Department of Energy
Washington, D.C. 20545

00839

Docket No. 50-537
HQ:E:82:015

April 30, 1982

Mr. Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Check:

AMENDMENT NO. XIII TO THE ENVIRONMENTAL REPORT FOR THE CLINCH RIVER BREEDER REACTOR PLANT

The application for a Construction Permit and Class 104(b) Operating License for the Clinch River Breeder Reactor Plant, docketed April 10, 1975, in NRC Docket No. 50-537, is hereby amended by the submission of Amendment No. XIII to the Environmental Report, pursuant to 10 CFR Part 51. This amendment incorporates revisions to Sections 1, "Purpose of the Proposed Facility," 2.3, "Regional Historic Scenic Cultural and Natural Landmarks," 2.6, "Meteorology," 3.9, "Transmission Facilities," 4.1, "Site Preparation and Plant Construction," 4.2, "Transmission Facilities Construction," 5.2, "Radiological Impact on Man and Biota," 9.2, "Alternative Sites and Plant Arrangements," and 10, "Plant Design Alternatives."

A Certificate of Service, confirming service of Amendment No. XIII to the Environmental Report upon designated local public officials and representatives of Government agencies, will be filed with your office after service has been made. Three signed originals of this letter and 41 copies of this amendment, each with a copy of the submittal letter, are hereby submitted.

Sincerely,

John R. Longenecker

John R. Longenecker, Manager
Licensing & Environmental
Coordination
Office of Nuclear Energy

Enclosure

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this 29 day of April, 1982.

Patricia G. Cibinsky
Notary Public

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CRBRP ENVIRONMENTAL REPORT

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1.0 PURPOSE OF PROPOSED FACILITY

1.1 INTRODUCTION

As indicated in Regulatory Guide 4.2, "Preparation of Environmental Reports For Nuclear Power Plants," Section 1 of the Environmental Report generally focuses on the need for the proposed facility. The suggested form and content for Section 1, however, are directed primarily toward conventional nuclear power plants (i.e., LWRs) built for the specific purpose of generating electrical power, and hence, are not strictly applicable to the Clinch River Breeder Reactor Plant (CRBRP). The electrical power generated by the CRBRP, although not insubstantial, will only be incidental to the achievement of the primary objective of the CRBRP, i.e., the demonstration of the feasibility of operating a Liquid Metal Fast Breeder Reactor (LMFBR) as part of the power generating facilities of an electric utility system.

The existing "arrangements, objectives and schedules" for the CRBRP Project were set forth in the Environmental Impact Statement (EIS) on the LMFBR Program issued by the Energy Research and Development Administration (ERDA) in 1975, the Findings of the ERDA Administrator which followed release of the EIS, and the Project Arrangements set forth in the Statement of General Information submitted to the NRC by the applicants for the CRBRP construction permit. In establishing the guidelines for consideration of specific issues in the CRBRP construction permit proceeding, the Nuclear Regulatory Commission concluded on August 30, 1976 that 13

> "the ERDA Impact statement and Congressional consideration have resolved for purposes of this proceeding issues that would otherwise be explored under the NEPA (National Environmental Policy Act) rubric of 'need' for the proposed action." (1)

Further, the Commission directed that the following issues were to be assumed as established for purposes of the construction permit proceeding:

> "The need for a liquid metal fast breeder reactor program, including its objectives, structure and timing:
>
> "The need for a demonstration-scale facility to test the feasibility of liquid metal fast breeder reactors when operated as part of the power generation facilities of an electric utility system, including its timing and objectives." (2)

Moreover, the Commission specified that the inquiry in the CRBRP proceedings must be limited to consideration of the likelihood that the CRBRP will meet the objectives of the demonstration plant project set forth in the ERDA LMFBR Program Statement.(2)

In addition, the recent Supplemental EIS for the LMFBR Program has reaffirmed the objectives of the CRBRP and established that the timing of the CRBRP is "as soon as possible". (3) Furthermore, the President's October 8, 1981 nuclear energy policy statement directed that goverment agencies proceed with the demonstration of breeder reactor technology, including completion of the CRBRP. 13

The scope of the inquiry contemplated in the Commission's decision of August 30, 1976 remains valid today and the scope of the construction permit proceeding, insofar as the need for and objectives of the proposed facility are concerned, should be confined to this scope. Accordingly, this Section of the Environmental Report will focus on the demonstration plant objectives and the manner in which the CRBRP will meet these objectives.

1.2 OBJECTIVES OF THE DEMONSTRATION PLANT

The objectives of the LMFBR demonstration plant project, as set forth in the LMFBR Program Environmental Impact Statement and the Commission's decision, are:

(1) to demonstrate the technical performance, reliability, maintainability, safety, environmental acceptability, and economic feasibility of an LMFBR central station electric power plant in a utility environment, and 13

(2) to confirm the value of this concept for conserving important nonrenewable natural resources.[1]

These CRBRP objectives are unchanged and are still valid today.[1,2,3]

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1.3 MANNER IN WHICH THE CRBRP WILL MEET THESE OBJECTIVES 13

The ways in which the CRBRP will meet the objectives of the LMFBR demonstration plant project are discussed in the following subsections.

1.3.1 TECHNICAL PERFORMANCE

The CRBRP and its auxiliary systems and subsystems are being designed to meet the technical performance criteria required to demonstrate that LMFBRs are capable of functioning as central station electric power plants on utility grid systems. These technical performance criteria include demonstration of rated power levels, meeting desired energy conversion, and specified breeding ratios, and other specific operating capabilities.

13

The CRBRP will demonstrate and develop the technology necessary to scale-up and successfully construct and operate larger near-commercial-sized LMFBR plants. This will include the manufacturing and testing of core hardware prototypical of larger plants; designing and testing instrumentation, components and systems for larger plants; and developing and applying design concepts, codes, standards and quality assurance procedures applicable to larger plants.

The CRBRP design will demonstrate a number of fundamental characteristics of LMFBRs which are not particularly sensitive to size. These include basic properties and characteristics such as high-temperature materials properties, thermal hydraulic characteristics, and such physics properties as breeding and burnup of the fuel and blankets. In addition, much of the CRBRP equipment, components and systems have some fundamental features and characteristics which are directly applicable to large

LMFBRs. The heterogeneous core of the CRBRP is more advanced than any built or planned in any of the foreign programs, and will provide vital information for future U.S. commercial-size LMFBRs.

Extensive research and development has been conducted to verify the high-temperature characteristics and the design methods required for the CRBRP piping and vessel designs. These characteristics and methods, which are applicable to commercial size LMFBRs, will be demonstrated for an integral system in the CRBRP. In addition, the CRBRP will provide verification in an operating system of thermal hydraulics analysis methods and will give confidence that the methods can be extrapolated to larger systems.

1.3.2 RELIABILITY

The CRBRP will demonstrate that LMFBRs are capable of providing a reliable source of electric power. Moreover, the CRBRP components and subsystems should be available for on-line operations for a high percentage of time in order to enable the plant to maintain the high "station factors" required of a reliable power plant. The availability of various reactor components and subsystems to function on demand will also be evaluated and the successful operation of these components and subsystems will provide a measure of the overall plant reliability. 13

The CRBRP is being designed to be available for the generation of electricity for an increasing period of time during the test phase (i.e., the first years of the demonstration period) and to ultimately achieve and maintain a station factor of 78 percent. This compares quite favorable with the generally accepted "reliability" of other base load plants which are available between 60 and 90 percent of the time.

1.3.3 MAINTAINABILITY

The CRBRP will be designed, constructed, and operated so that preventive and corrective maintenance can be performed on the plant with a minimum amount of "down time," minimum expenditure of manpower and resources, and maximum protection of plant employees in order to demonstrate the maintainability of LMFBRs in a utility environment. The primary components of the design are either removable or repairable in-place, and ample space around all major equipment is provided to assure ease of access. Scale models of all equipment arrangements and working spaces have also been developed to ensure that there are no obstructions which could adversely affect maintainability.

1.3.4 SAFETY

The CRBRP design is centered around the "defense-in-depth" concept, whereby numerous diverse and redundant safety systems are provided to protect worker and public health and safety under normal operating conditions and in the event of off-normal operations or malfunctions. The design also conforms with the ALARA concept in order to minimize occupational radiation exposures. 13

The adequacy of technical specifications in terms of health and safety of the public will be confirmed by the analysis of data taken during the course of operation and from tests performed under post-construction and approach-to-power experimental programs. The CRBRP will not only demonstrate the safety of an integrated LMFBR system as a whole, but will also provide valuable information on the safety of individual subsystems, controls, and components which are either expected to be utilized in commercial LMFBRs themselves or are expected to be scaled-up for use in commercial-size LMFBRs.

1.3.5 ENVIRONMENTAL ACCEPTABILITY

The CRBRP will demonstrate the distinct environmental advantages associated with the LMFBR technology. During operation, there will be no release of the combustion products associated with fossil fuel power plants (such as fly ash or sulfur dioxide emissions) and, due to increased thermal efficiency, less waste heat discharged to the environment than that associated with a comparably sized LWR. The greatly reduced mining, milling, and enrichment requirements of the CRBRP will also decrease the environmental disruption and occupational hazards associated with most other nuclear fuel cycles.

The CRBRP will produce some gaseous, liquid and solid radioactive waste materials. These wastes, with a few exceptions, will be similar in type to but smaller in quantity than those associated with light water nuclear plants. Because of this similarity, the CRBRP is expected to demonstrate a minimal impact on the environment resulting from radioactivity releases and waste disposal. 13

Solid radioactive wastes resulting from cleaning, decontamination and laboratory operations will be compacted and packaged for burial. Techniques for processing radioactive wastes containing sodium are being investigated for the FFTF and will be applied for similar wastes generated by the CRBRP.

The CRBRP is being designed to minimize the impact of its construction and operation on the Clinch River site and its environs. Effluent control systems are being incorporated into the design in order to reduce and control radioactive as well as liquid and solid wastes. Environmental monitoring programs have been established in order to preserve and protect the terrestrial and aquatic ecosystems and the quality of the environment in the vicinity of the site. The experience gained with regard to the environmental impact of the CRBRP is directly relevant to the environmental impact expected to occur with commercial-size LMFBRs and will provide valuable information concerning the environmental acceptability of commercial LMFBRs.

1.3.6 ECONOMIC FEASIBILITY

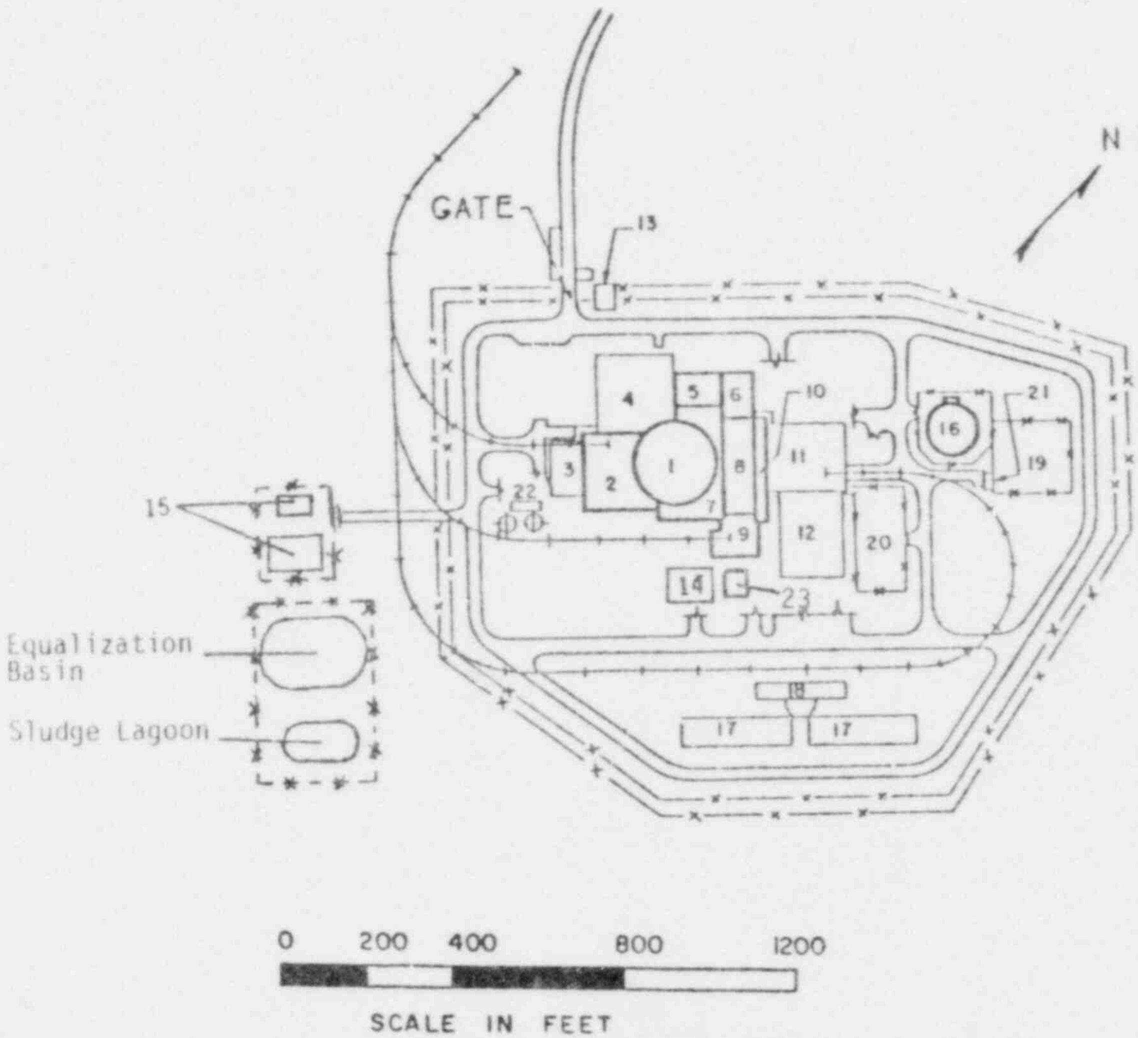
A comprehensive cost-accounting and reporting system for the CRBRP capital and operating expenses is being implemented which will provide the information required to help evaluate the economic feasibility of the LMFBR concept. From this information, projections can be made regarding the costs that can be expected with commercial-size LMFBRs. 13

1.3.7 UTILITY ENVIRONMENT

Upon the completion of the testing phase, the CRBRP will be operated as a base load plant on the TVA power grid and will be an integral part of the TVA power system. Moreover, over 750 other electric utility systems participating in the project will be evaluating the project in terms of their needs and methods of operation and factoring utility requirements into project operations.

1.3.8 CONSERVATION OF NONRENEWABLE NATURAL RESOURCES 13

The energy conversion process in conventional light water reactors (LWRs) utilizes approximately one to two percent of the potential energy available in the uranium fuel. By converting the non-fissionable U-238 to fissionable Pu-239, LMFBRs will increase this energy utilization potential to over 60%. The 13
CRBRP will not only demonstrate the ability to economically utilize lower-grade uranium ores, but also permit the efficient utilization of the depleted uranium which is produced as a by-product of the LWR fuel cycle.



1. REACTOR CONTAINMENT BUILDING
2. REACTOR SERVICE BUILDING
3. RADWASTE AREA
4. PLANT SERVICE BUILDING
5. CONTROL BUILDING
6. DIESEL GENERATOR BUILDING
7. INTERMEDIATE BAY
8. STEAM GENERATOR BUILDING
9. MAINTENANCE BAY
10. AUXILIARY BAY
11. TURBINE GENERATOR BUILDING
12. MAINTENANCE SHOP & WAREHOUSE
13. GATE HOUSE
14. Waste Water Treatment Area
15. Sewage Treatment Plant
16. EMERGENCY COOLING TOWERS
17. COOLING TOWER
18. C. W. PUMP HOUSE
19. GENERATING SWITCH YARD
20. STARTUP RESERVE YARD
21. SWITCHYARD RELAY HOUSE
22. FIRE PROTECTION PUMP HOUSE
23. Waste Disposal Building 13

Figure 2.1-4 ARRANGEMENT OF PLANT STRUCTURES

Figure 2.1-5 TOPOGRAPHY OF THE CRBRP SITE

Figure 2.1-6 AERIAL VIEW OF CLINCH RIVER SITE

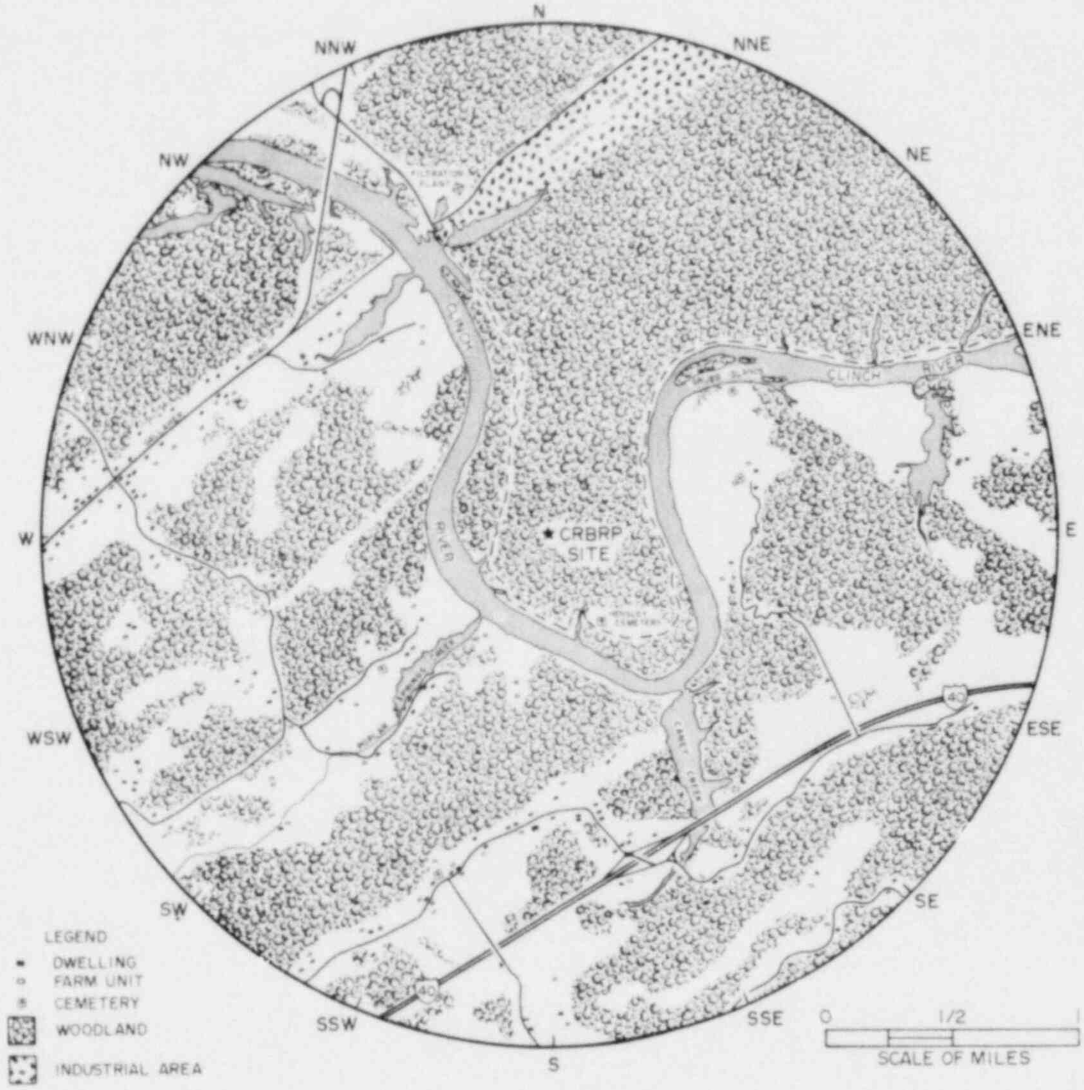


Figure 2.1-7 FARMS, DWELLINGS, INDUSTRIES AND WOODED AREAS WITHIN A 2-MILE RADIUS OF THE SITE

2.2.1.5 PUBLIC FACILITIES AND INSTITUTIONS

Area school population for years 1971, 1981, and 1991 within the 10-mile radius are shown in Table 2.2.11. Twenty-one schools located within a 13 10-mile radius of the Site, as shown in Figure 2.2-9, have a 1981 total enrollment of 8,870 students. Oak Ridge anticipates building a new elementary school (kindergarten through 6) for their system by 1990. This school will be located in the western part of Oak Ridge and will accommodate 725 students. However, this school and other new schools to be built in the foreseeable future will replace those presently in use as they become obsolete. Other school systems included within the 10-mile radius do not plan to expand beyond that necessary to accommodate future educational requirements as shown in Table 2.2.11 as obsolete plants and facilities are retired or renovated.

The neareast hospital to the Site is the Harriman City Hospital with 109 beds,[4] located about 9.5 miles to the west-northwest. The Loudon County Memorial Hospital, with 50 beds, is located about 10.5 miles to 10 the south-southeast and the Oak Ridge Hospital of the United Methodist Church, with 220 beds, is located about 15 miles to the northeast. A tabulation of additional hospital facilities and their respective capacities within 50 miles of the Site is shown in Table 2.2-12. No new hospitals are planned within the 10-mile radius in the foreseeable future (before 1995).

2.2.2 USES OF ADJACENT LANDS

Within a 10-mile radius of the Site, the region encompasses residential, farm, recreational and industrial areas. Land adjoining the Site is zoned for forestry, agriculture, industry or research use; the Site is zoned Industrial 2. No military installations exist in the area. Schools and hospitals, listed in Tables 2.2-11 and 2.2-12, respectively, are the only public facilities located within the 10-mile radius. The Site is served primarily by a highway system and barge transportation. Only one airport (Meadow Lake) is located within the 10-mile radius of the Site. Industrial and recreational areas are listed in Section 2.2.2.2 and Section 2.2.1.3, respectively. Although the eastern Tennessee area is generally of a rural type with agriculture playing an important part, there are only three commercial dairy farms within a 10-mile radius of ORNL. There is no mineral production within the 10-mile radius; however, mineral production primarily in the form of strip coal mining, does play an important role in the region. No wildlife preserves, sanctuaries or hunting areas are within a 5-mile radius of the Site. A waterfowl refuge which is part of the Long Island Wildlife Management area is located on the Tennessee River approximately eight radial miles southwest of the Site. Part of the Paint Rock Wildlife Management area is also located about eight radial miles southwest of the Site. A third Wildlife Management area is located at Kingston near the steam plant, approximately seven radial miles west of the Site.

