guards and from local law enforcement authorities. To provide the capability of continuous communication with local law enforcement authorities, two-way radio voice communications must be available in addition to conventional telephone service. All communications equipment must remain operable from independent power sources in the event of loss of primary power, and must be tested for operability and performance at least once at the beginning of each security personnel work shift.

Response Capability

Licensees must establish liaison with local law enforcement authorities, and be prepared to take immediate action to neutralize threats to the facility by appropriate direct action, calling for assistance from local law enforcement authorities, or both.

Records

Security records must be maintained of all individuals authorized access to vital and material access areas, including visitors, vendors, and others not employed by the licensee. Routine security tours, and all of the tests, inspections, and maintenance on security related equipment and structures must be documented. A record must be maintained on each alarm, false alarm, alarm check, intrusion indication, or other security incident, including the details of the response by facility guards.

Reports to NRC

Suspected thefts, unlawful diversions, and/or industrial sabotage must be reported immediately to NRC, followed by a written detailed report within 15 days.

PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIAL IN TRANSIT

Each licensee who transports or delivers to a carrier for transport uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium alone or in any combination in a quantity of 5,000 grams or more computed by the formula grams = (grams contained U-235) + 2.5 (grams U-233 + grams plutonium) must submit a plan to NRC for review and approval, outlining the methods to be used for the protection of special nuclear material in transit. Following approval, the licensee is not permitted to make any change that would decrease the effectiveness of the plan without the prior approval of the NRC. The plan must demonstrate the means to be used in meeting the following requirements:

General Requirements

If a common or contract carrier is used, the special nuclear material must be transported under the established procedures of the carrier which provides a system for the physical protection of valuable material in transit and requires a hand-to-hand receipt at origin and destination and at all points en route where there is a transfer of custody. Transit times of all shipments must be minimized and routes selected to avoid areas of natural disaster or civil disorders. Special nuclear material must be shipped in containers which are sealed by tamper-indicating type seals. The outer container or vehicle is required to be locked and sealed. No container weighing 500 pounds or less may be shipped on open vehicles, such as open truck or railway flatcars.

Road Shipments

All shipments by road must be made without any scheduled intermediate stops to transfer special nuclear material or other cargo between the point of origin and destination. All motor vehicles are required to be equipped with a radio-telephone. Calls must be made at predetermined intervals, normally not to exceed 2 hours, and if calls are not received when planned, the licensee or his agent must immediately notify an appropriate law enforcement authority and the NRC. Shipments by road must be accompanied by at least two people in the transport vehicle. When a specially designed transport vehicle with immobilization and penetration resistant features is used, armed guards are not required. In the absence of immobilization features, armed guards must accompany the shipment. In those instances when the transport vehicle has neither immobilization or penetration resistant features, at least two armed guards must accompany the shipment in a separate escort vehicle equipped with a radio-telephone.

Air Shipments

Shipments of special nuclear material in quantities exceeding 20 grams or 20 curies, whichever is less, of plutonium or uranium-233 and in excess of 350 grams of uranium-235 (enriched to 20% or more in the U-235 isotope) are prohibited on passenger aircraft. Shipments on cargo aircraft are required to be arranged so as to minimize the number of scheduled transfers. Such transfer, when necessary, must be monitored by armed guards.

Rail Shipments

Rail shipments must be escorted by two armed guards in the shipment car or in an escort car. Continuous on-board radio-telephone communications capability must be provided with conventional telephone backup. Periodic calls to the licensee or his agent are required at the same time intervals as for road shipments.

Sea Shipments

Shipments by sea must be made on vessels making the minimum ports of call. Transfer at domestic ports from other modes of transportation must be monitored by a guard. Shipments must be placed in a secure compartment which is locked and sealed. Export shipments must be escorted by an authorized individual, who may be a crew member from the last port in the U. S., until it is unloaded in a foreign port. Ship-to-shore communications must be made every twenty-four hours to relay position information and the status of the shipment as determined by daily inspections.