2.2.2.1 AGRICULTURE

The majority of the region within the 10-mile radius lies within Roane County with only small portions of Morgan, Anderson, Knox, and Loudon Counties included. Checks with county agents revealed that there are no commercial dairy farms located within the 10-mile radius in Morgan, Anderson, Loudon, and Knox Counties.[4a] There are three commercial dairy farms located in Roane County (see figure 2.2 - 9A). Two of the farms are located about 6 miles WNW of the site with herds of about 100 cows and 50 cows. The third farm is located about 3 miles SE of the plant site with the herd consisting of about 70 cows. In addition to commercial farms, there are three family farms located within a 10-mile radius of the CRBRP site. In Knox County there is one family farm (3 cows) located about 6 miles ENE of the Site. The other two family farms are located in Roane County, both having 5 cows each. One farm is located about 2 miles SSE of the Site with the other farm situated approximately 6 miles N of the Site. There is a combined total of about 235 dairy cows on the six farms within a 10-mile radius of the CRBRP Site.

Beef cattle raising is an important activity in the five-county area, with 37,200 head reported in 1980. However, this does represent a decline in beef cattle raising of about 12 percent as compared to the number of beef cows reported in 1978.[4a] Knox and Loudon Counties are the two largest cattle raising area accounting for 63.2 percent of the total number in the five-county area. The number of beef cattle within five miles of the site was identified to be about 475 head based on surveys completed in 1974. Scattered herds ranging in size from 20-30 head were located in the southeast, southwest, and northwest quadrants. Recent discussions completed with county agents in 1981 generally reconfirmed this to be the case. Two large beef cattle herds were identified during this most recent check regarding agricultural activities, one approximately 4 miles WNW of the site and the other about 8 miles ENE of the site at Gallaher Bend on Melton Hill Lake in Knox County. Agricultural crops grown within the 10-mile radius of the site are assumed to be similar to those reported on the 1974 survey, that is, grown on scattered plots for single-family use. 13

In general, farming in eastern Tennessee has followed the national trend of a steadily decreasing number of farms with the remaining farms increasing in average size.[4a] Because more off-farm employment opportunities exist now than in the past, the trend has been to shift from dairy cows and other forms of farming to raising beef cattle which requires less labor. In the five-county area, the number of head of beef cattle increased (28 percent) from about 29,000 to 37,000 head between 1969 and 1980 whereas the number of dairy cows reported for the same years decreased (29 percent) from about 10,700 to 7,600 head. This trend is believed to apply in the study area within a 10-mile radius of the CRBRP site.

2.2.2.2 INDUSTRY

Two large industrial activities are located within five miles of the plant site, as shown in Figure 2.2-10: the Oak Ridge Gaseous Diffusion Plant about three miles north-northwest and the Oak Ridge National Laboratory about four miles east-northeast.

Enriched uranium is produced at the Oak Ridge Gaseous Diffusion Plant (ORGDP). There are about 5,600 employees at ORGDP. Oak Ridge National Laboratory (ORNL) is a research and development facility which employs approximately 5,100 people. ORNL's work includes reactor and chemical technology, radiation effects, controlled fusion and other basic and applied research activities.

In addition, one small industrial activity is located on a 33 acre parcel of land in the Clinch River Consolidated Industrial Park (CRCIP) about one and one-half miles north of the center of the plant site and adjacent to the plant site boundary. The industry, Eagle Picher Inc., fabricates neutron absorbers for power reactors and employs 30 people. The remainder of the industrial park is currently undeveloped.[5] 10

Two additional industrial activities located between 5 and 10 miles are DOE's Y-12 facility, nine miles northeast and TVA's Kingston Steam Plant, seven and one-half miles west of the plant Site. The Y-12 facility provides production, research, and development facilities for DOE and employs approximately 6,300 people. About 800 employees work at TVA's Kingston Steam Plant which is a fossil-fired electrical generating plant with a capacity of 1,700,000 kilowatts.

2.2.2.3 MINERALS AND MINING

There is no mineral production within the 10-mile radius; however, mineral production does play an important role in the region, particularly in Morgan, Campbell, and Anderson Counties where the mining and processing of coal has been occurring for years.

2.2.2.4 TRANSPORTATION

2.2.2.4.1 HIGHWAYS

One major highway, Interstate 40, passes approximately 1.25 miles south 10
of the plant site as shown in Figure 2.2-11. The closest interchanges on I-40 are with State Routes 58 and 95, which are about four miles and three miles, respectively, from the plant site location. Existing average daily traffic (in both directions) near the Site is highest for Interstate Route I-40 and equals 21,130 vehicles per day west of the interchange of I-40 and State Route 58. Between this interchange and Oak Ridge, along State Routes 58-95, the average daily traffic count ranges between 7,350 and 9,700. Southward along Route 58 from this interchange to

US 70 (Kingston Pike), the average daily count equals 2,450. Along Route 95, between I-40 and the junction of Route 58, the average daily count equals 4,500. Along I-40 east of the interchange of I-40 and Route 95, the average daily traffic count is 20,030[6].

2.2.2.4.2 RAIL

Harriman Junction, approximately 10 miles northwest of the Site, has the closest major main rail line. It is served by the Southern Railway. A 13
spur line serving the Oak Ridge Gaseous Diffusion Plant (ORGDP) runs adjacent to S.R. 58 approximately 2 miles northwest of the Site (Figure 2.2-11).

2.2.2.4.3 WATER 10

The U.S. Army Corps of Engineers operates the locks at Melton Hill Dam and keeps logs of all barge traffic. Total tonnage for barge traffic and total commercial traffic through Melton Hill Dam for the period 1966-1980 is given in Table 2.2-13. Barge traffic passing the CRBRP site at the present time is primarily steel products. None of this traffic contains explosive, toxic, or hazardous materials. There have been no accidents involving barges reported near the CRBRP Site.

2.2.2.4.4 AIR

No airports are located near the Site. Airports within 25 miles are as follows:

Name	Type	Distance and Direction (miles)
Meadowlake Air Park	Sport	10 SW
Oak Ridge Air Park	Sport	11 NNE
Rockwood Municipal	Business/Sport	18 W
McGhee-Tyson	Commercial	24 ESE
Powell	Business/Sport	24 NE
Madisonville	Business/Sport	24 S
Ferguson	Sport	12 S
Little Creek	Sport	18 E

Of the eight, only McGhee-Tyson (Knoxville) has scheduled commercial
flights. The center of the nearest flight path, V16, is about 3 miles 13
south of the Site. Commercial aircraft approaching McGhee-Tyson would
be at a minimum altitude of 3,500 feet as they pass south of the site.[7] 10

2.2.3 WATER USE

2.2.3.1 SURFACE WATER USE

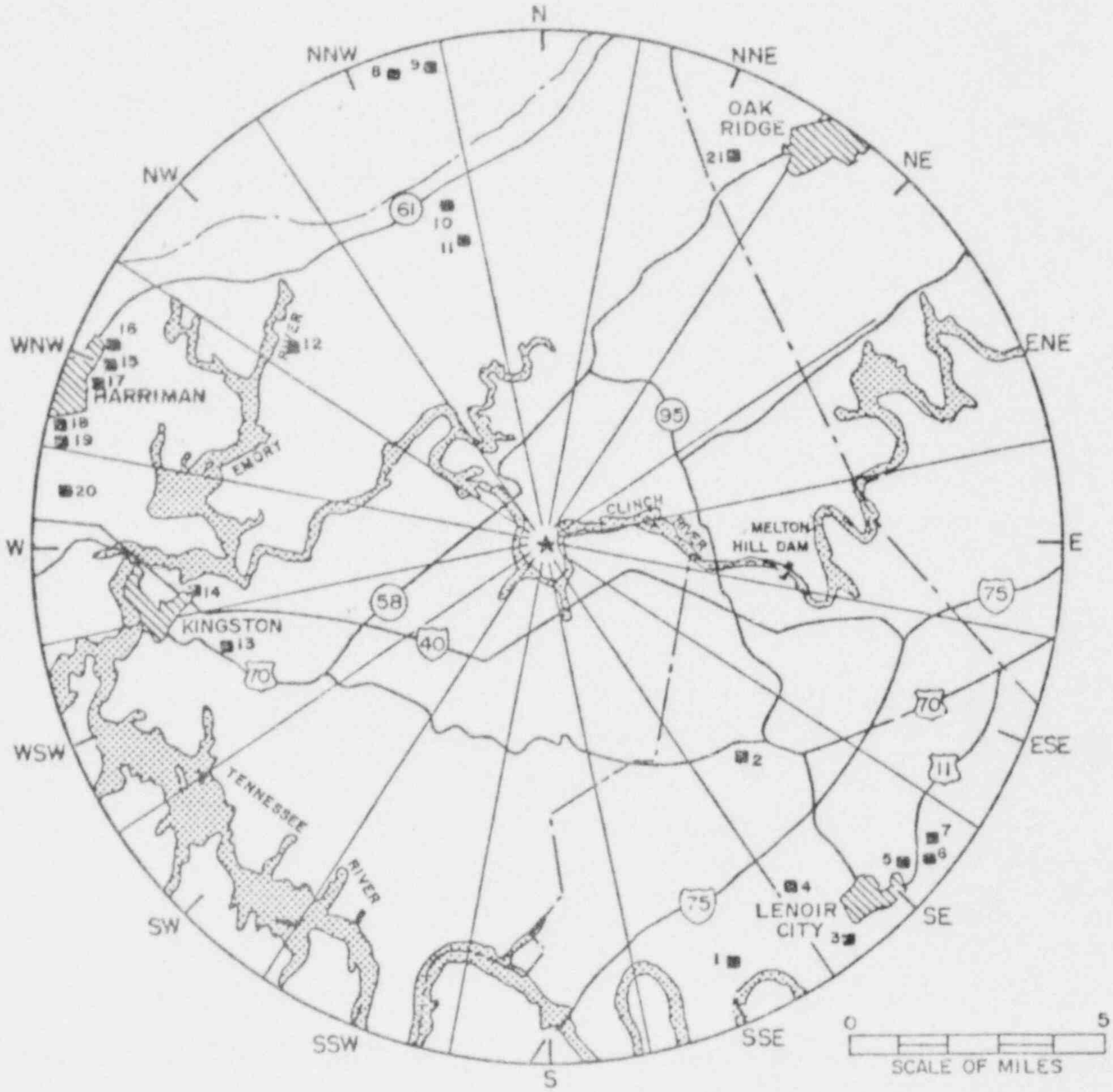
Twelve public water supplies withdrawing water from surface sources are located within a 20-mile radius of the Site (see Table 2.2-14). Four of these supplies are located where they could be influenced by the plant's waste discharges. The city of Rockwood, Tennessee, has a public water supply intake location on the King Creek embayment of Watts Bar Reservoir where the potential for reverse flow exists. Under certain conditions, Clinch River water could flow upstream in the Emory River. Such flow could possibly affect the Cumberland Utility District surface water intake and the Harriman water supply intake on the Emory River. Camp John Knox, located about 18 miles from the Site, has an intake located at Tennessee River Mile (TRM) 555.7, about 29 river miles downstream from the Site.

Within 50 miles downstream from the plant, two public water supplies can be influenced by water flowing past the CRBRP site. Spring City, which is 30 miles from the Site and had a 1980 population of 1,951, withdraws 120,000 gallons of water per day from the Piney River. Piney River is influenced by backwater from Watts Bar Dam. Spring City supplements this source with a spring yielding about 200,000 gallons per day. The city of Dayton, 44 miles from the Site, withdraws 1,400,000 gallons of water per day from the Tennessee River. Dayton had a 1980 population of 5,913.

Of the 15 industrial water supplies presently within a 20-mile radius of the Site, five are located where they could be influenced by water borne discharges from the CRBRP. The closest of these is located 1.6 miles downstream from the Site at Clinch River Mile (CRM) 14.4. This supply is used to provide potable water at the Oak Ridge Gaseous Diffusion Plant and the small industrial park at the north end of the Site property. 10

A DOE supply at CRM 11.5 and TVA's Kingston Steam Plant supply could be influenced by discharges from the Site. Water supply for the Kingston steam plant is withdrawn from the Emory River, which could be influenced by flow coming down the Clinch River during certain periods of the summer. It is used for inplant purposes, including potable uses, as well as cooling.

A. B. Long Quarries, Inc., and Mead Corporation are both located on the Emory River arm of Watts Bar Reservoir which could receive upstream flow from the Clinch River, but neither of these supplies is used for potable or sanitary purposes. Locations of industrial water supplies are shown in Figure 2.2-13. Identification, distance from the CRBRP site, average daily use, and source of water for industrial water supplies are provided in Table 2.2-15.



■ SCHOOL NUMBERS ARE KEYED TO TABLE 2.2-11

Figure 2.2-9 SCHOOLS WITHIN 10-MILE RADIUS OF THE CRBRP SITE. 10

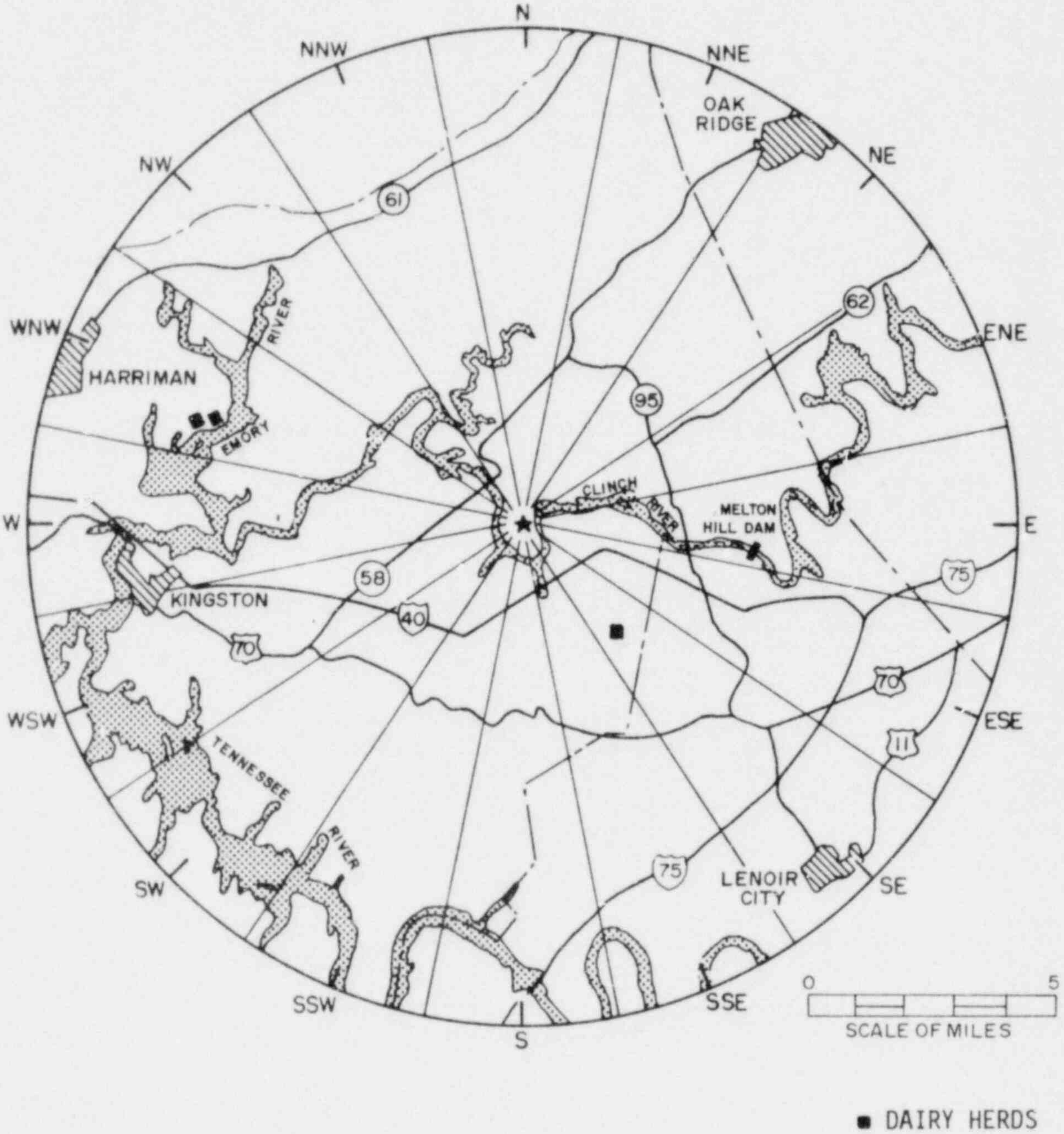
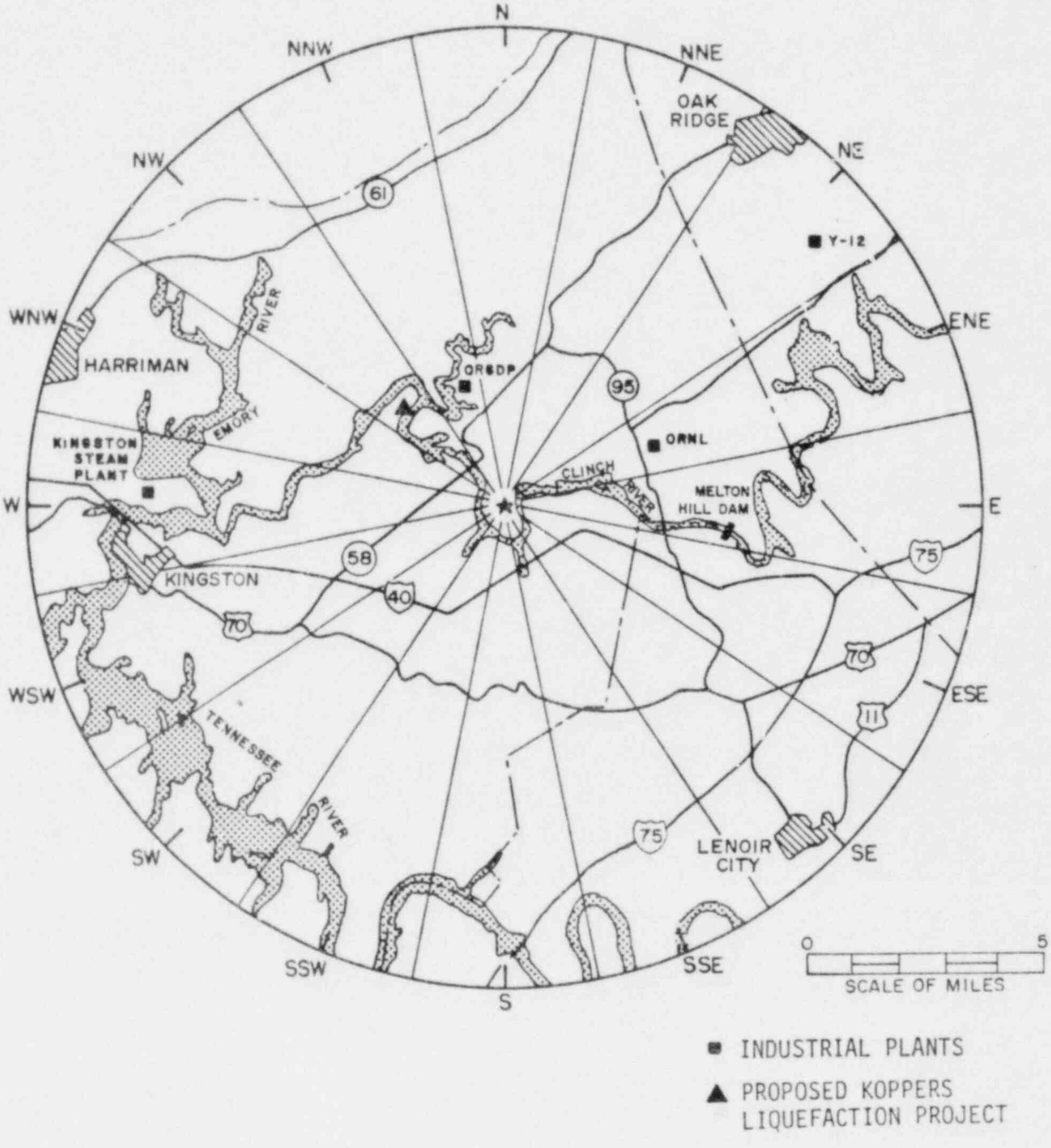


Figure 2.2-9A DAIRY HERDS WITHIN 10-MILE RADIUS OF THE CRBRP SITE



10

Figure 2.2-10 INDUSTRIAL PLANTS WITHIN 10-MILE RADIUS OF THE CRBRP SITE.

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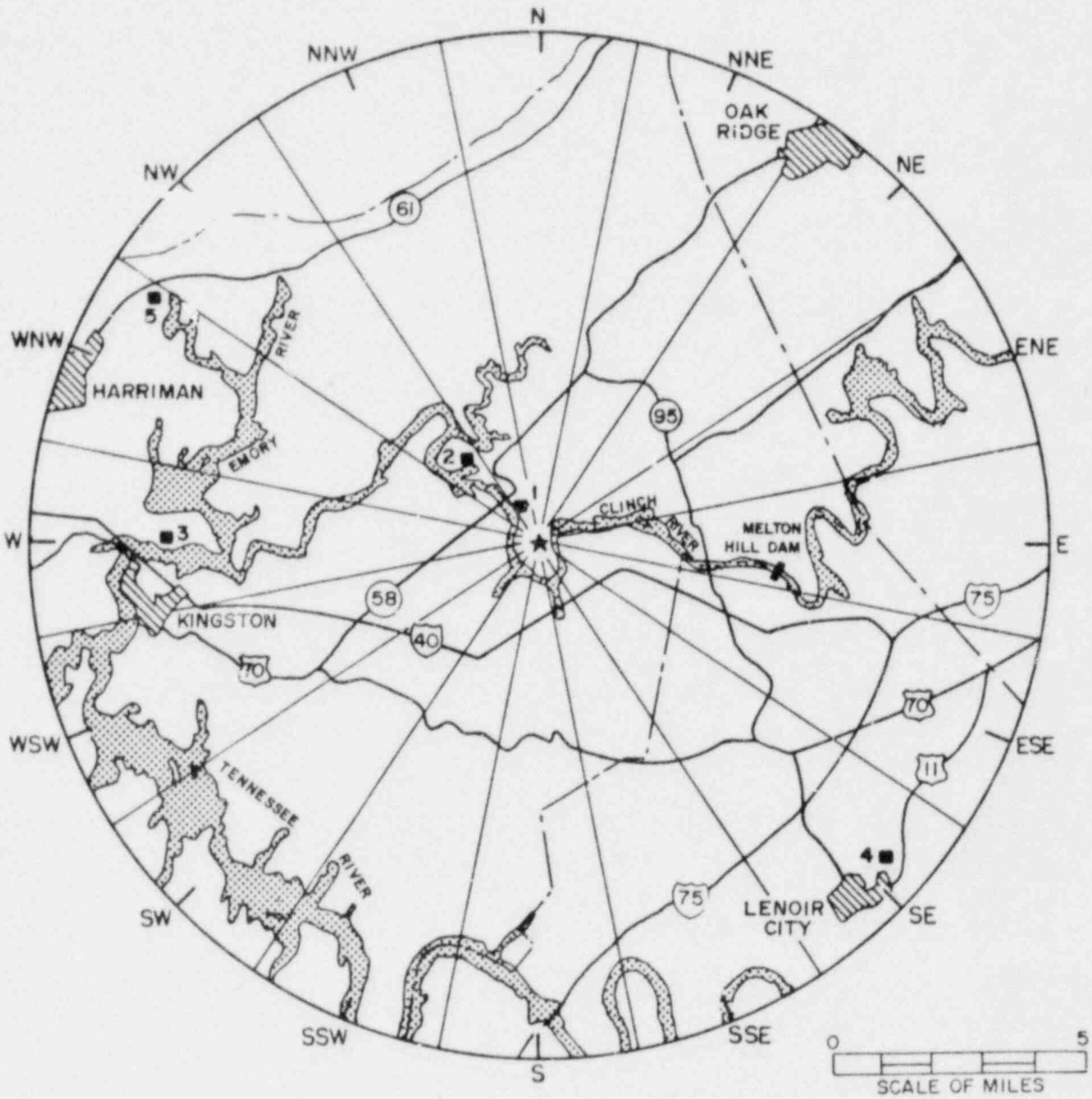


■ INDUSTRIAL WATER SUPPLY
NUMBERS ARE KEYED TO
TABLE 2.2-15

10

Figure 2.2-13 INDUSTRIAL WATER SUPPLIES WITHIN 10-MILE RADIUS OF CRBRP SITE.

2.3 REGIONAL HISTORICAL, ARCHAEOLOGICAL, SCENIC, AND NATURAL AREAS 13

The following discussion of features or landmarks, particularly of those located on the Site, has been separated into three sub-sections; (1) historical; (2) archaeological; and (3) scenic and natural. Historical and archaeological sub-sections include data from surveys conducted in 1972/73 and in 1981/82; along with data from salvage excavations conducted intermittently between October 1973 and April 13
1975. Historical features include those structures or sites that are of Euro-American origin. Native American mounds and midden loci are examples of prehistoric or archaeological sites.

In Figure 2.3-1 from the 1972/73 survey, archaeological sites have 13
been designated by triangles and historical sites by circles; one exception is the Hensley Cemetery which has been designated by a square. Each site has been numbered in accordance with the 13
Smithsonian Trinomial Site Designation System used throughout the United States. In this system, the first number or numbers indicate the state (numbered alphabetically), the letters indicate the county in that state and the final number or numbers indicate the sequential recording of the sites discovered in that county. For example, 40RE123 means this site is located in the state of Tennessee (40), Roane County (RE) and is the 123rd site to be discovered and recorded in Roane County. Thus, when a new site is discovered, it is assigned a "key" number and recorded in county, state and national registers. In Figure 2.3-4, from the 1981/82 survey, all sites are designated by a stippled elliptical area. Each site was given a temporary number, 13
either preceded by SS (for those discovered during the shoreline survey) or T (for those discovered during shovel tests along a transect).

2.3.1 HISTORICAL FEATURES 13

The "National Register of Historic Places" lists the X-10 (ORNL) 8
Graphite Reactor in Oak Ridge, the Roane County Court House in

Kingston, Southwest Point in Kingston, Harriman City Hall in Harriman, and the Lenoir Cotton Mill in Lenoir City. (1) The distances of these sites from the CRBRP are approximately 4 miles, 8 miles, 8 1/2 miles, 13 10 miles and 9.5 miles respectively. The CRBRP facility will not be visible from these sites. Historic sites within the Project boundary are discussed below and shown in Figure 2.3-1.

An historical reconnaissance was conducted by Dr. Gerald F. Schroedl, 13 Research Assistant Professor, and Dr. Prentice M. Thomas, Jr., Assistant Professor of Anthropology, University of Tennessee, in October 1972 and January 1973. Four Euro-American farmsteads 13 (40RE120, -121, -122, and -123) and a cemetery (40RE119), shown in Figure 2.3-1, were located and recorded. The following descriptions of these sites were abstracted from reports written by Dr. Gerald F. Schroedl[2] and Dr. Prentice M. Thomas, Jr.[3].

<u>Site 40RE119, Hensley Cemetery.</u> The cemetery is on the southern 13 tip of the peninsula outside the area of construction impact. It is a fenced 1640-foot-square area containing five marked graves. Identifiable markers include those of S. S. Hensley (1854-1927), Lou Anna Peters (1885-1917), Callie D. Peters (1883-1941) and Stella Harvey (1921-1922). These four graves are located along the northern edge of the cemetery. In addition, there is one small illegible metal marker in the southeast corner of the cemetery. 13

<u>Site 40RE120.</u> Remains consist of a collapsed house, a standing 13 limestone fireplace with two opposing hearths, a limestone-lined root cellar, a rectangular brick-lined cistern, a portion of a fence of split logs and a shed.

<u>Site 40RE121.</u> This site consists of the remains of a house, well, cellar, two small outbuildings and three rectangular pits, all enclosed by a hand-split picket fence. Remains of three chimneys (one standing and two collapsed), four limestone corner

supports and two porch supports characterize the house. The remains of a log crib face a rectangular stone-lined cellar on the south side of the house. East of the house are two additional structures, a well-house covering a circular stonelined well and the remains of a barn.

Site 40RE122. The site consists of a wood frame house and barn. Both are standing, but numerous roof and floor supports have collapsed. Both structures appear to date from the early twentieth century.

Site 40RE123. When the initial investigation of the site was made in 1972, a single isolated rectangular log structure was recorded. The structure was constructed of large hand-hewn logs and was covered by a partially collapsed peak-frame roof. It was a single entry structure which had no fireplace or windows. This suggested that the structure had been utilized as a storage facility rather than a dwelling. Size of the logs and the construction technique suggested that the building may have dated from the second half of the nineteenth century. In October 1973, Dr. Schroedl reported that this structure had been destroyed sometime between October 1972 and October 1973 when the detailed photographs and drawings were to be made. 13

None of the above sites or structures has historical significance that would qualify for inclusion in the National Register.[4] With the exception of Site 40RE123, detailed photographs and drawings have been 13 completed for each site identified in the initial field survey and preservation of these sites is not required.

13
A subsequent record/archival search done by Schroedl and Thomas revealed additional sites within the project boundary which were photographed and recorded (Sites 40RE120 and 40RE121, and Locales 12 and 16; Figure 2.3-1). None of these sites were eligible for the National Register.[5]

A 1981-82 review of historical considerations in the project area was done by the Cultural Resources Program staff of the Tennessee Valley Authority. This review indicated that the broad outlines of historic development of the area have been adequately treated [6,7,8]. A review of available information about the 1942 period and the Manhattan Engineering District history is being completed as a part of this process. Also included was a field reconnaissance and evaluation 13
of the possibility of offsite impacts to potentially significant historic sites and structures. Initial findings, based on the survey, indicate that the only structures within the area of the project potentially eligible for listing in the National Register are located immediately across the river from the construction site. Four buildings (three log and one frame) appear to be original homesteads of the earliest settlers of this section of the Clinch River Valley (c. 1820-1850). Two of these structures are no longer used as houses. One of the remaining two appears to have been significantly altered. However, since these structures are privately owned and will not be directly impacted by the project, no further action toward determination of eligibility is planned.

2.3.2 ARCHAEOLOGICAL FEATURES

Results of the archaeological surveys conducted during 1972/73 13
indicated the presence of significant archaeological resources[9]. 13
Three burials discovered during preliminary tests of Site 40RE124 indicated that a more detailed investigative program was needed.

Previous archaeological reconnaissance and excavation had been conducted in the region. In April 1886, Cyrus Thomas and his associates visited the lower Clinch River and reported a complex of mounds and associated camps, villages and burials on the north side of the Clinch River between CRM 20 and 21[10]. Further archaeological surveys were not conducted until 1941 when reconnaissance of the Watts

Bar Reservoir area was made.[5] At that time five sites were located in the area between CRM 15 and 18, but none of these sites were tested or excavated. Additional surveys and excavations along the Clinch River were initiated in 1960 and 1961 in the Melton Hill Dam Reservoir area.[11,12]

The intent of investigations in 1972 was to re-evaluate archaeological 13
sites located during the previous surveys and to determine if other archaeological resources existed. This investigation concentrated on 13
the immediate area of the proposed plant construction and along the anticipated routes of the access highway and railroad. No new sites of archaeological interest were located.

The 1972 survey concentrated on locating, testing and evaluating the 13
six archaeological sites (40RE102, -105, -106, -107, -108 and -124) originally recorded during the 1941 survey. Though several test pits 13
were excavated at each of these sites, diagnostic cultural materials were recovered only from the burial mound and the two midden (refuse) locations (40RE124, -107 and -108, respectively). These materials indicated the presence of significant archaeological resources and the need for further study and excavation of these three sites.

Locations of the six archaeological sites are shown in Figure 2.3-1a. 13
The site descriptions below were abstracted from Dr. Schroedl's reports on the test excavations.[2,9]

<u>Sites 40RE104, -105 and -106.</u> These sites yielded few cultural materials. It was impossible to confirm the cultural affiliation of each site from the artifacts recovered. Test excavations indicated no further investigation of these sites would be required.

<u>Site 40RE107.</u> Cultural material recovered from this site included six chips of cryptocrystalline debris and one cryptocrystalline preform.

<u>Site 40RE108.</u> Cultural material from this site consisted of one knife or projectile point tip, two grit tempered plain body sherds, one limestone tempered plain body sherd, one limestone tempered fabric-marked body sherd and numerous whole and fragmented river mussel shells.

<u>Site 40RE124, Burial Mound.</u> A test excavation consisting of a 20- by 3-foot trench was made into the undisturbed conical burial mound. The discovery of three burials and a variety of cultural materials indicated that a more detailed program of investigation was needed. A security fence was erected around the mound to protect it from vandalism.

From preliminary analyses, it appeared that sites 40RE107 and -108
were occupied during the Early Woodland Period. Since little is known 13
about the Woodland Period Cultures on the lower Clinch River, it was 13
decided that further testing of 40RE107 and extensive excavations of
the shell midden at 40RE108 would help establish possible cultural
relationships between Woodland Period sites in the Melton Hill and
Norris Reservoir areas with those elsewhere in the Tennessee River
Valley. Artifacts and burials found at site 40RE124 suggested a Late
Woodland occupation and a possible association with the Hamilton 13
occupations on the lower Clinch River and the Tennessee River in the
Watts Bar Reservoir area.

Subsequently, an agreement was signed between the Tennessee Valley 13
Authority and the Department of Anthropology, University of Tennessee,
based on the research proposal, "Salvage Archaeology in the Clinch
River Liquid Metal Fast Breeder Reactor Plant Area."(13) The proposed
work included excavation and detailed study of sites 40RE107-, -108
and -124, completion of necessary laboratory analyses following the
field excavations and publication of a descriptive and interpretive
report.

Field excavations began in October 1973 on the burial mound (site 40RE124), another suspected mound feature near the lake bank (40RE129), and the midden areas (40RE108 and -107), and were completed in several stages by April 30, 1975. Laboratory analyses necessary to determine the eligibility of the areas, including washing, cataloguing, processing and analyzing the volume of cultural remains, human skeletal remains, faunal remains and botanical specimens have been completed. 13

Results of the field investigations have been briefly summarized below. These summaries were abstracted from Dr. Schroedl's monthly progress reports.(14,15,16,17)

Site 40RE107. Subsurface testing, in December 1974, by means of ten 1 x 2 meter test pits demonstrated that this "midden" deposit consists of prehistoric cultural material in redeposited sediments, lacking features and archaeologically significant stratification. This site was judged not to warrant further archaeological investigation. 8 13

Site 40RE108. Initial test excavations revealed a shell midden which had been exposed by slow erosion of the present river bank. Further excavation on the east side of this shell deposit revealed a small, dark organic midden.

A second shell midden was located in November 1973 approximately 820 feet upstream. In December 1973, further examination of the beach and river bank downstream from the initial excavation revealed a third but smaller shell deposit (approximately 260 feet to the north). About 160 feet beyond this shell deposit, an extensive organic midden was exposed in the river bank. Lithic debris and artifacts, pottery sherds and firecracked rocks were 8

associated with this deposit, but no shells were observed. These last two middens were not recorded during the 1941 survey of Watts Bar Reservoir. Because these middens were in the same vicinity and contained similar ceramics, they probably represented similar and contemporary occupations; the four areas may have served related, but possibly distinct, activities. The 8
latter two midden subareas of site 40RE108 were tested during the 13
December 1974 field season. Subsequent investigations were not warranted.

Site 40RE124. The most important archaeological site located within the Site boundaries was a Late Woodland Period burial mound. Importance of this mound can been attributed to three unique facts; the burial mound had not been plowed, substantially eroded, or plundered by relic collectors.

Field work at site 40RE124 was completed by February 1, 1974. Virtually all mound sediments had been removed down to the original premound surface. All burials and features were recorded and removed. The distribution of burials by mound construction stage at 40RE124 is shown in Table 2.3-1. These assignments were based on field interpretations. Preliminary 13
interpretations of the recovered samples show that a probable minimum number of 36 individuals were interred in the mound.

Completed salvage excavations confirmed the hypothesis that three 13
distinct mound construction stages existed as shown in Figure 2.3-2. Construction Stage 1 was initiated with the interment of a single individual in a shallow oval pit dug into the premound surface. Fill was placed over the burial pit to form a low conical mound. A second burial, containing two individuals, was placed along the southeast edge of the mound and more fill added. Limestone slabs were then placed in a regular densely-packed circular configuration on the slopes of the mound, but no slabs

were placed on the summit.

Construction Stage 2 contained 17 burials, the greatest number recovered from a single stage. This stage was not uniformly added to the original mound. Three individuals were interred on the west side of the mound where portions of the limestone slabs had been disturbed or removed.

The majority of the burials and the mound fill were added to the south half of the original mound. Thus, in Construction Stage 2, the mound center gradually shifted to the southeast as shown in Figure 2.3-2. Most of the individuals were placed on their side with knees in either a flexed or semi-flexed position and were oriented clockwise around the mound facing the center. Large limestone slabs and charred logs were placed on the surface to terminate Stage 2.

The configuration of the mound again shifted to the southeast during Construction Stage 3 as shown in Figure 2.3-2. Stratigraphic profiles indicated that this stage did not completely cover the northeast side and that considerably less moundfill was utilized for these burials. Fifteen burials were interred in the final mound construction stage. Preservation of the skeletal remains associated with this stage was extremely poor and determination of the minimum number of individuals could not be made. Large limestone slabs also marked the termination of Construction Phase 3. The construction stage could not be determined for one burial. 13

An unexpected but important discovery was that of a midden adjacent to the northeast quarter of the mound. Test excavations and associated stratigraphic interpretation of the mound indicate occupation of this site was initiated shortly after completion of the burial mound. Although the mound is associated with the Late

Woodland Period, artifacts recovered from the midden are typical of the Early Mississipian Period. Excavation in 1975 and 13 subsequent laboratory analysis and evaluation indicated that these remains were redeposited.[18] 13

Site 40RE129. This large earth mound, resembling a subconical Late Woodland Period burial mound, on the first terrace of the Clinch River between sites 40RE107 and 40RE108, was assigned an 8 archaeological site number. However, it was suspected to be of recent origin because, although it appeared in 1942 aerial photographs, it was not recorded during the 1941 Watts Bar survey. Testing in December 1974 by means of manual and backhoe trenching documented that this feature is no more than a mound of spoil dirt probably deposited in 1941 during construction 13 activities.

An additional cultural resources survey of the CRBRP area was conducted during the winter of 1981-82. The work concentrated on those portions of the Project area outside the immediate construction site to identify sites potentially eligible for inclusion in the National Register.

Three methods were employed to complete the cultural resources survey 13 of the project area. These were: 1) a shovel cut testing program; 2) a shoreline survey; and 3) a buried sites reconnaissance.

1) The shovel cut testing program was used in areas that had extensive vegetation cover. These areas encompassed the majority of the project area and included all the uplands and portions of older alluvial terraces. Transects were placed in all high probability areas (i.e., ridge tops) and shovel cuts were excavated at 25 meter intervals. Each unit was the size of a shovel width (33 cm.) and was excavated to subsoil. All excavated dirt was screened through 1/4 inch hardware cloth. A

total of 26 transects were completed and over 200 shovel cut tests excavated (See Figure 2.3-3). Fourteen previously unrecorded archaeological sites were discovered using this technique.

2) A pedestrian survey of uninvestigated portions of the shoreline was conducted (See Figure 2.3-3). Archaeological sites exposed along the shoreline are readily visible on the surface, thus, shovel cut testing was not necessary. A total of three previously unrecorded sites were located using this survey approach.

3) A buried sites reconnaissance was conducted. Chapman[19] has formulated a model predicting the occurrence of buried sites in the Tellico Valley. Aspects of Chapman's model were used; however, dense stands of trees and terrain prohibited backhoe access to all high potential areas. A total of 8 backhoe trenches were excavated. One buried component was defined at one of the sites discovered during the shoreline survey. 13

A total of 17 previously unrecorded sites and two potentially significant loci were recorded (See Figure 2.3-4). Table 2.3-2 and Section 2.3A provide a summary listing of major site components and recommendations.

SS2 (temporary site number for shoreline survey sites) is a significant cultural resource. It is the first buried Early Archaic (8,000 - 6,000 B.C.) site recorded in the Clinch River Valley. The site contains undisturbed cultural deposits. Three features (two pits and a concentration of fire cracked rock) were discovered. Ethnobotanical specimens were recovered from the features. The site contains data relevant to Early Archaic settlement and subsistence in the Clinch River Valley. The site will not be impacted by the proposed construction plans for CRBRP.

Two clusters of rock mounds (T-17 and T-23) are a potentially significant resource. Prehistoric stone mounds with burials have been excavated in the adjacent Powell River drainage[20]. The two mound clusters within the CRBRP project area are similar to prehistoric mounds[15]; however, they may represent historic collections of rock gathered from plowed fields. Since both rock mound clusters were outside of the impact area, the sites were not tested and permanent site numbers were not assigned. The dating and function of these mounds can be determined only by site excavation which would not be undertaken unless project plans are modified and call for disturbance of the mounds. 13

2.3.3 SCENIC AND NATURAL LANDMARKS 13

Steep limestone ridges, hills and knobs are characteristic features of the region. Numerous small wet-weather streams drain the area and in many places along the river, thick alluvial sediments form flood plains which vary in width from a few feet to several hundred feet. The plant site and the surrounding area are heavily wooded with both coniferous and deciduous trees. A combination of various vines, grasses, shrubs and trees forms a dense ground cover.

The peninsula on which the plant will be located is formed by a meander of the Clinch River approximately between river miles 15 and 18. A detailed description of the area is in Section 2.1 and Figure 2.1-3 shows the CRBRP in relation to the Site.

Investigation of the Site has revealed no unique points of scenic or natural significance.[21] Natural landscape of the area will restrict public view of the Site. A portion of the dome of the Reactor Confinement structure may be visible from the Gallaher Bridge on the Oak Ridge Turnpike. Certain homes on the southern side of the Clinch River will have a limited view of the plant. The Site has been owned 8 by the U. S. Government since the 1940's and thus, has been restricted to the public and visitation has been limited. Until the Site was proposed as the area for the Clinch River Breeder Reactor Plant, it had been designated by TVA for industrial development.(22) 8

2.3.4 EFFECTS OF PLANT CONSTRUCTION AND OPERATION

Hensley Cemetery, a historical period site, is located within the project boundary. The cemetery does not meet the criteria of eligibility for inclusion in the National Register of Historic Places, and it will not be disturbed by the project construction. Existing access rights for visitation to the cemetery held by the Hensley family will continue to be honored.

Four buildings located across the river from the construction site may be eligible for listing in the National Register of Historic Places. Although the project would be visible from these structures, they are sufficiently separated from the plant site by the river to be 13
considered out of the area of project impact and thus will not be affected by the project.

As final analysis and report preparation from the archaeological survey conducted on the site nears completion, sufficient information exists to determine that the proposed plant construction and operation will have no effect on identified archaeological resources that may be eligible for inclusion in the National Register. Certain potentially significant sites (SS3, SS5, T17, and T23) would require additional investigation and treatment if project plans were changed to involve disturbance of the sites. Present construction and operating plans indicate that these sites and site SS2, which has been identified as potentially eligible for inclusion in the National Register, will be avoided by the project. Site 40RE124, located within the construction site, was considered significant but was fully investigated and excavated during the period 1973-74. Therefore, it is not necessary to consider this site further.