Reports on Nuclear Shipments

A licensee who makes a shipment must notify the consignee of the shipment schedule and details, including the estimated time of arrival of the shipment. A licensee who receives a shipment must immediately notify the shipper. Shipments which fail to arrive at the destination on time must be traced.

Reports to NRC

Unaccounted for shipments must be reported immediately to NRC, followed by a detailed written report within 15 days.

SPECIAL NUCLEAR MATERIAL ACCOUNTABILITY

Each person who is licensed or applies for a license to possess at any one time and location more than one effective kilogram* of special nuclear material in unsealed form is required to comply with detailed material accountability requirements as stipulated in his fundamental nuclear material control plan, which he must submit to NRC for approval. The plan must demonstrate compliance with the following:

Facility Organization

Responsibility for the material accountability functions must be assigned to a single individual at an organizational level sufficient to provide independence of action. The SNM custodial, measurement, accounting, and audit functions must be separated in a manner which assures that the activities of one organizational unit or individual serves as controls over and checks the activities of another organizational unit or individual.

A manual of approved current material accountability procedures must be maintained and reflected in the facility process specifications, manufacturing instructions and standard operating procedures. A formal program for the training and periodic requalification of personnel assigned to SNM accountability functions must be developed and documented.

Facility Operation

Material Balance Areas (MBAs) or Item Control Areas (ICAs) must be established for physical and administrative control of nuclear material. The custody of all nuclear material within any MBA or ICA must be the responsibility of a single individual. Each MBA must be an identifiable physical area such that material assigned to a given area is kept separate from material assigned to any other area, and such that the quantity of nuclear material moved into or out of an MBA is represented by a measured value.

Item Control Areas (ICAs) may be established according to the same criteria as that used for Material Balance Areas (MBAs) except material is inventoried, and moved into or out of ICAs by item identity and count. The validity of previously measured quantities of SNM must be assured by the application of tamper-indicating seals or devices applied to each item or container.

The number of ICAs and MBAs established at a plant must be sufficient to localize nuclear material inventory discrepancies.

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*"Effective kilograms of special nuclear material" means: (1) for plutonium and U-233, their weight in kilograms; (2) for uranium with an enrichment in the isotope U-235 of 0.01 (1%) and above, its element weight in kilograms multiplied by the square of its enrichment expressed as a decimal weight fraction; and (3) for uranium with an enrichment in the isotope U-235 below 0.01(%), its element weight in kilograms multiplied by 0.0001.

Measurement and Statistical Controls

The licensee is required to determine by measurement the nuclear material content of all receipts, shipments, discards, and material on inventory. The identity of the various measurements that are used in nuclear material control, including a description of measurement methods and procedures with statements of measurement uncertainties must be provided. Error models including the basic statistical methodology and techniques are required to demonstrate the licensee's capability of meeting adequate measurement criteria.

A system of control must be established and maintained that will assure that measurement uncertainties during any material balance period does not exceed (i) 200 grams of plutonium or uranium-233, 300 grams of highly enriched uranium or the uranium-235 contained in greater than 20% enriched uranium, (ii) those limits specified in the following table, or (iii) other limits approved by the NRC as discussed below.

Material Type	Measurement Uncertainty on Any Total Plant Inprocess Material Balance (expressed as a percentage of additions to or removals from material in process, whichever is greater)
Plutonium element or uranium-233 in a chemical reprocessing plant	1.0%
Uranium element and fissile isotope in a reprocessing plant	0.7%
Plutonium element, uranium-233, or high enriched uranium element and fissile isotope - all other	0.5%
Low enriched uranium element and fissile isotope - all other	0.5%

The NRC will approve higher limits than specified if an applicant demonstrates that he has made reasonable efforts and cannot meet the prescribed limits and he has or will initiate a program to enable him in time to meet these limits.

Plant operators are required to establish and maintain a measurement control program covering all of the components of measurements used for material accountability purposes. This program must include organizational controls for the management of measurement quality, training and performance qualification requirements, a standards and calibration system, a quality testing system for the determination and the control of systematic and random errors, a records evaluation system for the collection and statistical analysis of data, and a system of management audits and reviews.