Accordingly, the Tennessee State Historic Preservation Office will be asked to concur in a determination of "no effect" from plant construction and operation on cultural resources either listed in or eligible for inclusion in the National Register of Historic places. 13

TABLE 2.3-1

DISTRIBUTION OF BURIALS BY MOUND CONSTRUCTION STAGE AT 40RE124(17) 13

Burial	Probable Minimum No. of Individuals	Probable Mound Construction Stage 1	2	3
1	1			X
2A,2B,2C	undetermined			X
2D*,2E*	but probably 3			
3	1			X
4	1			X
5	1	[Associated with Construction Stage 3, but could be intrusive		
6,10	1		X	
7A,7B,7C*	2			X
8	1			X
9	1			X
11	1		X	
12	1		X	
13	1		X	
14	1			X
15	1	Undetermined		
16A,16B	2		X	
17	1		X	
18*	1			X
19*	1		X	
20*	1		X	
21*	1		X	
22*	1			X
23*	1			X
24*	1		X	
25*	1		X	
26*	1		X	
27*	1		X	
28*	1	X		
29A*,29B*	2		X	
30*	1		X	
31A*,31B*	2	X		
Total	36	3	17	15

*Burial excavated, recorded and removed during January, 1974.

13

TABLE 2.3-2 SITE COMPONENTS AND RECOMMENDATIONS

TEMPORARY SITE NUMBER	CULTURAL COMPONENTS						RECOMMENDATIONS
	Archaic	Woodland	Mississippian	Unassigned Prehistoric	Historical	Unassigned	
T-1				X			1
T-2				X			1
T-4				X			1
T-7				X			1
T-10				X			1
T-13 (5)				X			1
T-13 (15)				X			
T-13 (23)				X			1
T-15				X			1
T-19				X			1
T-20				X			1
T-22				X			1
T-25				X			1
T-26				X			1
SS2	X						3
SS3	X	X					2
SS5	X	X	X				2
<u>Potentially Signficant Loci</u>							
T-17						X	2
T-23						X	2

13

<u>Key for Recommendations</u>

1. No further work necessary
2. Further evaluation necessary to determine eligibility for inclusion in the National Register of Historic Places if the proposed construction and operation plans are altered and the site is to be impacted.
3. Significant resource potentially eligible for inclusion in the National Register of Historic Places.

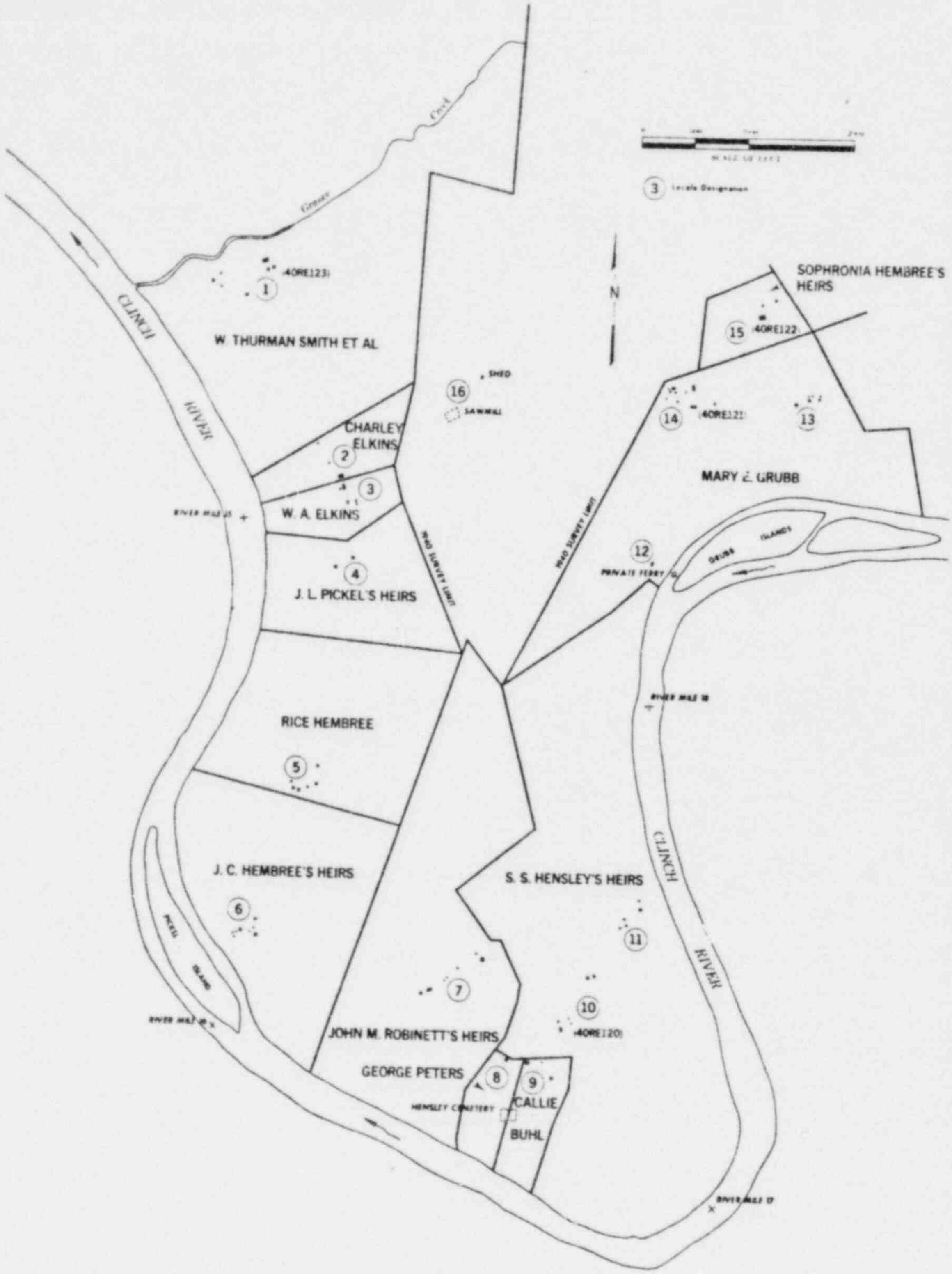


Figure 2.3-1. Location of Historic Sites in the Clinch River Fast Breeder Reactor Plant Area (adapted from US-TVA Watts Bar Reservoir land acquisition map dated December 1940). (Ref. 5)

13

Legend to Figure 2.3-1

Historic Sites

Locale No.	Property of
1	W. Thurman Smith, et al
2	Charley Elkins
3	W. A. Elkins
4	J. L. Pickel's Heirs
5	Rice Hembree
6	J. C. Hembree's Heirs
7	John M. Robinett's Heirs
8	George Peters
9	Callie Buhl
10	S. S. Hensley's Heirs (40RE120)
11	S. S. Hensley's Heirs
12	Mary E. Grubb
13	Mary E. Grubb
14	Mary E. Grubb
15	Sophronia Hembree's Heirs (40RE122)
16	Former Property Owner Undetermined

13

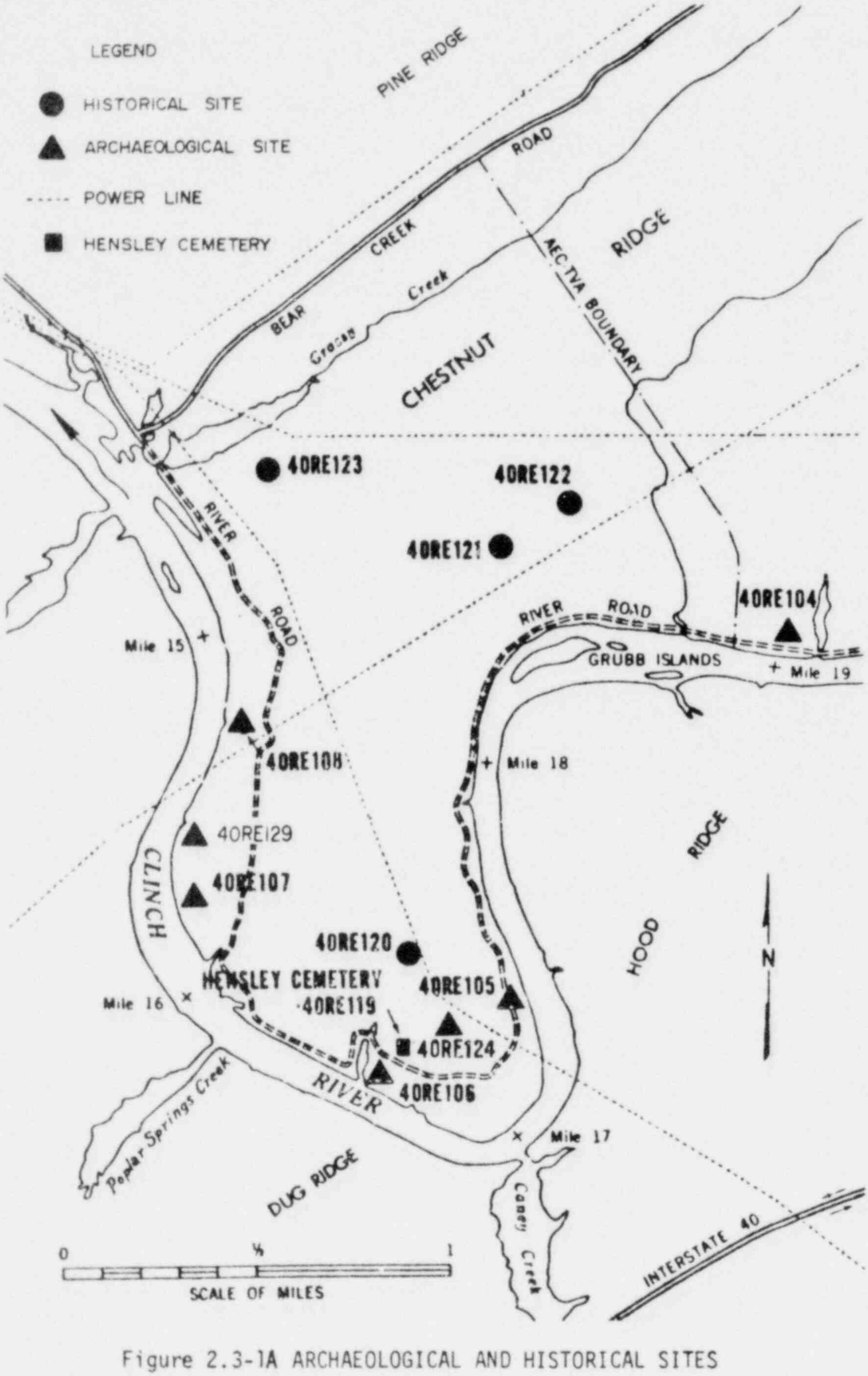


Figure 2.3-1A ARCHAEOLOGICAL AND HISTORICAL SITES

8

13

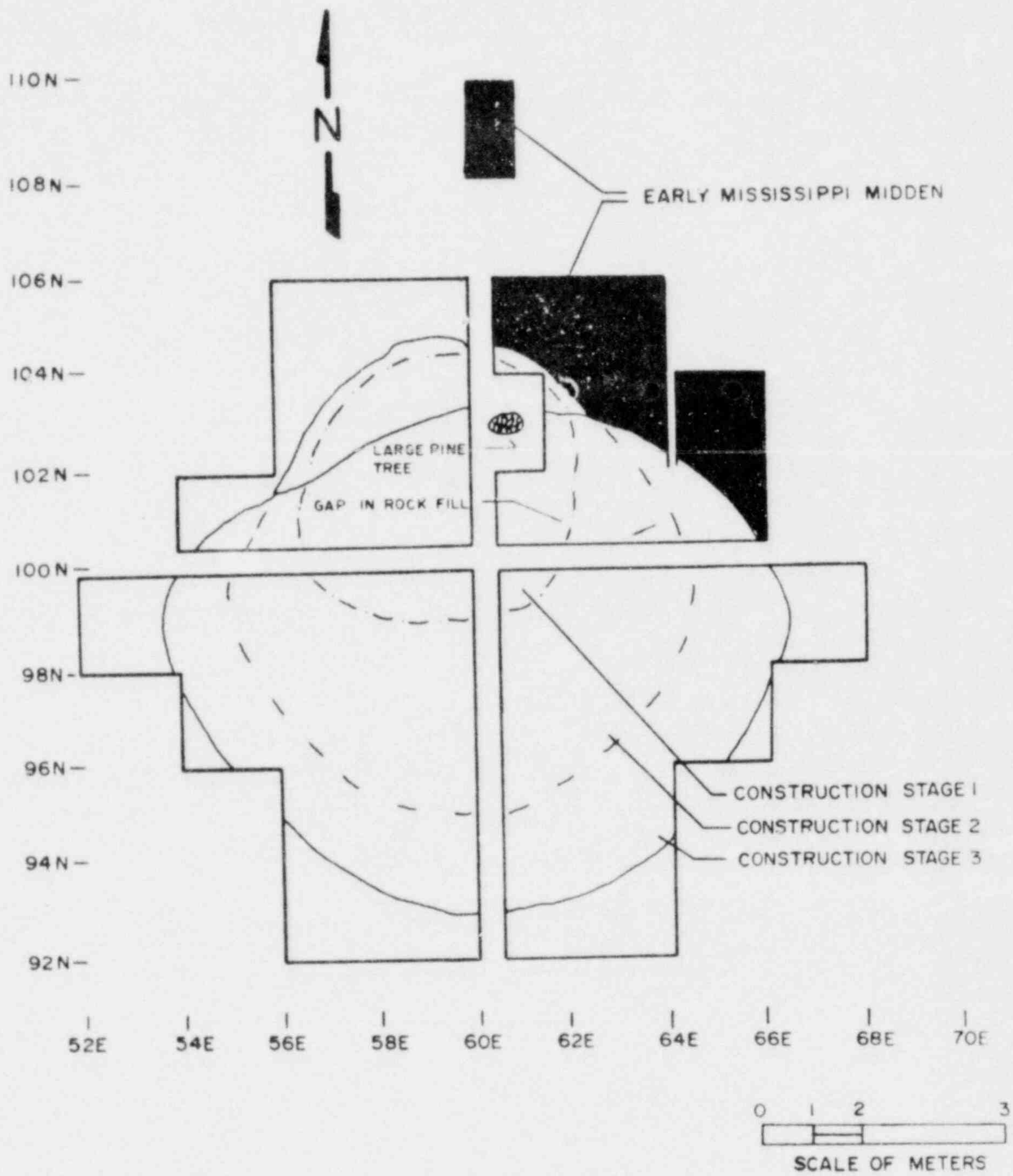
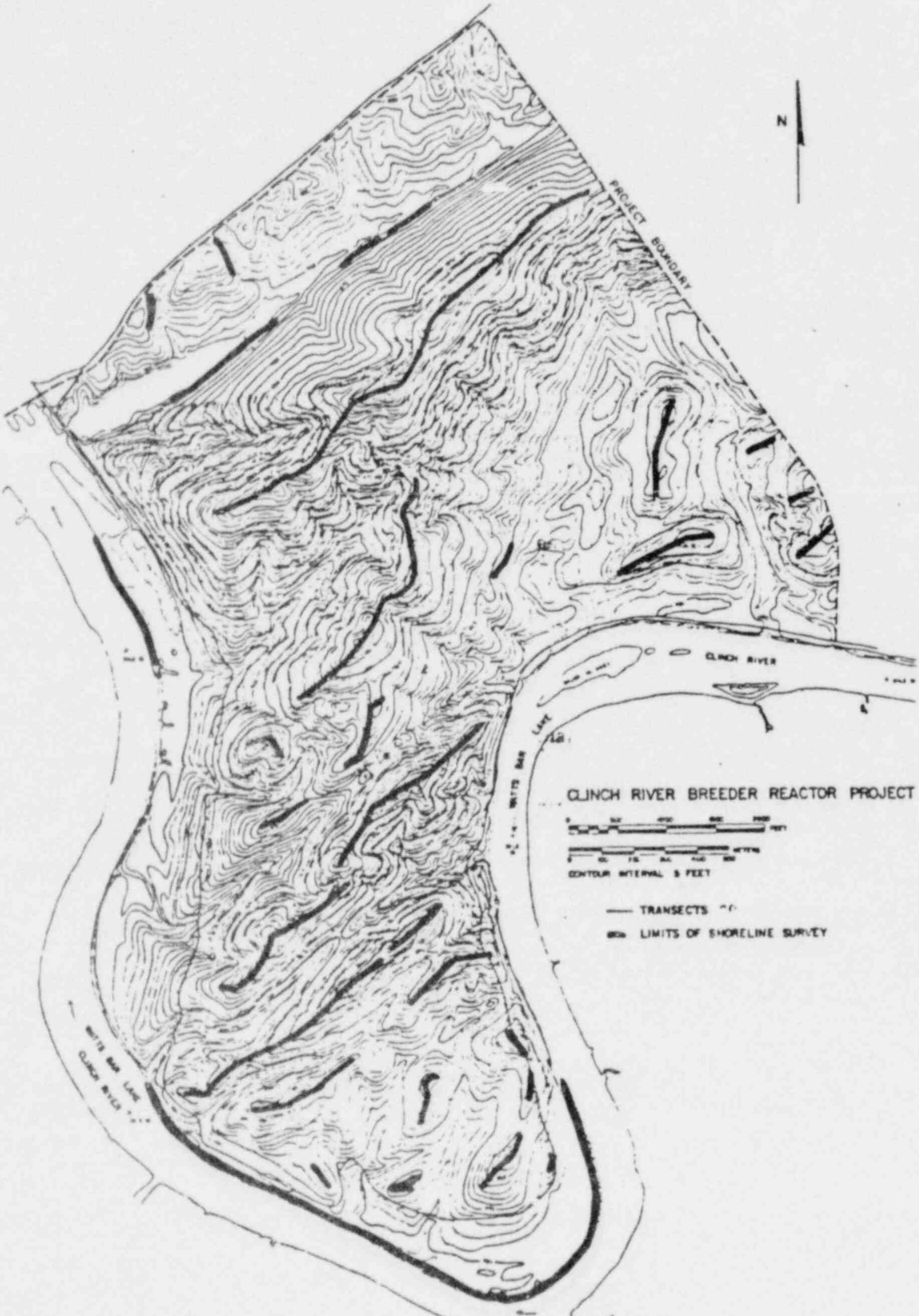


Figure 2.3-2 PLANVIEW OF EXCAVATIONS, MOUND CONSTRUCTION STAGES AND ADJACENT MIDDEN DEPOSITS (17) | 13



13

Fig 2.3-3 Location of shovel cut transects and shoreline survey.

13

Fig 2.3-4 Location of newly recorded loci and sites.

SECTION 2.3A: SITE INVENTORY - 1981/82 ARCHAEOLOGICAL SURVEY

Temporary Site Number:		T-1		
Location:	N. Lat.	35°	53'	07"
	W. Long.	84°	22'	27"
Site Dimensions:		145 m (NE-SW) by 50 m (NW-SW)		
Work Conducted:		Shovel Cut Testing 3 Test Units (1 x 1 meter)		
Cultural Material Recovered:				
	Prehistoric	unifacial tools lithic debitage		
	Historic	20th century remains		
Recommendations:		No further work necessary		

Temporary Site Number:		T-2		
Location:	N. Lat.	35°	53'	07"
	W. Long.	84°	22'	19"
Site Dimensions:		100m (E-W) by 50m (N-S)		
Work Conducted:		Shovel cut testing 2 test units (1 x 1 meter)		
Cultural Material Recovered:				
	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T-4		
Location:	N. Lat.	35°	53'	35"
	W. Long.	84°	22'	22"
Site Dimensions:		100 m (SW-NE) by 25 m (NW-SE)		
Work Conducted:		Shovel cut testing		
Cultural Material Recovered:				
	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

13

Temporary Site Number:		T-7		
Location:	N. Lat.	35°	53'	08"
	W. Long.	84°	22'	08"
Site Dimensions:		150 m (NW-SE) by 60 m (NE-SW)		
Work Conducted:		Shovel cut testing 4 test units (1 x 1 meter)		
Cultural Material Recovered:				
	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T-10		
Location:	N. Lat.	35^{o}	54'	21"
	W. Long.	84^{o}	22'	29"
Site Dimensions:		25 m (NW-SE) by 10 m (NE-SW)		
Work Conducted:		Shovel cut testing		
Cultural Material Recovered:	Prehistoric	lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T-13 (5)		
Location:	N. Lat.	35^{o}	53'	43"
	W. Long.	84^{o}	22'	13"
Site Dimensions:		20 m (NW-SE) by 20 m (NE-SW)		
Work Conducted:		Shovel cut testing 1 test unit (1 x 1 meter)		
Cultural Material Recovered:	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T-13 (15)		
Location:	N. Lat.	35^{o}	53'	47"
	W. Long.	84^{o}	22'	20"
Site Dimensions:		90 m (NE-SW) by 45 m (NW-SE)		
Work Conducted:		Shovel cut testing		
Cultural Material Recovered:	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T 13 (23)		
Location:	N. Lat.	35^{o}	53'	53"
	W. Long.	84^{o}	22'	27"
Site Dimensions:		150 m (NE-SW) by 25 m (NW-SE)		
Work Conducted:		Shovel cut testings 1 test unit (1 x 1 meter)		
Cultural Material Recovered:	Prehistoric	unifacial tools lithic debitage		
Recommendations:		No further work necessary.		

Temporary Site Number:		T-15		
Location:	N. Lat.	35^{o}	53'	30"
	W. Long.	84^{o}	22'	5"
Site Dimensions:		180 m (NE-SW) by 20 m (NW-SE)		
Work Conducted:		Shovel cut tests		

13

		1 test unit (1 x 1 meter)		
Cultural Material Recovered:				
	Prehistoric			
		unifacial tools		
		lithic debitage		
Recommendations:		No further work necessary.		
Temporary Site Number:		T-19		
Location:	N. Lat.	35°	54'	12"
	W. Long.	84°	21'	52"
Site Dimensions:		80 m (SW-NE) by 15 m (NW-SE)		
Work Conducted:		Shovel cut tests		
		1 test unit (1 x 1 meter)		
Cultural Material Recovered:				
	Prehistoric			
		unifacial tools		
		lithic debitage		
Recommendations:		No further work necessary.		
Temporary Site Number:		T-20		
Location:	N. Lat.	35°	54'	13"
	W. Long.	84°	21'	55"
Site Dimensions:		50 m (NW-SE) by 10 m (NE-SW)		
Work Conducted:		Shovel cut tests		
Cultural Material Recovered:				
	Prehistoric			
		lithic debitage		
Recommendations:		No further work necessary.		
Temporary Site Number:		T-22		
Location:	N. Lat.	35°	53'	22"
	W. Long.	84°	21'	57"
Site Dimensions:		10 by 10 meters		
Work Conducted:		Shovel cut tests		
Cultural Material Recovered:				
	Prehistoric			
		unifacial tools		
		lithic debitage		
	Historic			
		20th century remains		
Recommendations:		No further work necessary.		
Temporary Site Number:		T-25		
Location:	N. Lat.	35°	53'	37"
	W. Long.	84°	22'	27"
Site Dimensions:		10 m (E-W) by 5 m (N-S)		
Work Conducted:		Shovel cut tests		
Cultural Material Recovered:				
	Prehistoric			
		unifacial tools		
		lithic debitage		

13

Recommendations: No further work necessary.

<u>Temporary Site Number</u>: T-26
Location: N. Lat. 35^{o} 53' 21"
W. Long. 84^{o} 22' 28"
Site Dimensions: 100 m (N-S) by 25 m (E-W)
Work Conducted: Shovel cut tests
1 test unit (1 x 1 meter)
Cultural Material Recovered:
<u>Prehistoric</u> unifacial tools
lithic debitage
Recommendations: No further work necessary.

<u>Temporary Site Number</u>: SS2
Location: N. Lat. 35^{o} 53' 12"
W. Long. 84^{o} 23' 09"
Site Dimensions: 100 m (NW-SE) by 25 m (NE-SW)
Work Conducted: Shoreline survey
Backhoe testing
Cultural Material Recovered:
<u>Prehistoric</u> Early Archaic
1 Kirk corner notched projectile point/knife
Late Archaic
1 Late Archaic stemmed projectile point/knife
Unassigned
unifacial tools
lithic debitage
fire cracked rock
Recommendations: This is the first buried Early Archaic site discovered along the Clinch River. It is a significant resource and may be eligible for inclusion in the National Register of Historic Places. If the proposed construction plans are altered and this site is to be impacted, the site is recommended for mitigation. 13

<u>Temporary Site Number</u>: SS3
Location: N. Lat. 35^{o} 53' 08"
W. Long. 84^{o} 23' 02"
Site Dimensions: 750 m (NW-SE) by 50 m (NE-SW)
Work Conducted: Shoreline survey
Backhoe testing
Cultural Material Recovered:
<u>Prehistoric</u> Middle Archaic
1 Stanly cluster projectile point/knife
Terminal Archaic
1 steatite sherd
Woodland
1 small triangular proj. point
Unassigned

unifacial tools
lithic debitage
1 notched netsinker
1 pitted hammerstone

Recommendations: Further evaluation is neccesary if the proposed construction plans are altered and the site is impacted.

Temporary Site Number: SS5
Location: N. Lat. 35° 52' 58"
W. Long. 84° 22' 38"
Site Dimensions: 200 m (NW-SE) by 50 m (NE-SW)
Work Conducted: Shoreline survey
Cultural Material Recovered:
Prehistoric
Early Archaic
1 Kirk corner notched projectile point/knife
Woodland
1 limestone tempered sherd
Mississippian
1 shell tempered sherd
Unassigned
lithic debitage

Recommendations: Further evaluation to determine the eligibility of the site for inclusion in the National Register of Historic Places is necessary if the proposed construction plans are altered and the site is to be impacted.

Temporary Site Number: T-17
Location: N. Lat. 35° 54' 30'
W. Long. 84° 22' 38"
Site Dimensions: 60 m (N-S) by 80 (E-W)
Work Conducted: Plane Table Map
Site Description:
Site consists of 19 stone mounds varying in height from .4 to 1 meter. 13

Recommendations: Further evaluation is necessary to determine if these are prehistoric mounds if the proposed construction plans are altered and the site is to be impacted.

Temporary Site Number: T-23
Location: N. Lat. 35° 54' 27"
W. Long. 84° 22' 06"
Site Dimensions: 65 m (N-S) by 55 m (E-W)
Work Conducted: Plane table map.
Site Description: Site consists of 15 stones mounds varying in height from .5 to 1 meter.

Recommendations: Further evaluation is necessary to determine if these are prehistoric mounds if the proposed construction plans are altered and the site is to be impacted.

TABLE 2.5-2

PERIODS OF ZERO-RELEASE FROM MELTON HILL DAM[7]
MAY 1963 THROUGH DECEMBER 1979 | 9

Consecutive Days of Zero-Release	Number of Occurrences	Percentage of Total Number of Occurrences
1	159	55.6
2	83	29.0
3	27	9.4
4	9	3.1
5	3	1.0
6	--	--
7	2	0.7
8	1	0.4
9	--	--
10	--	--
11	1	0.4
29	1	0.4
TOTAL	286	

TABLE 2.5-3

AVERAGE MONTHLY TURBINE AND GATE DISCHARGES IN DAY-SECOND-FEET*[7]

MELTON HILL DAM

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1963					1,115	4,302	2,728	2,806	5,391	5,450	3,106	3,655	
1964	2,783	2,398	1,854	2,442	2,323	3,062	2,976	2,529	3,404	4,124	7,500	7,441	3,571
1965	10,126	5,123	3,568	5,891	3,997	2,505	2,390	5,099	5,626	3,524	4,269	3,181	4,608
1966	2,491	1,369	179	2,110	1,066	2,414	3,471	6,226	5,094	2,498	1,781	7,224	2,994
1967	7,098	4,505	10,184	3,399	1,011	4,683	5,011	6,132	7,121	7,296	3,920	10,608	5,914
1968	12,146	4,856	1,530	849	393	2,789	6,325	7,060	1,699	3,376	3,897	3,153	4,006
1969	2,850	4,930	2,444	1,607	2,276	3,002	4,506	3,310	2,557	1,734	3,296	3,434	2,996
1970	6,101	6,705	4,533	2,826	4,491	4,708	5,243	5,098	5,357	3,622	2,844	3,653	4,598
1971	3,522	5,855	2,490	2,508	5,719	6,342	3,332	5,564	5,483	6,073	7,580	7,187	5,138
1972	11,750	9,002	6,468	4,902	6,875	5,712	4,495	6,229	4,127	3,617	6,970	17,020	7,264
1973	8,463	4,914	9,898	4,090	8,905	9,278	4,929	7,451	5,456	3,838	5,147	10,288	6,888
1974	25,455	15,306	7,414	8,193	5,797	5,137	6,433	5,983	4,177	4,535	4,247	4,532	8,071
1975	6,033	12,702	13,313	11,186	6,158	7,237	7,186	6,717	4,870	3,120	3,125	4,527	7,143
1976	6,459	4,974	3,999	4,249	2,082	2,531	3,628	5,912	4,192	3,258	3,267	4,529	4,091
1977	5,698	3,931	1,639	10,045	5,492	5,252	5,238	4,430	3,691	3,301	7,824	14,581	5,935
1978	11,280	7,689	3,496	3,823	1,820	4,341	5,274	7,501	6,928	2,578	3,168	5,558	5,276
1979	11,806	10,377	13,340	5,863	3,647	6,209	7,303	8,168	6,503	6,895	6,539	5,377	7,662
Av.**	8,379	6,540	5,397	4,626	3,716	4,678	4,733	5,660	4,804	4,049	4,616	6,820	5,385
Seasonal Av.		6,772			4,339			5,066			5,161		

9

13

* Day-second-feet equals the average daily discharge in cubic feet per second (cfs).

** Averages are for the period 1964-1979.

2.6 METEOROLOGY

2.6.1 REGIONAL CLIMATOLOGY

Meteorological data from the Oak Ridge Area Station X-10,[1,2] located 4.5 miles northeast of the Clinch River Breeder Reactor Plant (CRBRP) Site, were used to characterize the Meteorology/Climatology of the region including the Site. Oak Ridge Area Station X-10 was a first order Weather Bureau Station from 1944 to 1964. (First order Weather Bureau Stations are usually located at major airports and are manned 24 hours a day. These stations record hourly visual observations as well as wind, temperature, dewpoint, etc. Second order stations only record and/or transmit data on physical phenomena.) From 1964 to 1972 only wind, temperature, dewpoint and differential temperature were recorded. The station was discontinued in December 1972. Other climatological data sources used in characterizing regional climatology are the Knoxville Airport Weather Station,[3] located about 20 miles east of the Site, and the Weather Bureau's Oak Ridge City Office,[4] located 10 miles northeast of the Site. Locations of these weather stations are shown in Figure 2.6-1. General information on the climate of the State is available from the U.S. Weather Bureau[5]. Other sources of specialized data are referenced as they appear in this section. 11

This Site is located in Roane County, Tennessee in a broad valley between the Cumberland Mountains to the northwest and the Great Smoky Mountains to the southeast. Topography of the Site is characterized by subparallel ridges with intervening valleys, as discussed in Section 2.4. Elevations of the ridge crests range between 900 and 1,200 feet. Site elevation is approximately 820 feet. 11

Topography of the Site is characterized by a series of parallel ridges separated by long, narrow valleys extending in a northeast-southwest direction. The Site lies along a rolling flank of one of these ridges. Differences in elevation influence the pattern of the changes in climate along a NE-SW axis; stations at a similar elevation have similar annual mean temperatures and precipitation normals[5]. 11

Prevailing winds in the region reflect the channeling of air flow caused by
the orientation of valleys and ridges of the southern Appalachians; winds are
generally northeasterly or southwesterly. Mean annual wind speeds are low
compared to other areas of Tennessee and the United States [6]. The mean 8
speed during the 16-year period of record is 4.4 miles per hour at the Oak
Ridge City Office[4]. 13

The region has a mild climate, classified Caf by Koppen; it is humid, has a
mean temperature for the warmest month of the year in excess of 71.6 degrees F
and has no distinct dry season[7]. March is normally the wettest month and
October the driest. Precipitation is heaviest from December through March
when cyclonic activity is high and in July and August when convective showers
occur. Maximum recorded rainfall in a 24-hour period was 7.75 inches; this
occurred at Oak Ridge Area Station X-10 in September 1944[1]. Temperatures 11
above 90 degrees F occurred about 30 days[4] per year. Zero and sub-zero 13
temperatures at the X-10 Station were observed during the months of December,
January or February in fewer than half the years from 1945 through 1964.
Synoptic (regional) scale weather systems move through eastern Tennessee with
irregularity. These storm systems are most frequent during December and
January and cause a maximum monthly number of cloudy days and extensive
precipitation. Summer season storm systems are usually weaker and tend to
pass to the north, leaving eastern Tennessee with sunshine interspersed with
thunderstorm activity. Between 50 and 60 thunderstorm days occur per year,
with a peak number of storms occurring in July[5]. About nine thunderstorms
per month occur during the period of May through August. The region,
including the Site, is subject to a small probability of tornado occurrence.

Humidity varies with wind direction, generally being lowest with northeast
winds and highest with southeasterly to southwesterly winds. Relative 11
humidity averages lowest in the afternoons and highest at night. Average
annual humidity in Tennessee is near 70 percent[6]. This is about average for
most of the United States east of the 95th meridian. 11

2.6.1.1 MAXIMUM RAINFALL

Maximum recorded point rainfall for the Knoxville Airport for intervals of 5 minutes to 24 hours is listed in Table 2.6-1[8]. Maximum monthly and annual precipitation recorded at the Oak Ridge City Office was 19.27 inches in July 1967 and 76.33 inches in 1973, respectively[4]. Monthly and annual extremes of 14.11 inches in July 1967 and 66.20 inches in 1950, respectively, were recorded at Oak Ridge Area Station X-10[2]. Maximum measured annual rainfall at Knoxville was 61.49 inches in 1957[3]. Calculated rainfall for the Site area for time periods of 0.5, 1, 2, 3, 6, 12, and 24 hours for a recurrence interval of 100 years is given in Table 2.6-2[9].

2.6.1.2 SEVERE SNOW AND GLAZE STORMS

Winter storms which produce a snowfall in excess of one inch or glaze are uncommon
in eastern Tennessee. The area can expect about three significant snowfalls per 11
year (one or more inches)[5]. It is unusual to have snow cover for more than a
week at a time[3]. Records over a period of 26 years show that, in March 1960, a
single storm maximum of 21 inches accumulated, with 12 inches in a single day. 11
Normal snowfall for March is 1.4 inches[4]. Highest average normal monthly total 13
is 3.1 inches, occurring in January.

Glaze occurred from three to six times per year during a 28-year survey period
ending in 1953[10]. Freezing rain can occur during the normally colder months of
the year when rain falls through a very shallow layer of cold air from an overlying
warm layer. Rain then freezes on contact with the ground or other objects to form
glaze. December through early March is the period with the highest frequency of
glaze storms. Based on limited periods of data collection, significant glaze 8
storms producing a glaze ice thickness of 0.25 inch or more on wires occur in
eastern Tennessee on an average of one storm every two years[10]. Occurrences for
glaze storms applicable to the area including the Site are as follows[10]:

Thickness of 0.25 inch or greater	Once every two years
Thickness of 0.50 inch or greater	Once every five years
Thickness of 0.75 inch or greater	Once every ten years

2.6.1.3 THUNDERSTORMS AND HAIL

Thunderstorms occur on an average of 53 days per year(4). The month of July 13
usually has the most. An average of about nine thunderstorm days per month
occur throughout the season from May through August. As can be seen in Table
2.6-3, the months of October through January have the fewest thunderstorms.

Hail is not too frequent but it does occur with stronger thunderstorms. On an 11
index of potential hail damage to residential property, calculated for each 11
area formed by one degree of latitude and one degree of longitude, the Site is
in a region of low potential loss due to hail(11). Maximum values of the
index occur in northwest Kansas where the index is 50. The index in eastern
Tennessee is about 5. Therefore, on a geographical basis, the Site is 11
situated in a region where hail is not a significant factor.

2.6.1.4 TORNADOES

The Site is located in an area infrequently affected by tornadoes(12,13). For 11
the purpose of comparison, Tennessee ranked 25th among all states in the
number of tornadoes from 1955 to 1967(14). Divided along the 86th Meridian,
the western half of the entire state has reported observing three times as 11
many tornadoes as were observed in the eastern half, which includes the 11
Site(13). The Oak Ridge-Clinch River area has one of the lowest probabilities
of tornado occurrence in the entire State(14,15).

Tornado frequencies calculated by Thom(16) for each one-degree square of
latitude and longitude for the period 1953 to 1962 show the Site to be
situated in a one-degree square with an annual frequency of 0.5. Probability
that a tornado will strike any point in a particular one-degree square, such
as the Site, is calculated as 3.63×10^{-4} per year. Recurrence interval is 8 13
one over the probability, which is once in 2,760 years. Raw count data on
tornado occurrence for those counties near the Site for the period 1916 to
1972 are presented in Figure 2.6-2(12,17). Roane County is the only one of
several counties within the one-degree square used for the calculation of the
tornado probability. Roane County itself has not recorded a tornado in the
57-year period of 1916 to 1972.

the region, including the Site. Fogs which restrict the visibility to 1,100
yards or less were observed, on the average, 91 days per year at the Bull Run 8
Creek site (about 15 miles northeast of the CRBRP site) and 119 days per year
at the Melton Hill Dam site (about 4.5 miles east of the CRBRP site) for the
period January 1964 to October 1970.

Fog which restricted visibility to less than 550 yards was recorded at the
Melton Hill Dam site on an average of 106 days per year[24]. This value is 8
about three times that recorded at Oak Ridge.

2.6.2.6 WIND AND STABILITY DATA

Source of this information for developing a diffusion climatology to represent
the Site is a one-year record of wind and temperature measurements made on a 11
370-foot tower at the CRBRP site. The year of record covers the period 13
February 17, 1977 through February 16, 1978. The joint recovery rate for wind 9 11
and stability data (33- to 200-foot temperature differences) is 97 percent for
the 33-foot wind level and 97 percent for the 200-foot wind level. 11

The method of sorting the observations into the Pasquill Stability Classes is 8
based on the temperature gradient scheme of NRC Regulatory Guide 1.23 which
associates a Pasquill Class with a discrete range of temperature difference
values for a 321-foot vertical interval. The values obtained from the Site 11
temperature measurements at 33 feet and 200 feet (167-foot interval) were
converted to corresponding values for the larger interval of 321. 9

Annual wind records are summarized in Table 2.6-5 through 2.6-12 for the 11
33-foot level aboveground and in Tables 2.6-13 through 2.6-20 for the 200-foot
level aboveground. These tables present the joint percentage frequency
distribution of wind speed and direction for the seven Pasquill Stability
Classes, A through G, and for all observations. Annual and seasonal wind
roses are shown for the 33-foot level in Figures 2.6-4 through 2.6-8 and for
the 200-foot level in Figures 2.6-9 through 2.6-13.

Annual, winter, spring, summer and fall wind roses for the 33-foot level show
the tendency for the wind to align with the general west-northwest to 8 9 11

east-southeast orientation of the portion of the Clinch River valley where the Site
is located. At the 200-foot level, the tendency is toward alignment with the
approximately southwest to northeast orientation of the ridge in the area. Most
frequent wind directions for annual wind roses are west-northwest at 33 feet and 8 9 11
west-southwest at 200 feet. The winter season wind roses, for both levels, show
the influence of winter storms and passage of cold frontal systems by the increased
percentages of winds from the west-northwest sector. The summer and fall wind
roses reflect meteorological conditions with a high frequency of occurrence of 11
light winds. This is consistent with persistence of high pressure over or slightly
to the north of the Site area. Pressure patterns published in the Climatic Atlas
of the United States[6] support this conclusion.

The 33-foot winds for the annual period are from the west-southwest plus or minus
one 22.5 degree sector approximately 26 percent of the time, from the west-
northwest plus or minus one 22.5 degree sector approximately 25 percent of the
time, and from the west plus or minus one 22.5 degree sector approximately 29 9
percent of the time on an annual basis. The percentage of south-southwest winds
increases slightly during the spring months. During the fall season the percentage 8 11
of winds is very similar (within two percentage points) to the annual wind rose.

The 33-foot model wind speed group is 0.8 to 3 mph for the year, as can be seen in
Table 2.6-12. Calms are few in all seasons of the year. The annual percent 11
occurrence of calm is 3.19 percent at the 33-foot level and 0.47 percent at the 8
200-foot level.

The distribution of the seven Pasquill Stability Classes on a monthly basis is
summarized in Table 2.6-28. Adverse dispersion categories, Stability Classes F and 9 11
G, contribute about 85 percent of the weight in the calculation of atmospheric
factors. Type G stability is a minimum in the month of January with a frequency of
occurrence of about five percent. Type G is a maximum in the month of March, with 8 11
a frequency of about 28 percent.

Type F stability is a minimum in January with a frequency of about six percent. 8 11
Type F stability is a maximum in the month of July with a frequency of about 25
percent and August and September are close behind the frequencies of about 24
percent in these months. At the other end of the atmospheric

stability spectrum, the combined occurrence of types A and B stabilities occurs most frequently in the month of June with a frequency of about 6 percent. September shows the fewest occurrences of type A stability. 8 11

On an annual basis, Pasquill's type D (neutral stability) class is most common. Type D stability is a maximum in the month of January when it occurs 8 with a frequency of about 49 percent. Small frequencies of occurrence of 9 stability types B and C are largely a product of the classification scheme used to define the range of temperature difference values that define these 11 classes. 11

2.6.3 POTENTIAL INFLUENCE OF THE PLANT AND ITS FACILITIES ON LOCAL METEOROLOGY

Some influence on local meteorology will be exerted by the plant itself. Because the plant itself will be cleared of trees, leveled, bladed, graded and black topped, it will change the albedo (reflective power) of the earth in this area and produce a small local heat island which would be discernable with a proper set of micrometeorological measuring systems. The increase in temperature would be similar to that found by Norwine[25], which was two 8 11 degrees F for a shopping center.

The shape of the buildings erected on the plant site will create aerodynamically disturbed air flow which in turn will alter the distribution pattern and diffusion rates of windborne contaminants on the leeward side of the buildings. This effect is discussed in Section 2.6.6.1.1.

It is planned to dissipate waste heat carried by recirculated cooling water in cooling towers. Evaporation of water into the atmosphere will form a visible vapor plume if the atmosphere is either very humid, or very cold and moderately humid. The vapor plume will alter, to a small degree, the amount of sunshine received in the small areas most frequently in the shadow formed by the plume. On rare occasions small cumulus clouds could form above or remote from the tower, depending on atmospheric temperature and water vapor conditions in the first few thousand feet above the cooling tower. The plume may diffuse to ground level and form fog, and in freezing temperatures cause rime ice on vertical structures and road systems. These environmental impacts are discussed in Section 5.1.

2.6.4 TOPOGRAPHICAL DESCRIPTION

The Site is on a peninsula approximately between river miles 15 and 18 on the
Clinch River. This region is characterized by a series of parallel ridges
oriented approximately along a northeast-southwest axis. The Site lies along 11
a rolling flank of one of these ridges which slopes gradually toward the
Clinch River. The terrain is further complicated by the generally
east-southeast to west-northwest orientation of the river valley, as it cuts
through the ridges for about 8 direct miles. The Site is located 11 13
approximately midway along this stretch of the river. Normal reservoir pool
elevation is 740 feet. Mean elevation of the Site is 862 feet MSL.

Figures 2.6-14 and 2.6-15 are topographic maps showing the area surrounding
the Site. Topographic profile cross-sections in each of the eight cardinal
compass directions radiating from the Site are shown in Figure 2.6-16. A
topographical profile cross-section indicating the meteorological tower
location, sensor heights and center of containment building with respect to
the current topography is given in Figure 2.6-17. Terrain to the south of the
Site, approximately 3,700 feet beyond Watts Bar Lake, rises abruptly to a
height of about 240 feet above plant grade, which is 815 feet. This obstacle
to air flow will influence the dispersion rate at this distance. The expected
effect is discussed below. Hills or ridges of similar height are found within
two miles of the Site practically every direction except towards the 13
northwest, northeast and southwest.