Inventories

NRC requires physical inventories of plutonium, uranium-233, and uranium enriched 20% or more in the isotope uranium-235 to be conducted every two months except for material that is in the inaccessible portion of an irradiated-fuel reprocessing plant. Uranium enriched less than 20% in the isotope uranium-235, plutonium-238 and all special nuclear material in the inaccessible portion of irradiated-fuel reprocessing plants must be inventoried every 6 months. (Licensees authorized to possess less than one effective kilogram, but more than 350 grams of special nuclear material, are required to conduct annual physical inventories.)

The principal measure of special nuclear material control is the magnitude of inventory discrepancies. This measure is a calculated value which represents the difference between the amount of material that is supposed to be present according to the accounting records (taking into account measured receipts, transfers, and discards) and the amount of material actually found to be present during a physical inventory. The probability that no inventory discrepancy will exist is very small since the measurements required to establish the amount of material present are subject to error. A knowledge of the magnitude of these measurement errors is necessary for the proper interpretation of an inventory discrepancy.

The Commission is proposing new guidelines to assure that corrective action will be taken when the amount of inventory discrepancy reaches NRC's allowable limits. Under the regulation published for public comment on July 17, 1975, explicit limits are specified for inventory discrepancies. More significantly, the new regulation would require specific actions to be taken such as immediate reinventory, investigation of excessive inventory discrepancies or adoption of new procedures to prevent recurrence. In the case of a reinventory, it may be necessary in some cases to shut down the plant.

Storage and Internal Control

A documented system of control over the nuclear material within a facility must be maintained. All transfers of material between MBAs and ICAs must be documented and validated. A centralized accounting system using double entry bookkeeping with subsidiary accounts for each material balance area and item control area must be established and maintained. Procedures for reconciliation of control and subsidiary accounts with each other and to the results of a physical inventory at the end of each accounting period must be established and followed. Storage and internal handling controls must be established, maintained, and followed to provide information on a timely basis related to the identity, quantity, and location of all SNM within a plant in discrete items or containers. A unique item identification system must be established to ensure that no two items can have the same number. All containers and items of material in the form of unopened receipts, finished products or waste, and scrap awaiting offsite transfer should be stored on the basis of measurements. Records must be maintained which show the identity, source and disposition of all items.

A program must be developed and implemented for the control, processing, and disposition of scrap. The uncertainty of such measurements, if large, could be used to mask a theft. No item of scrap generated in a facility that is measured with an uncertainty of greater than $\pm$ 10 percent is permitted to remain on inventory longer than six months when such scrap contains plutonium, U-233, or uranium enriched 20 percent or more in the isotope U-235, or twelve months when such scrap contains uranium enriched to less than 20 percent in the isotope U-235 or plutonium containing 80 percent or more by weight of the isotope Pu-238.

Shipping/Receiving

As a rule, shipments and receipts are required to be independently measured by both the shipper and receiver.

Shipper/receiver differences must be reviewed and evaluated on an individual container or lot basis, on a shipment basis, and on a cumulative basis for shipments of like-type material. Appropriate investigative action must be taken on all shipper-receiver differences greater than 50 grams which are statistically significant at the 95% confidence level to decide whether corrective action is necessary, or more important, whether diversion or theft has occurred. The detection of missing material and, in turn, the discovery of diversion or theft should be timely. Receipts should be piece-counted and item-identified for comparison with the shipment bill of lading as soon as possible. The integrity of the tamper-safing devices should be verified, and receipts should be checked by weighing and, to the extent practical, by nondestructive analyses (NDA) for comparison with the shipper's values. The more accurate and precise receipt measurement must be made as soon as possible. Records of shipper-receiver difference evaluations, investigations, and corrective actions must be maintained on file at the facility for a period of five years.

Management of Material Accountability System

Audits are required of the material accountability programs annually by licensee management not connected with the safeguards program. The results of these reviews must be documented, reported to appropriate plant management, and be kept available at the facility for inspection for a period of five years. Investigation of losses of discrete items or containers must be conducted and the results of the investigation reported to licensee management and to the NRC.