The highest point within a radius of five miles of the Site is Melton Hill,
elevation 1,356 feet MSL, about 4.75 miles east-northeast of the plant.
Lowest points within a radius of five miles of the Site are along the margins
of Watts Bar Lake, the surface of which averages approximately 740 feet MSL. 11

It is anticipated that the irregular terrain will have a significant effect on
dispersion rates. In stable air with light winds, pockets of stagnation may
develop at the base of sharply rising hills or bluffs or near the mouths of 11
nearby creeks. This could cause short-term increases in pollutant 8
concentration levels. However, due to the increase in wind meander under

light winds, it has been shown that the plume effluent could spread over an angle of 180 degrees or more[26]. 8 11

Slopes which face the southeast through southwest directions present a surface which is more nearly normal to the incidence of solar radiation. This effect will enhance and improve dispersion rates for any air contaminants approaching the slope due to the production of thermally induced vertical air motions. However, no credit for this effect is considered in the calculations of atmospheric dilution factors. 11

Modification of the air mass due to travel over water is not considered to be significant as the over-water fetch is limited and the temperature contrast between air and water does not reach the magnitude required for rapid air mass modification. 11

It is difficult to generalize on the overall effect of terrain on the long-term average dilution factor. Normally, irregular terrain will promote mechanical turbulence and enhance the dispersion of effluents. But, average wind speeds in the area are low and during the summer and fall seasons periods of stagnation are fairly common. 11 In most circumstances, it is believed that the net effect of the irregular terrain could be demonstrated to improve dispersion rates near the Site as observed in the Mountain Iron Diffusion Trials[27]. 11 In these trials of diffusion over rugged terrain, valley location sampling points were lower in concentration than ridge lines by about 50 percent[27]. 11

2.6.5 ON-SITE METEOROLOGICAL MONITORING PROGRAM

See Section 6.1.3.1 of the Environmental Report.

2.6.6 SHORT-TERM (ACCIDENT) DIFFUSION ESTIMATES

A statistical analysis using hourly data from the CRBRP 370-foot permanent 13 11 meteorological tower for the period from February 17, 1977 through February 16, 1978 8 was performed to estimate atmospheric dilution factors (x/Q). 9 11 The Pasquill stability classes were determined by temperature differences between 33 and 200 feet and wind speed and direction at 33 feet. Data recovery was 97 percent.

Fifty (50) percent x/Q values representative of post-release time periods up to 30 days are presented in Table 2.6-29 for downwind distances as far as 50 miles from the reactor plant including the minimum exclusion distance (2,200 feet). The fifty (50) percent value is the average value of dilution exhibited by the data and is used to assess the consequences of postulated plant releases evaluated in the Environmental Report. 8 9 11 8

2.6.6.1 CALCULATIONS

Fifty (50) percent x/Q values for time intervals up to 30 days following postulated releases were estimated for downwind distances up to 50 miles from the reactor plant. The time intervals selected for this analysis were the same five perods specified in NRC Regulatory Guide 1.4; 0 to 2 hours, 0 to 8 hours, 8 to 24 hours, 1 to 4 days and 4 to 30 days. Other NRC Regulatory Guides used in the Calculation and Methodc.ogy are Reg. Guide 1.70, Reg. Guide 4.2, Reg. Guide 1.145 and Reg. Guide 1.111. 8 11 9

A computer program was developed for x/Q calculations. At each downwind distance for each cardinal wind direction, this model calculates hourly x/Q values using hourly data from the CRBRP meteorological tower (February 17, 1977 through February 16, 1978) and equations to be described below. For the 0-2 hour time interval, the program ranks each sector in descending order, all x/Q values associated with each sector. A log-probability plot of the resulting ordered list of x/Q values is prepared for each of the wind directions. 11

For a given downwind distance, the 50 percentile x/Q values for each averaging time, given in Table 2.6-29, are the highest of the 16 values (one for each wind sector) determined. The highest x/Q values occurred in the northwest to west-northwest sectors. X/Q values in Table 2.6-29 correspond to either southeast or east-southeast wind directions (i.e., wind blowing from the southeast toward the northwest or east-southeast toward west-northwest), whichever provided the maximum x/Q values. 9 11 11 where:

X = Activity concentration, Curies/m^3

Q = Activity release rate, Curies/sec

σ_z = Vertical dispersion parameter, meter

x = Distance downwind, meters

T = Open terrain correction factor (1 to 4) depending on distance downwind

8

This equation assumes that the plume meanders uniformly over a 22.5 degree sector. For all downwind distances, stabilities, and wind speeds, the effect 9 11 of the turbulent wake is taken into account by adding to the dispersion parameter an effect based on the maximum allowed under NRC Regulatory Guide 1.4 or the height of the building as suggested by Sagendorf[30]. In practice, 11 Sagendorf increases σ_z by the square root of three or substitutes $(\sigma_z^2 + \frac{CD^2}{\pi})^{1/2}$ in Equation (3). In this case, C is the wake factor equal to 0.5 and D the 9 building height, taken as 51.5 meters. Equation (3) is evaluated for both changes in σ_z and the results are compared and the larger values used. The open terrain correction factor (T) is used to simulate the differences between a constant mean wind direction X/Q equation and a fluctuation mean wind 9 direction X/Q equation. This open terrain correction factor is from NRC reg. Guide 1.111, Rev. 0, 1976.

2.6.7 LONG-TERM AVERAGE DIFFUSION ESTIMATES

Hourly average dilution factors (X/Q) are calculated using Equation (3), with 9 the building wake factor, for the year of record for downwind distances up to 11 50 miles using the 33-foot level wind data (wind speed and wind direction) and the 33- to 200-foot stability data. All X/Q values corresponding to a given wind sector for the entire year are summed and divided by the total number of X/Q values for all wind sectors. This procedure is applied to all 16 wind sectors, yielding an annual average X/Q value for each sector and a given downwind distance. Results are listed in Table 2.6-30. 11

Least dilution is found in the sectors that lie to the northwest of the plant 13
which is consistent with the relatively high percentage of type F and G 8
stability conditions associated with light winds that blow from the southeast. 13

TABLE 2.6-1

MAXIMUM RECORDED POINT RAINFALL(8)
KNOXVILLE, TENNESSEE AIRPORT
(1899-1961)

Rainfall in Indicated Periods (inches)

Minutes					Hours				
5	10	15	30	60	2	3	6	12	24
0.58	0.99	1.37	2.57	3.52	3.57	3.97	4.88	5.60	6.20

Maximum monthly: 11.74

Maximum annual: 61.49

TABLE 2.6-2

CALCULATED MAXIMUM RAINFALL FOR VARIOUS TIME PERIODS (9)
RECURRENCE INTERVAL 100 YEARS
CRBRP SITE AREA

13

Time Period (hours)	Rainfall inches
0.5	2.50
1.0	3.00
2.0	3.75
3.0	4.00
6.0	4.80
12.0	5.80
24.0	6.50

TABLE 2.6-3

MEAN NUMBER OF DAYS WITH SNOW AND/OR ICE WITH THUNDERSTORMS
OAK RIDGE CITY OFFICE

13

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Snow, Ice Pellets+ 1.0 inch or more	1	1	**	0	0	0	0	0	0	0	0	1
Thunderstorms++	1	2	3	5	8	9	11	9	3	1	1	1

*Mean number of days
**Less than one-half day
+1953-1973
++1949-1964

TABLE 2.6-4

MONTHLY CLIMATOLOGICAL TEMPERATURE DATA
OAK RIDGE AREA STATION, X-10(1)
1945-1964

Month	Climatological Standard Normals 1931-1960: Mean Monthly (°F)	Daily Maximum (°F)	Daily Minimum (°F)	Highest Temp. (°F)	Lowest Temp. (°F)
December	40.4	49.4	31.3	76	-5
January	40.1	48.9	31.2	77	-8
February	41.7	51.6	31.8	77	0
Winter	40.7	50.0	31.4	77	-8
March	48.0	58.9	37.0	87	4
April	58.2	70.0	46.3	89	24
May	66.9	79.0	54.8	94	32
Spring	57.7	69.3	46.0	94	4
June	74.7	86.1	63.3	99	41
July	77.4	88.0	66.7	103	49
August	76.5	87.4	65.6	99	44
Summer	76.2	87.2	65.2	103	41
September	71.1	83.0	59.2	103	33
October	60.0	72.2	47.7	91	21
November	47.6	58.6	36.5	83	4
Fall	59.6	71.3	47.6	103	4
Annual	58.5	69.4	47.6	103	-8
Oak Ridge City Office(4) Climatological Standard Normals 1941-1970					
Annual	57.8	68.6	47.0	105*	-9*
Knoxville Vicinity(3) Climatological Standard Normals 1941-1970					
Annual	59.7	69.8	49.5	104**	-16**

*May 1947 - October 1974

**1874 - October 1974

TABLE 2.6-5
ANNUAL JOINT FREQUENCY OF WIND DIRECTIONS AND WIND SPEEDS FOR
STABILITY CLASS A
CRBRF PERMANENT TOWER, 33-FOOT LEVEL
FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
NNE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
NE	.000000	.000000	.000000	.000117	.000117	.000000	.000000	.000000	2	.000235	6.8
ENE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
E	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
ESE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SE	.000000	.000000	.000000	.000117	.000000	.000000	.000000	.000000	1	.000117	6.0
SSE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
S	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSW	.000000	.000000	.000117	.000000	.000000	.000000	.000000	.000000	1	.000117	4.8
SW	.000000	.000000	.000117	.000235	.000586	.000117	.000000	.000000	9	.001055	7.4
WSW	.000000	.000000	.000000	.000235	.000704	.000352	.000000	.000000	11	.001290	8.6
W	.000000	.000000	.000000	.000235	.000469	.000235	.000000	.000000	8	.000938	8.4
WNW	.000000	.000000	.00000C	.000000	.002597	.000152	.000000	.000000	26	.003049	8.4
NW	.000000	.000000	.000000	.000000	.001407	.000000	.000000	.000000	12	.001407	8.4
NNW	.000000	.000000	.000000	.000000	.000235	.000000	.000000	.000000	2	.000235	7.9
HRS		0	2	8	53	9	0	0	72		
FREQ	.000000	.000000	.000235	.000938	.006216	.001055	.000000	.000000		.008444	
AVGSPD	.0	.0	4.2	5.7	7.9	12.7	.0	.0			8.2

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

TABLE 2.6-6

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS B

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

11 13

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000000	.000117	.000000	.000117	.000000	.000000	.000000	2	.000235	5.2
NNE	.000000	.000000	.000000	.000235	.000000	.000000	.000000	.000000	2	.000235	5.4
NE	.000000	.000000	.000117	.000117	.000352	.000000	.000000	.000000	5	.000586	6.9
ENE	.000000	.000000	.000352	.000352	.000235	.000000	.000000	.000000	8	.000938	5.8
E	.000000	.000000	.000352	.000117	.000000	.000000	.000000	.000000	4	.000469	4.5
ESE	.000000	.000000	.000117	.000235	.000117	.000000	.000000	.000000	4	.000469	6.1
SE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSE	.000000	.000000	.000000	.000117	.000117	.000000	.000000	.000000	2	.000235	7.3
S	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSW	.000000	.000000	.000235	.000235	.000000	.000000	.000000	.000000	4	.000469	4.4
SW	.000000	.000000	.000586	.001407	.001055	.000117	.000000	.000000	27	.003166	6.3
WSW	.000000	.000000	.000821	.000938	.000821	.000821	.000000	.000000	29	.003401	7.6
W	.000000	.000000	.000117	.000352	.001055	.000352	.000000	.000000	16	.001876	8.1
WNW	.000000	.000000	.000000	.000469	.002345	.000469	.000000	.000000	28	.003284	7.9
NW	.000000	.000000	.000000	.000469	.002228	.000000	.000000	.000000	23	.002697	7.6
NNW	.000000	.000000	.000000	.000117	.000821	.000000	.000000	.000000	8	.000938	7.3
HRS	0	0	24	44	79	15	0	0	162		
FREQ	.000000	.000000	.002815	.005160	.009265	.001759	.000000	.000000		.018998	
AVGSPD	.0	.0	4.2	5.7	7.8	12.2	.0	.0			7.1

9

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

11 13

TABLE 2.6-7

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS C

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

11 | 13

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000352	.001173	.000235	.000352	.000000	.000000	.000000	18	.002111	4.3
NNE	.000000	.000821	.001407	.000938	.000117	.000000	.000000	.000000	28	.003284	4.0
NE	.000000	.000117	.002580	.001642	.000117	.000000	.000000	.000000	38	.004456	4.5
ENE	.000000	.000117	.001994	.000821	.000352	.000000	.000000	.000000	28	.003284	4.6
E	.000000	.000235	.001642	.000821	.000117	.000000	.000000	.000000	24	.002815	4.5
ESE	.000000	.000000	.000704	.000117	.000000	.000000	.000000	.000000	7	.000821	4.2
SE	.000000	.000117	.000235	.000117	.000000	.000000	.000000	.000000	4	.000469	3.9
SSE	.000000	.000000	.001525	.000821	.000000	.000235	.000000	.000000	22	.002580	5.2
S	.000000	.000000	.000117	.000235	.000000	.000000	.000000	.000000	3	.000352	5.5
SSW	.000000	.000000	.001525	.000586	.000000	.000000	.000000	.000000	18	.002111	4.3
SW	.000000	.000235	.004456	.002463	.002228	.000117	.000000	.000000	81	.009499	5.5
WSW	.000000	.000235	.002463	.001759	.000704	.000235	.000000	.000000	46	.005395	5.3
W	.000000	.000000	.000704	.000821	.000704	.000352	.000000	.000000	22	.002580	6.7
WNW	.000000	.000000	.000469	.002345	.002463	.000352	.000000	.000000	48	.005629	6.7
NW	.000000	.000117	.000352	.000704	.002463	.000000	.000000	.000000	31	.003636	6.8
NNW	.000000	.000117	.000235	.00469	.00704	.000000	.000000	.000000	13	.001525	5.9
HRS	0	21	184	127	88	11	0	0	431		
FREQ	.000000	.002463	.021579	.014894	.010320	.001290	.000000	.000000		.050545	
AVGSPD	.0	2.5	4.0	5.5	7.7	12.1	.0	.0			5.3

9

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-8

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS D

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

11 | 13

Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.008209	.003049	.000235	.000000	.000000	.000000	.000000	98	.011493	2.5
NNE	.000000	.007623	.004808	.000704	.000000	.000000	.000000	.000000	112	.013135	2.9
NE	.000000	.008913	.010907	.002815	.000235	.000000	.000000	.000000	195	.022869	3.4
ENE	.000000	.014190	.016301	.004926	.000117	.000000	.000000	.000000	303	.035534	3.4
E	.000117	.012666	.008444	.000821	.000352	.000000	.000000	.000000	191	.022399	2.9
ESE	.000117	.006216	.004691	.000235	.000000	.000000	.000000	.000000	96	.011258	2.8
SE	.000000	.004691	.002815	.00117	.000000	.000000	.000000	.000000	65	.007623	2.7
SSE	.000000	.008209	.011376	.004222	.002697	.001173	.000000	.000000	236	.027677	4.3
S	.000000	.005277	.005864	.000938	.000938	.000117	.000000	.000000	112	.013135	3.8
SSW	.000000	.004808	.004456	.001407	.000000	.000000	.000000	.000000	91	.010672	3.3
SW	.000000	.008913	.016301	.008678	.005746	.001407	.000117	.000000	351	.041163	4.7
WSW	.000000	.011962	.018647	.008326	.007154	.002697	.000117	.000000	417	.048903	4.8
W	.000000	.008092	.008326	.002111	.002463	.001173	.000000	.000000	189	.022165	4.3
WNW	.000000	.007623	.007857	.010672	.010555	.002815	.000000	.000000	337	.039522	5.6
NW	.000000	.004222	.005043	.004105	.005864	.001173	.000000	.000000	174	.020406	5.3
NNW	.000000	.006450	.002345	.003049	.000938	.000000	.000000	.000000	109	.012783	3.5
HRS	2	1092	1119	455	316	90	2	0	3076		
FREQ	.000235	.128064	.131230	.053360	.037059	.010555	.000235	.000000		.360736	
AVGSPD	.7	2.2	3.8	5.5	7.7	11.5	16.7	.0			4.1

9

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

11 | 13

TABLE 2.6-9

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS E

CRBRP PERMANENT METEOROLOGICAL TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000469	.011610	.000352	.000000	.000117	.000000	.000000	.000000	107	.012548	1.5
NNE	.000352	.010437	.000936	.000000	.000000	.000000	.000000	.000000	100	.011727	1.8
NE	.000352	.009147	.002932	.000586	.000235	.000000	.000000	.000000	113	.013252	2.5
ENE	.000352	.008913	.004105	.000704	.000000	.000000	.000000	.000000	120	.014073	2.5
E	.000586	.015715	.001525	.000586	.000235	.000000	.000000	.000000	159	.018647	2.9
ESE	.000000	.007623	.001055	.000117	.000469	.000000	.000000	.000000	79	.009265	2.0
SE	.000235	.012900	.000821	.000235	.000000	.000000	.000000	.000000	121	.014190	1.7
SSE	.000117	.012548	.003166	.00938	.001642	.000586	.000000	.000000	162	.018998	2.9
S	.000235	.007857	.002580	.000938	.000235	.000000	.000000	.000000	101	.011845	2.6
SSW	.000117	.003166	.001407	.001407	.000704	.000000	.000000	.000000	58	.006802	3.5
SW	.000469	.008561	.003166	.000938	.001642	.000117	.000000	.000000	127	.014894	3.1
WSW	.000235	.014190	.006685	.002345	.001759	.000235	.000000	.000000	217	.025449	3.2
W	.000586	.018529	.007857	.001759	.000704	.000000	.000000	.000000	251	.029436	2.7
WNW	.000117	.018178	.005160	.002932	.001759	.000352	.000000	.000000	243	.028498	2.9
NW	.000352	.014073	.003166	.003049	.000586	.000117	.000000	.000000	182	.021344	2.6
NNW	.000117	.011376	.001525	.000586	.000117	.000000	.000000	.000000	117	.013721	1.9
HRS	40	1576	396	146	87	12	0	0	2257		
FREQ	.004691	.184825	.046441	.017122	.010203	.001407	.000000	.000000		.264689	
AVGSPD	.7	1.6	3.7	5.5	7.8	11.4	.0	.0			2.5

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-10

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS F

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000352	.004808	.000117	.000117	.000000	.000000	.000000	.000000	46	.005395	1.2
NNE	.000469	.004574	.000117	.000000	.000000	.000000	.000000	.000000	44	.005160	1.1
NE	.001407	.005395	.000352	.000000	.000000	.000000	.000000	.000000	61	.007154	1.2
ENE	.000469	.009851	.000235	.000000	.000000	.000000	.000000	.000000	90	.010555	1.2
E	.000000	.10672	.000000	.000000	.000000	.000000	.000000	.000000	91	.010672	1.2
ESE	.001055	.010437	.000235	.000000	.000000	.000000	.000000	.000000	100	.011727	1.1
SE	.002228	.020406	.000000	.000000	.000000	.000000	.000000	.000000	193	.022634	1.2
SSE	.000938	.014307	.000117	.000000	.000000	.000000	.000000	.000000	131	.015363	1.2
S	.000000	.002580	.000117	.000000	.000000	.000000	.000000	.000000	23	.002697	1.3
SSW	.000000	.003166	.000117	.000000	.000000	.000000	.000000	.000000	28	.003284	1.2
SW	.001055	.003284	.000000	.000000	.000000	.000000	.000000	.000000	37	.004339	1.0
WSW	.000469	.006450	.001173	.000000	.000000	.000000	.000000	.000000	69	.008092	1.5
W	.000821	.011258	.000469	.000000	.000000	.000000	.000000	.000000	107	.012548	1.4
WNW	.000352	.013487	.001173	.000000	.000000	.000000	.000000	.000000	128	.015011	1.4
NW	001876	.009382	.000000	.000000	.000000	.000000	.000000	.000000	96	.011258	1.1
NNW	.000469	.007036	.000117	.000000	.000000	.000000	.000000	.000000	65	.007623	1.1
HRS	102	1169	37	1	0	0	0	0	1309		
FREQ	.011962	.137094	.004339	.000117	.000000	.000000	.000000	.000000		.153512	
AVGSPD	.7	1.2	3.5	6.3	.0	.0	.0	.0			1.2

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

TABLE 2.6-11

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS G

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

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Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.001759	.000000	.000000	.000000	.000000	.000000	.000000	15	.001759	1.0
NNE	.000586	.003636	.000000	.000000	.000000	.000000	.000000	.000000	36	.004222	1.0
NE	.000704	.004456	.000000	.000000	.000000	.000000	.000000	.000000	44	.005160	1.0
ENE	.001642	.007740	.000117	.000000	.000000	.000000	.000000	.000000	81	.009499	1.1
E	.000352	.016301	.000117	.000000	.000000	.000000	.000000	.000000	143	.016770	1.1
ESE	.001290	.010672	.000000	.000000	.000000	.000000	.000000	.000000	102	.011962	1.0
SE	.003870	.024745	.000000	.000000	.000000	.000000	.000000	.000000	244	.028615	1.0
SSE	.001642	.016301	.000117	.000000	.000000	.000000	.000000	.000000	154	.018060	1.1
S	.000352	.003636	.000000	.000000	.000000	.000000	.000000	.000000	34	.003987	1.1
SSW	.000704	.002815	.000000	.000000	.000000	.000000	.000000	.000000	30	.003518	.9
SW	.000352	.003753	.000000	.000000	.000000	.000000	.000000	.000000	35	.004105	.9
WSW	.000000	.006098	.000117	.000000	.000000	.000000	.000000	.000000	53	.006216	1.2
W	.000352	.010320	.000117	.000117	.000000	.000000	.000000	.000000	93	.010907	1.4
WNW	.002463	.008678	.000117	.000000	.000000	.000000	.000000	.000000	96	.011258	1.2
NW	.000352	.003401	.000000	.000000	.000000	.000000	.000000	.000000	32	.003753	1.0
NNW	.000352	.002932	.000000	.000000	.000000	.000000	.000000	.000000	28	.003284	1.0
HRS	128	1085	6	1	0	0	0	0	1220		
FREQ	.015011	.127243	.000704	.000117	.000000	.000000	.000000	.000000		.143075	
AVGSPD	.7	1.1	3.5	6.1	.0	.0	.0	.0			1.1

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-12

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

ALL STABILITY CLASSES

CRBRP PERMANENT TOWER, 33-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000821	.026739	.004808	.000586	.000586	.000000	.000000	.000000	286	.033541	2.0
NNE	.001407	.027090	.007271	.001876	.000117	.000000	.000000	.000000	322	.037762	2.2
NE	.002463	.028029	.016888	.005277	.001055	.000000	.000000	.000000	458	.053712	2.8
ENE	.002463	.040812	.023103	.006802	.000704	.000000	.000000	.000000	630	.073883	2.7
E	.001055	.055388	.012079	.002345	.000704	.000000	.000000	.000000	612	.071772	2.1
ESE	.002463	.034948	.006802	.000704	.000586	.000000	.000000	.000000	388	.045503	1.8
SE	.006333	.062859	.003870	.000586	.000000	.000000	.000000	.000000	628	.073648	1.4
SSE	.002697	.051366	.016301	.006098	.004456	.001994	.000000	.000000	707	.082913	2.7
S	.000586	.019350	.008678	.002111	.001173	.000117	.000000	.000000	273	.032016	2.8
SSW	.000821	.013956	.007857	.003636	.000704	.000000	.000000	.000000	230	.026073	2.9
SW	.001876	.024745	.024628	.013721	.011258	.001876	.000117	.000000	667	.078222	4.2
WSW	.000704	.038935	.029905	.013604	.0111141	.004339	.000117	.000000	842	.098745	4.0
W	.001759	.048200	.017591	.005395	.005395	.002111	.000000	.000000	686	.080450	3.1
WNW	.002932	.047965	.014777	.016418	.019819	.004339	.000000	.000000	906	.106251	4.0
NW	.002580	.031195	.008561	.008326	.012548	.001290	.000000	.000000	550	.064501	3.7
NNW	.000938	.027911	.004222	.004222	.002815	.000000	.000000	.000000	342	.040108	2.5
HRS	272	4943	1768	782	623	137	2	0	8527		
FREQ	.031899	.579688	.207341	.091709	.073062	.016067	.000235	.000000		1.000000	
AVGSPD	.7	1.5	3.8	5.5	7.8	11.7	16.7	.0			3.0

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-13

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS A

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

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Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
NNE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
NE	.000000	.000000	.000000	.000000	.000118	.000118	.000000	.000000	2	.000235	10.6
ENE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
E	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
ESE	.000000	.000000	.000000	.000000	.000118	.000000	.000000	.000000	1	.000118	7.4
SE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
S	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSW	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SW	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
WSW	.000000	.000000	.000118	.000235	.000823	.000706	.000235	.000353	21	.002469	12.0
W	.000000	.000000	.000000	.000118	.000118	.000588	.000470	.000000	11	.001294	12.9
WNW	.000000	.000000	.000000	.000000	.000588	.001999	.000000	.000000	22	.002587	10.7
NW	.000000	.000000	.000000	.000000	.00470	.001294	.000000	.000000	15	.001764	10.6
NNW	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
HRS	0	0	1	3	19	40	6	3	72		
FREQ	.000000	.000000	.000118	.000353	.002234	.004704	.000706	.000353		.008467	
AVGSPD	.0	.0	4.7	6.1	8.7	11.2	18.7	23.0			11.4

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-14

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS B

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000000	.000000	.000118	.000000	.000000	.000000	.000000	1	.000118	5.9
NNE	.000000	.000000	.000118	.000000	.000000	.000000	.000000	.000000	1	.000118	4.7
NE	.000000	.000000	.000000	.000353	.000823	.000470	.000000	.000000	14	.001646	9.1
ENE	.000000	.000000	.000000	.000353	.000235	.000000	.000000	.000000	5	.000588	6.5
E	.000000	.000000	.000118	.000118	.000235	.000000	.000000	.000000	4	.000470	6.3
ESE	.000000	.000000	.000000	.000000	.000118	.000000	.000000	.000000	1	.000118	9.4
SE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	0	.000000	.0
SSE	.000000	.000000	.000000	.000000	.000118	.000118	.000000	.000000	2	.000235	9.3
S	.000000	.000000	.000000	.000000	.000118	.000000	.000000	.000000	1	.000118	7.6
SSW	.000000	.000000	.000245	.000000	.000000	.000000	.000000	.000000	2	.000235	3.3
SW	.000000	.000000	.000000	.000118	.000706	.000000	.000000	.000000	7	.000823	7.4
WSW	.000000	.000000	.000235	.001411	.001764	.001058	.000353	.000470	45	.005292	10.0
W	.000000	.000000	.000000	.000118	.000823	.001058	.000235	.000235	21	.002469	12.6
WNW	.000000	.000000	.000000	.000000	.000588	.001646	.000235	.000000	21	.002469	11.5
NW	.000000	.000000	.000000	.000118	.002117	.001529	.000000	.000000	32	.003763	9.8
NNW	.000000	.000000	.000000	.000118	.000235	.000235	.000000	.000000	5	.000588	8.6
HRS	0	0	6	24	67	52	7	6	162		
FREQ	.000000	.000000	.000706	.002822	.007879	.006115	.000823	.000706		.019050	
AVGSPD	.0	.0	4.1	5.7	8.3	12.0	18.2	22.6			9.9

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

TABLE 2.6-15

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS C

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.000235	.000235	.000118	.000118	.000000	.000000	.000000	6	.000706	4.3
NNE	.000000	.000235	.001294	.000353	.00235	.000353	.000000	.000000	21	.002469	5.2
NE	.000000	.000118	.002234	.002469	.003293	.000470	.000000	.000000	73	.008584	6.2
ENE	.000000	.000118	.000941	.001294	.000706	.000000	.000000	.000000	26	.003057	5.3
E	.000000	.000000	.000353	.000706	.000470	.000000	.000000	.000000	13	.001529	5.9
ESE	.000000	.000000	.000588	.000353	.000118	.000000	.000000	.000000	9	.001058	4.7
SE	.000000	.000000	.000118	.000118	.000118	.000000	.000000	.000000	3	.000353	5.7
SSE	.000000	.000000	.000118	.000470	.000588	.000000	.000118	.000000	11	.001294	7.5
S	.000000	.000000	.000235	.000353	.000235	.000118	.000000	.000000	8	.000941	6.8
SSW	.000000	.000000	.000235	.000353	.000353	.000000	.000000	.000000	8	.000941	5.8
SW	.000000	.000235	.000941	.001646	.001881	.000706	.000118	.000000	47	.005527	7.1
WSW	.000000	.000000	.002587	.002234	.002469	.001529	.000235	.000000	77	.009055	7.3
W	.000000	.000118	.000706	.001058	.000941	.000706	.000118	.000235	33	.003881	8.5
WNW	.000000	.000000	.000235	.000588	.002940	.001646	.000235	.000000	48	.005644	9.0
NW	.000000	.000000	.000118	.000706	.001999	.001294	.000000	.000000	35	.004116	9.0
NNW	.000000	.000000	.000353	.000118	.000823	.000235	.000000	.000000	13	.001529	7.4
HRS	0	9	96	110	147	60	7	2	431		
FREQ	.000000	.001058	.011289	.012935	.017286	.007056	.000823	.000235		.050682	
AVGSPD	.0	2.1	4.0	5.6	7.8	12.0	18.8	22.7			7.1

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-16

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR
STABILITY CLASS D
CRBRP PERMANENT TOWER, 200-FOOT LEVEL
FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

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Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.002469	.001176	.000588	.001058	.000000	.000000	.000000	45	.005292	4.1
NNE	.000000	.004821	.004468	.001294	.000941	.000118	.000000	.000000	99	.011642	3.6
NE	.000000	.008819	.016228	.007291	.009290	.001529	.000000	.000000	367	.043156	5.0
ENE	.000000	.007173	.010936	.009525	.007173	.000470	.000000	.000000	300	.035278	4.9
E	.000000	.008937	.006115	.001881	.001058	.000118	.000000	.000000	154	.018109	3.5
ESE	.000000	.002587	.006468	.001411	.000235	.000000	.000000	.000000	91	.010701	3.7
SE	.000000	.001646	.002352	.000353	.000118	.000000	.000000	.000000	38	.004468	3.5
SSE	.000000	.003057	.004821	.002469	.001294	.000470	.000353	.000000	106	.012465	5.1
S	.000000	.001646	.005174	.005056	.005762	.002822	.000353	.000235	179	.021049	6.9
SSW	.000000	.002822	.005409	.004116	.002822	.000823	.000000	.000000	136	.015992	5.1
SW	.000000	.003881	.012582	.010583	.013993	.003881	.000470	.000000	386	.045390	6.4
WSW	.000000	.005762	.015287	.008114	.008349	.006115	.001999	.000823	395	.046449	6.9
W	.000000	.005527	.007879	.002940	.003293	.006585	.001058	.000823	239	.028104	7.3
WNW	.000000	.002822	.003175	.003645	.011524	.010230	.001999	.000000	284	.033396	8.8
NW	.000000	.002940	.004116	.001999	.006938	.004468	.000823	.000000	181	.021284	7.5
NNW	.000000	.002117	.001646	.001764	.002705	.000235	.000000	.000000	72	.008467	5.3
HRS	0	570	917	536	651	322	60	16	3072		
FREQ	.000000	.067027	.107832	.063029	.076552	.037865	.007056	.001881		.361242	
AVGSPD	.0	2.2	3.9	5.6	8.0	12.3	17.8	23.4			6.0

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-17

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS E

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

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Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000000	.004233	.001646	.000588	.001294	.000235	.000000	.000000	68	.007996	3.9
NNE	.000118	.007879	.002117	.001294	.000588	.000000	.000000	.000000	102	.011994	2.9
NE	.000000	.008114	.006232	.003410	.006468	.000941	.000000	.000000	214	.025165	4.7
ENE	.000118	.009643	.005997	.005527	.005292	.000118	.000000	.000000	227	.026693	4.4
E	.000118	.013523	.005409	.001176	.000706	.000235	.000000	.000000	180	.021167	3.0
ESE	.000118	.006232	.002587	.001058	.000706	.000353	.000000	.000000	94	.011054	3.4
SE	.000000	.002822	.001881	.000118	.000118	.000118	.000000	.000000	43	.005056	3.0
SSE	.000000	.002469	.000823	.000706	.000706	.000353	.000118	.000000	44	.005174	4.7
S	.000000	.003998	.002469	.002469	.003175	.001881	.000706	.000000	125	.014699	6.2
SSW	.000000	.003410	.003528	.002940	.001058	.001411	.000000	.000000	105	.012347	5.0
SW	.000000	.004704	.006232	.004821	.004939	.002940	.000118	.000000	202	.023754	5.8
WSW	.000000	.008467	.009878	.005056	.006115	.002940	.000353	.000000	279	.032808	5.3
W	.000000	.008231	.005409	.004351	.005997	.001764	.000118	.000235	222	.026105	5.2
WNW	.000000	.004821	.002705	.001999	.005880	.001999	.000470	.000000	152	.017874	6.2
NW	.000000	.005527	.002234	.002469	.003881	.001411	.000118	.000000	133	.015640	5.4
NNW	.000000	.004468	.001176	.000353	.000706	.000235	.000000	.000000	59	.006938	3.2
HRS	4	838	513	326	405	144	17	2	2249		
FREQ	.000470	.098542	.060325	.038335	.047625	.016933	.001999	.000235		.264464	
AVGSPD	.7	2.0	3.9	5.6	7.9	11.9	17.4	23.5			4.8

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-18

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS F

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

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Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000118	.004351	.000470	.000470	.000235	.000118	.000000	.000000	49	.005762	2.5
NNE	.000118	.006468	.000706	.000000	.000118	.000000	.000000	.000000	63	.007408	2.0
NE	.000000	.008819	.002352	.001411	.000235	.000118	.000000	.000000	110	.012935	2.8
ENE	.000235	.007291	.003645	.001764	.001058	.000118	.000000	.000000	120	.014111	3.4
E	.000000	.011054	.001881	.000706	.000118	.000000	.000000	.000000	117	.013758	2.3
ESE	.000000	.006585	.000235	.000000	.000000	.000000	.000000	.000000	58	.006820	1.9
SE	.000000	.006115	.000235	.000118	.000000	.000000	.000000	.000000	55	.006468	1.7
SSE	.000235	.006938	.000706	.000235	.000000	.000000	.000000	.000000	69	.008114	1.9
S	.000353	.007173	.001056	.000235	.000353	.000000	.000000	.000000	78	.009172	2.3
SSW	.000000	.003881	.001999	.000470	.000706	.000000	.000000	.000000	60	.007056	3.3
SW	.000118	.003645	.001881	.001176	.000823	.000000	.000000	.000000	65	.007643	3.4
WSW	.000353	.010230	.005174	.001999	.001764	.000000	.000000	.000000	166	.019520	3.2
W	.000000	.009525	.002469	.001176	.000706	.000000	.000000	.000000	118	.0138766	2.8
WNW	.000000	.006468	.000941	.000118	.000823	.000000	.000000	.000000	71	.008349	2.7
NW	.000118	.006115	.001294	.000706	.000235	.000000	.000000	.000000	72	.008467	2.7
NNW	.000000	.002822	.000353	.000118	.000235	.000000	.000000	.000000	30	.003528	2.2
HRS	14	914	216	91	63	3	0	0	1301		
FREQ	.001646	.107479	.025400	.010701	.007408	.000353	.000000	.000000		.152987	
AVGSPD	.7	1.8	3.8	5.5	7.6	11.2	.0	.0			2.7

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-19

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS G

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Wind Direction	Wind Speed (Knots*) .0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000118	.001999	.000000	.000000	.000000	.000000	.000000	.000000	18	.002117	1.4
NNE	.000353	.005762	.000823	.000000	.000000	.000000	.000000	.000000	59	.006938	2.1
NE	.000470	.009995	.002234	.001176	.000823	.000118	.000000	.000000	126	.014817	2.6
ENE	.000470	.005997	.002940	.002822	.000706	.000118	.000000	.000000	111	.013053	3.4
E	.000235	.010583	.002117	.000823	.000118	.000000	.000000	.000000	118	.013876	2.3
ESE	.000118	.004704	.000470	.000000	.000118	.000000	.000000	.000000	46	.005409	2.0
SE	.000000	.003410	.000235	.000000	.000118	.000000	.000000	.000000	32	.003763	2.0
SSE	.000118	.004233	.000235	.000000	.000118	.000000	.000000	.000000	40	.004704	2.0
S	.000235	.005527	.001176	.000118	.000353	.000000	.000000	.000000	63	.007408	2.6
SSW	.000000	.004116	.003293	.001529	.000470	.000000	.000000	.000000	80	.009407	3.5
SW	.000000	.003410	.003057	.001764	.001294	.000000	.000000	.000000	81	.009525	3.9
WSW	.000118	.011289	.005997	.003410	.001764	.000000	.000000	.000000	192	.022578	3.4
W	.000118	.008114	.003645	.001646	.001176	.000118	.000000	.000000	126	.014817	3.3
WNW	.000118	.004116	.001529	.000823	.000118	.000000	.000000	.000000	57	.006703	2.8
NW	.000118	.004116	.000823	.000235	.000118	.000000	.000000	.000000	46	.005409	2.3
NNW	.000000	.001881	.000588	.000118	.000000	.000000	.000000	.000000	22	.002587	2.5
HRS	22	759	248	123	62	3	0	0	1217		
FREQ	.002587	.089252	.029163	.014464	.00729:	.000353	.000000	.000000		.143109	
AVGSPD	.7	1.8	3.8	5.5	7.6	11.2	.0	.0			2.9

* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7
The .7 knots is the stall threshold speed of the wind direction sensor.

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TABLE 2.6-20

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

ALL STABILITY CLASSES

CRBRP PERMANENT TOWER, 200-FOOT LEVEL

FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978 11 13

Wind Speed (Knots*)

Wind Direction	.0-.7	.8-3.0	3.1-4.8	4.9-6.5	6.6-10.0	10.1-16.1	16.2-21.1	21.2-99.9	HRS	FREQ	AVGSPD
N	.000235	.013288	.003528	.001881	.002705	.000353	.000000	.000000	187	.021990	3.4
NNE	.000588	.025165	.009525	.002940	.001881	.000470	.000000	.000000	345	.040569	2.9
NE	.000470	.035865	.029280	.016110	.021049	.003763	.000000	.000000	906	.106538	4.5
ENE	.000823	.030221	.024459	.021284	.015169	.000823	.000000	.000000	789	.092780	4.3
E	.000353	.044097	.015992	.005409	.002705	.000353	.000000	.000000	586	.068909	2.9
ESE	.000235	.020108	.010348	.002822	.001411	.000353	.000000	.000000	300	.035278	3.1
SE	.000000	.013993	.004821	.000706	.000470	.000118	.000000	.000000	171	.020108	2.6
SSE	.000353	.016698	.006703	.003881	.002822	.000941	.000588	.000000	272	.031985	3.9
S	.000588	.018344	.010113	.008231	.009995	.004821	.001058	.000235	454	.053387	5.3
SSW	.000000	.014229	.014699	.009407	.005409	.002234	.000000	.000000	391	.045978	4.5
SW	.000118	.015875	.024694	.020108	.023636	.007526	.000706	.000000	788	.092662	5.8
WSW	.000470	.035748	.039276	.022460	.023048	.012347	.003175	.001646	1175	.138170	5.6
W	.000118	.031515	.020108	.011406	.013053	.010818	.001999	.001529	770	.090546	5.6
WNW	.000118	.018227	.008584	.007173	.022460	.017521	.002940	.000000	655	.077023	7.2
NW	.000235	.018697	.008584	.006232	.015757	.009995	.000941	.000000	514	.060442	6.1
NNW	.000000	.011289	.004116	.002587	.004704	.000941	.000000	.000000	201	.023636	4.1
HRS	40	3090	1997	1213	1414	624	97	29	8504		
FREQ	.004704	.363358	.234831	.142639	.166275	.073377	.011406	.003410		1.000000	
AVGSPD	.7	1.9	3.9	5.6	8.0	12.1	17.9	23.2			4.9

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* 1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Note: The frequencies of calms winds are given in the first wind speed column, 0.0-0.7 The .7 knots is the stall threshold speed of the wind direction sensor. 11 13

TABLE 2.6-29 11

FIFTIETH PERCENTILE χ /Q VALUES FOR VARIOUS DOWNWIND DISTANCES
33-FT WIND SPEED AND DIRECTION: 200-FT TO 33-FT DELTA T 11
DATA FROM FEBRUARY 17, 1977 THROUGH FEBRUARY 16, 1978

Distance (miles)	50th Percentile χ/Q Values (sec/m^3) 2-hr	8-hr	16-hr	72-hr	624-hr	
0.1	1.02E-2	1.50E-3	1.60E-3	9.72E-4	1.16E-3	
0.2	3.07E-3	4.53E-4	4.61E-4	2.82E-4	3.35E-4	
0.3	1.53E-3	2.45E-4	2.21E-4	1.37E-4	1.62E-4	
0.34	1.22E-3	1.94E-4	1.75E-4	1.08E-4	1.28E-4	
0.42	1.01E-3	1.55E-4	1.23E-4	7.69E-5	9.06E-5	
0.5	8.25E-4	1.27E-4	9.28E-5	5.78E-5	6.76E-5	
0.6	7.16E-4	1.07E-4	6.91E-5	4.30E-5	5.02E-5	
0.7	6.19E-4	9.29E-5	5.43E-5	3.36E-5	3.93E-5	
1.0	4.29E-4	6.51E-5	2.70E-5	1.67E-5	1.93E-5	
1.5	2.81E-4	4.30E-5	1.07E-5	6.69E-6	7.73E-6	
2.0	2.08E-4	3.03E-5	5.61E-6	3.50E-6	4.06E-6	9
2.5	1.59E-4	2.30E-5	3.58E-6	2.29E-6	2.60E-6	
3.0	1.26E-4	1.83E-5	2.58E-6	1.60E-6	1.85E-6	
3.5	1.03E-4	1.49E-5	1.96E-6	1.19E-6	1.40E-6	
4.0	8.69E-5	1.24E-5	1.55E-6	9.35E-7	1.11E-6	
4.5	7.49E-5	1.09E-5	1.26E-6	7.66E-7	9.06E-7	
5.0	6.58E-5	9.46E-6	1.06E-6	6.42E-7	7.64E-7	
7.0	4.21E-5	6.04E-6	5.87E-7	3.66E-7	4.32E-7	
7.5	3.90E-5	5.57E-6	5.28E-7	3.30E-7	3.88E-7	
9.0	3.07E-5	4.44E-6	4.27E-7	2.65E-7	3.10E-7	
10.0	2.73E-5	3.99E-6	3.77E-7	2.31E-7	2.72E-7	
15.0	1.70E-5	2.46E-6	2.28E-7	1.36E-7	1.63E-7	
20.0	1.21E-5	1.76E-6	1.56E-7	9.47E-8	1.14E-7	
21.0	1.14E-5	1.66E-6	1.47E-7	8.91E-8	1.07E-7	
25.0	9.26E-6	1.34E-6	1.17E-7	7.22E-8	8.67E-8	
35.0	6.43E-6	9.33E-7	7.98E-8	4.89E-8	5.82E-8	
45.0	4.88E-6	7.60E-7	5.89E-8	3.71E-8	4.37E-8	
50.0	4.32E-6	6.25E-7	5.16E-8	3.29E-8	3.90E-8	

TABLE 2.6-30

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ANNUAL AVERAGE χ/Q's (In Sec/m^3) AT VARIOUS DOWNWIND DISTANCES FOR EACH WIND SECTOR BASED ON PERMANENT TOWER DATA

FEBRUARY 17, 1977 - FEBRUARY 16, 1978

(33-Foot Wind and 200-Foot to 33-Foot Delta T)

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Annual Average Value (sec/m^3)*
Wind Direction**

Downwind Distance (Miles)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.1	2.95E-4	3.40E-4	4.20E-4	6.23E-4	8.05E-4	5.50E-4	1.29E-3	9.29E-4	2.51E-4	2.21E-4	3.91E-4	5.13E-4	6.57E-4	7.58E-4	4.88E-4	3.69E-4
0.2	8.44E-5	9.78E-5	1.21E-4	1.60E-4	2.32E-4	1.91E-4	3.74E-4	2.68E-4	7.22E-5	6.38E-5	1.12E-4	1.47E-4	1.89E-4	2.18E-4	1.40E-4	1.06E-4
0.3	4.18E-5	4.84E-5	5.99E-5	8.88E-5	1.15E-4	9.34E-5	1.83E-4	1.32E-4	3.58E-5	3.15E-5	5.61E-5	7.34E-5	9.31E-5	1.07E-4	6.89E-5	5.21E-5
0.34	3.35E-5	3.86E-5	4.78E-5	7.08E-5	9.08E-5	7.39E-5	1.44E-4	1.04E-4	2.85E-5	2.51E-5	4.50E-5	5.88E-5	7.40E-5	8.55E-5	5.49E-5	4.16E-5
0.42	2.43E-5	2.77E-5	3.42E-5	5.06E-5	6.47E-5	5.24E-5	1.02E-4	7.41E-5	2.05E-5	1.79E-5	3.25E-5	4.25E-5	5.30E-5	6.12E-5	3.95E-5	2.99E-5
0.5	1.86E-5	2.10E-5	2.59E-5	3.81E-5	4.88E-5	3.92E-5	7.59E-5	5.57E-5	1.56E-5	1.35E-5	2.47E-5	3.24E-5	4.03E-5	4.63E-5	2.99E-5	2.27E-5
0.6	1.41E-5	1.58E-5	1.94E-5	2.85E-5	3.64E-5	2.92E-5	5.62E-5	4.14E-5	1.18E-5	1.01E-5	1.86E-5	2.44E-5	3.02E-5	3.47E-5	2.25E-5	1.71E-5
0.7	1.12E-5	1.25E-5	1.53E-5	2.24E-5	2.86E-5	2.89E-5	4.39E-5	3.245E-5	9.28E-5	7.92E-5	1.47E-5	1.93E-5	2.39E-5	2.74E-5	1.79E-5	1.36E-5
1.0	5.49E-5	6.03E-6	7.41E-6	1.08E-5	1.37E-5	1.10E-6	2.11E-6	1.56E-5	4.46E-5	3.80E-5	7.04E-6	9.31E-6	1.16E-5	1.33E-5	8.79E-6	6.65E-6
1.5	2.32E-6	2.45E-6	2.97E-6	4.24E-6	5.39E-6	4.33E-6	8.20E-6	6.19E-6	1.81E-6	1.49E-6	2.81E-6	3.77E-6	4.73E-6	5.37E-6	3.66E-6	2.76E-6
2.0	1.13E-6	1.24E-6	1.52E-6	2.22E-6	2.81E-6	2.30E-6	4.41E-6	3.23E-6	9.07E-7	7.77E-7	1.42E-6	1.89E-6	2.39E-6	2.74E-6	1.84E-6	1.38E-6
2.5	7.07E-7	7.77E-7	9.56E-7	1.39E-6	1.78E-6	1.46E-6	2.82E-6	2.05E-6	5.70E-7	5.89E-7	8.82E-7	1.18E-6	1.51E-6	1.73E-6	1.16E-6	8.70E-7
3.0	4.97E-7	5.52E-7	6.80E-7	9.96E-7	1.27E-6	1.05E-6	2.03E-6	1.47E-6	4.06E-7	3.50E-7	6.27E-7	8.36E-7	1.07E-6	1.23E-6	8.18E-7	6.15E-7
3.5	3.70E-7	4.13E-7	5.09E-7	7.47E-7	9.56E-7	7.89E-7	1.53E-6	1.11E-6	3.04E-7	2.62E-7	4.67E-7	6.23E-7	8.04E-7	9.21E-7	6.12E-7	4.60E-7
4.0	2.91E-7	3.26E-7	4.02E-7	5.91E-7	7.39E-7	6.27E-7	1.22E-6	8.79E-7	2.40E-7	3.68E-7	3.68E-7	4.90E-7	6.35E-7	7.28E-7	4.82E-7	3.62E-7
4.5	2.36E-7	2.65E-7	3.26E-7	4.80E-7	6.18E-7	5.11E-7	9.97E-7	7.16E-7	1.95E-7	1.69E-7	2.97E-7	3.97E-7	5.17E-7	5.92E-7	3.92E-7	2.94E-7
5.0	1.97E-7	2.22E-7	2.73E-7	4.03E-7	5.20E-7	4.31E-7	8.42E-7	6.03E-7	1.63E-7	1.42E-7	2.49E-7	3.32E-7	4.34E-7	4.97E-7	3.28E-7	2.46E-7
7.0	1.08E-7	1.23E-7	1.52E-7	2.25E-7	2.93E-7	2.43E-7	4.79E-7	3.40E-7	9.10E-8	7.95E-8	1.37E-7	1.83E-7	2.42E-7	2.77E-7	1.82E-7	1.36E-7
7.5	9.66E-8	1.11E-7	13.7E-7	2.03E-7	2.63E-7	2.19E-7	4.32E-7	3.07E-7	8.18E-8	7.15E-8	1.23E-7	1.64E-7	2.17E-7	2.49E-7	1.63E-7	1.22E-7
9.0	7.59E-8	8.76E-8	1.08E-7	1.61E-7	2.10E-7	1.75E-7	3.46E-7	2.45E-7	6.48E-8	5.68E-8	9.67E-8	1.29E-7	1.72E-7	1.98E-7	1.29E-7	9.67E-8
10.0	6.60E-8	7.64E-8	9.42E-7	1.40E-7	1.84E-7	1.53E-7	3.04E-7	2.14E-7	5.65E-7	4.97E-8	8.41E-8	1.12E-7	1.50E-7	1.72E-7	1.12E-7	8.45E-8
15.0	3.81E-8	4.47E-8	5.53E-8	8.27E-8	1.09E-7	9.14E-8	1.82E-7	1.27E-7	3.31E-8	2.93E-8	4.88E-8	6.52E-8	8.83E-8	1.01E-7	6.54-8	4.92E-8
20.0	2.61E-8	3.10E-8	3.83E-8	5.75E-8	7.61E-8	6.40E-8	1.28E-7	8.92-8	2.30E-8	2.04E-8	3.37E-8	4.49E-8	6.14E-8	7.04E-8	4.52E-8	3.40E-8
21.0	2.45E-8	2.91E-8	3.59E-8	5.40E-8	7.15E-8	5.02E-8	1.20E-7	8.38E-8	2.16E-8	1.92E-8	3.15E-8	4.21E-8	5.76E-8	6.61E-8	4.25E-8	3.19E-8
25.0	1.95E-8	2.33E-8	2.88E-8	4.34E-8	5.76E-8	4.85E-8	9.74-8	6.76E-8	1.73E-8	1.54E-8	2.5[illegible]E-8	3.37E-8	4.63E-8	5.31E-8	3.40E-8	2.56E-8
35.0	1.27E-8	1.54E-8	1.90E-8	2.88E-8	3.86E-8	3.25E-8	6.57E-8	1.54E-8	1.15E-8	1.03E-8	1.66E-8	2.21E-8	3.06E-8	3.52E-8	2.22E-8	1.68E-8
45.0	9.31E-9	1.14E-8	1.41E-8	2.14E-8	2.89E-8	2.43E-8	4.93E8	.39E-8	8.54E-9	7.67E-9	1.22E-8	1.63E-8	2.28E-8	2.61E-8	1.64E-8	1.24E-8
50.0	8.23E-9	1.02E-8	1.25E-8	1.91E-8	2.58E-8	2.17E-8	4.41E-8	.03E-8	7.61E-9	6.84E-9	1.08E-8	1.44E-8	2.02E-8	2.32E-8	1.45E 9	1.10E-8

* Computed according to R.G. 1.111
** Direction from which wind is blowing

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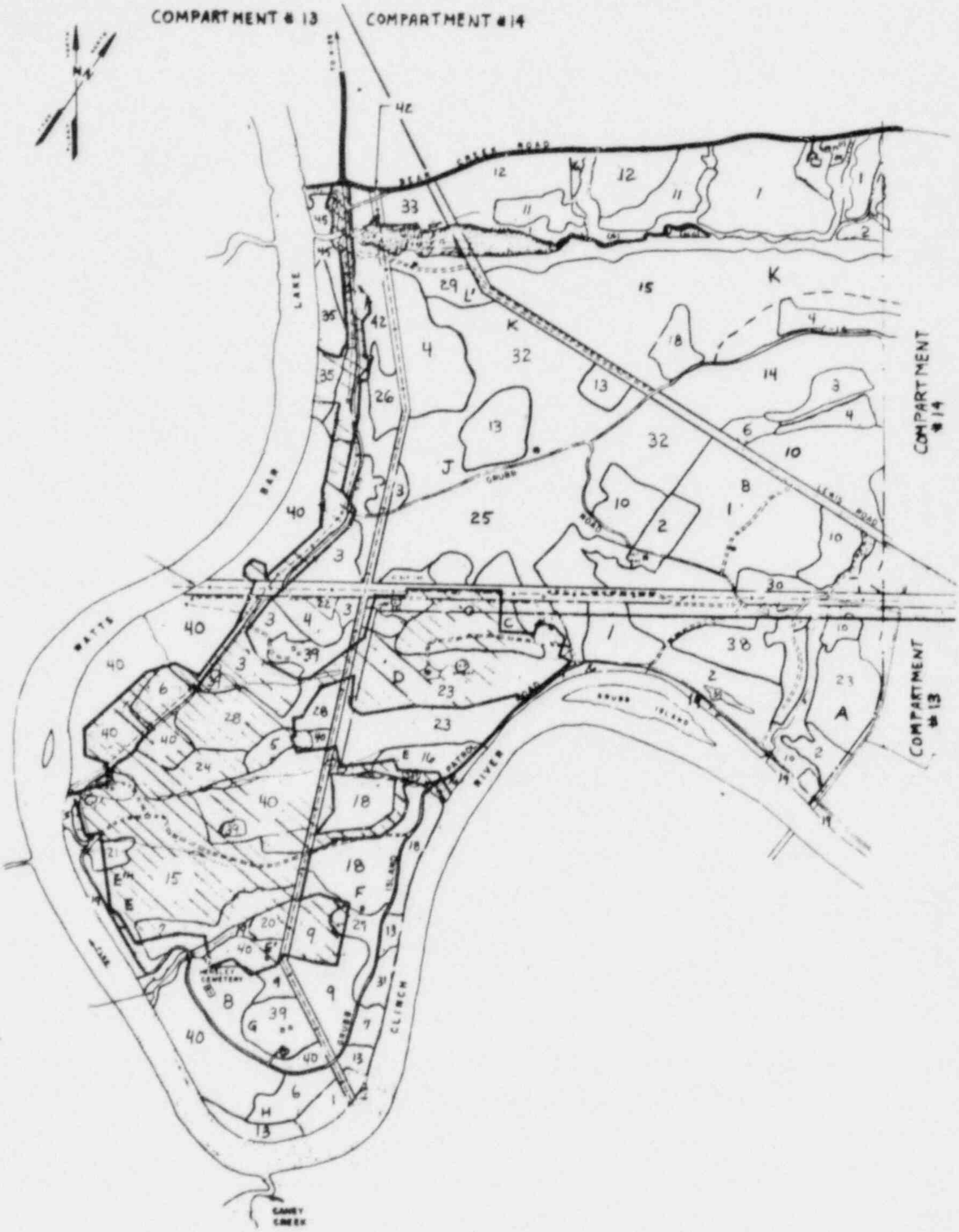

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Figure 2.7-6. SITE STUDY AREAS AND OVERSTORY VEGATATION (Legend on Pages 2.7-507, 2.7-508 and 2.7-509. Alphabetic letters designate study areas.)

LEGEND FOR FIGURE 2.7-6

Compartment No. 13 13

Stratum No.	Forest Cover Type	Acreage TVA
1	Loblolly pine plantation, 1951	63
2	White pine plantation, 1951	32
3	White pine plantation, 1952	32
4	Virginia pine plantation, 1952	24
5	Virginia white pine plantation, 1952	4
6	Shortleaf Virginia pine plantation, 1952	13
7	Loblolly pine plantation, 1954	13
8	Virginia pine plantation, 1954	11
9	Virginia shortleaf pine plantation, 1954	23
10	Loblolly pine plantation, 1979	55
11	Hybrid poplar, cottonwood plantation, 1979	1
12	Cottonwood plantation, 1979	3
13	Natural pine	31
14	Shortleaf pine, white pine	3
15	Cedar	48
16	Cedar, natural pine	28
17	Cedar, red oak, white oak	0
18	Cedar, white oak, red oak	40
19	Cedar, ash, hackberry	13
20	Red oak, shortleaf pine	3
21	Red oak, cedar, poplar	3
22	Red oak, white oak	1
23	Red oak, white oak, poplar	66
24	Southern red oak, white oak, cedar	11
25	Red oak, hickory, poplar	49
26	Red oak, poplar	32
27	Southern red oak, poplar, shortleaf pine	6
28	White oak, red oak, poplar	20

13

LEGEND FOR FIGURE 2.7-6
(Continued)

Compartment No. 13 | 13

Stratum No.	Forest Cover Type	Acreage TVA
29	White oak, beech	8
30	Hickory, red oak	4
31	Poplar, red oak	6
32	Poplar, red oak, hickory, white oak, cottonwood	76
33	Sweetgum, Virginia pine, sycamore	10
34	Sweetgum, maple	3
35	Elm, boxelder, ash	9
36	Elm, maple	2
37	Ash, sycamore	6
38	Chinkapin oak, ash, red oak	12
39	Non Forested	23
40	Clearcut, cutover	126
41	Cemeteries, Homesites, Indian Mound	1
42	Powerline, Gasline, Right-of-way	55
43	Roads	28
44	Quarry	1
45	Inundated Land	14
46	Rivers, Streams and creeks	37
47	Beetle Kill	0
	TOTALS	1049

13

LEGEND FOR FIGURE 2.7-6
(Continued)

Compartment No. 14 13

Stratum No.	Forest Cover Type	Acreage TVA
1	Loblolly plantation, 1948	39
2	Loblolly plantation, 1949	3
3	Loblolly plantation, 1951	7
4	White pine plantation, 1952	12
5	Loblolly plantation, 1978	0
6	Loblolly plantation, 1979	4
7	White pine, 1979	0
8	Walnut plantation, 1979	2
9	Cottonwood, plantation, 1979	0
10	Cottonwood sycamore, 1979	30
11	Natural pine, shortleaf pine, Virginia pine	16
12	Sweetgum, Virginia pine, shortleaf pine	25
13	Shortleaf pine, Virginia pine, cedar	2
14	Southern red oak, poplar, cottonwood	37
15	Cottonwood, red oak, poplar	57
16	Ash, sweetgum, elm	34
17	Sludge Plot (cottonwood, sycamore)	1
18	Clear cut	6
19	Roads	14
20	Powerlines, Gasline, Right-of-way	17
21	Non-Forested Land	0
22	Buildings	4
23	Inundated	5
	TOTALS	315

13

gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective MPC value and calculation of the percent of MPC for a known mixture of radionuclides is performed as specified in 10 CFR 20, Appendix B.

Data on the concentrations of radionuclides measured in the Clinch River for 1979 are given in Table 2.8-13. Data on the concentrations of uranium in surface streams and the quantities of radioactivity released to surface streams are given in Tables 2.8-14 and 2.8-15.

Analysis of water supplies collected at the juncture of White Oak Creek and the Clinch River indicated that the yearly average concentration of radionuclides was approximately 16 percent of the applicable MPC for uncontrolled areas. The calculated average concentration of radionuclides in the Clinch River, based on the analysis of water samples collected at White Oak Dam (Station W-1) and the dilution afforded by the river, was determined to be 0.2 percent of the applicable concentration guide for uncontrolled areas assuming complete mixing. The average dilution factor for 1979, based on the flow of White Oak Creek and the Clinch River, was 511. The measured average concentrations of radionuclides in the Clinch River upstream and downstream of White Oak Creek outfall were less than 0.25 percent of the applicable MPC. 9

The calculated average concentration of transuranic alpha emitters in the Clinch River resulting from effluent releases was 4×10^{-12} uCi/ml, which is less than 0.01 percent of the MPC for water containing a known mixture of radionuclides.

Trends in water discharges and calculated percent MPC levels in the Clinch River are presented in Figures 2.8-9 and 2.8-10. Discharges of ^{90}Sr and ^{3}H are shown in Figure 2.8-9 as these nuclides contribute the majority of the radiological dose downstream. These graphs and a comparison of Table 2.8-9 with Table 2.8-13 indicate a decline in radioactivity released to the Clinch River by Oak Ridge facilities.

Several species of fish which are commonly taken by fishermen from the Clinch River and sampled each year for radionuclides. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man. | 13

Data on the 1979 concentrations of radionuclides in Clinch River fish are given in Table 2.8-16. Consumption of 16.8 kilograms of bluegill per year[33] taken from the river near White Oak Creek outfall would result in approximately 2 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing one MPC of the radionuclides in question. 9

A comparison of the data in Table 2.8-16 with that in Table 2.8-11, which comprises the Sr and Cs data for 1971 and 1972, shows two facts: (1) the quantity of ^{90}Sr in fish flesh is reduced on the average by a factor of three, correlating with the factor of three reduction in Curies discharged as seen in Figure 2.8-9; and (2) the large variation in concentration as reported above from Jinks and Eisenbud's work[32] is confirmed. One variant indicated is fish species.

A resurvey of radioactivity in Clinch River sediment by ORNL's Division of Health, Safety and Environmental Affairs has been completed and is expected to be reported in early 1981.[34] Data showing ranges of fission product activity found in bottom sediments of the Clinch, Emory and Tennessee Rivers within the area of interest are provided in Figures 2.8-11 and 2.8-12. Similar data for ranges of transuranic activities are presently being prepared and will be supplied in a following amendment.

After 1963, ^{131}I was not routinely reported since levels at the majority of the network status were below the practical reporting level of 10 uCi/l.[45]

It is useful to see data from results of routine sampling by the Oak Ridge Environmental Monitoring Program for the years 1971 and 1972,[2,3] where the average ^{90}Sr and ^{137}Cs in U.S. milk had decreased to 10 pCi/liter for both radionuclides. (See Table 2.8-27 showing the average concentration for all EPA-PMN samples taken for fiscal 1972.)[46]

The data for 1972 can be examined to discriminate local and non-local releases. Tables 2.8-28 and 2.8-29 show data for each sample collected in the immediate environs during 1972. Table 2.8-30 shows data for each sample collected in the remote environs. Table 2.8-31 gives the overall average for each of the set of tables of the Oak Ridge stations. Looking at ^{90}Sr for 1972, we see that the value of 10.9 $\pm$ 0.30 pCi/liter is tabulated for the remote stations. It would appear that Oak Ridge facilities contaminated the immediate environs to an average amount of 2.3 $\pm$ 0.35 pCi ^{90}Sr/liter. The potential low doses resulting from these low concentrations are discussed below. 9

Well established atmospheric diffusion principles[47,48,49] confirm that the contour patterns of Figures 2.8-19 and 2.8-20 are normal for long distance pollution transport. The magnitude of variance is determined by local weather conditions. The ^{90}Sr concentrations observed at selected EPA-PMN stations within 100 miles of Oak Ridge (Table 2.8-32) do not differ significantly from the average-value data in Table 2.8-31 for the remote and immediate environs stations. Therefore, it can be concluded that worldwide fallout contributed about 80 percent of the contamination to the grass-cow-milk-human pathway of the immediate Oak Ridge facilities environment, while Oak Ridge contributed about 20 percent for the years 1971 and 1972.

Similarly, information from such data can be used to determine the source of radioiodine, whether locally released or not. Radioiodine was detected during the third week of 1972 in one remote sampling station (Table 2.8-30, Watts Bar station). It is noted that no radioiodine was detected in any immediate environs station, thereby lending strong evidence that no Oak Ridge facility was the source. In addition, the EPA-RAN reported the few U.S. stations for that January which had detectable radioiodine (Table 2.8-33), one of which was a Tennessee station.[53] EPA-RAN reported that the worldwide source was from a foreign detonation.[54] 13

Although the EPA no longer publishes fallout data, reports of the ongoing sampling program are available.[7]

The CRBRP monitoring program will be able to measure and evaluate contamination in the environs. TVA plans to have both immediate and remote environs sampling, as seen in Section 6, and thus shall be able to distinguish between contamination from its own facility and that from other facilities or from world-wide fallout. 9

2.8.4.2.2 PRESENT MONITORING PROGRAM FOR MILK

The Department of Energy's Environmental Monitoring Program[1] for the Oak Ridge facilities monitors raw milk for ^{131}I and ^{90}Sr by the collection and analysis of samples from 14 sampling stations located within a radius of 50 miles (80 kilometers) of Oak Ridge. Samples are normally collected weekly at each of eight stations located near the Oak Ridge area. Six stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 2.8-21 and 2.8-22. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to concentration limits and dose guides specified by the Federal Government.

TABLE 2.8-12 9

CONCENTRATION FACTORS FOR CLINCH RIVER FISH

$$CF^* = \frac{C_o}{C_w} \text{ Wet Weight Basis}$$

	1971		1972	
	Sr-90	Cs-137	Sr-90	Cs-137
White Crappie	142	570	67	617
Smallmouth Buffalo	114	561	NA	NA
Carp	NA	NA	38	143

*CF = Concentration Factor

C_o = Concentration of radioisotope in the organism

C_w = Concentration of radioisotope in the ambient water

NA = Not available

TABLE 2.8-13

RADIONUCLIDES IN THE CLINCH RIVER WATER
1979(1)

Location	Number of Samples	Range	Concentration of Radionuclides of Primary Concern Units of 10^{-9} µCi/ml ^{90}Sr	^{137}Cs	^{106}Ru	^{60}Co	^{3}H	% MPC*
C-2, CRM 23.1	4	Max.	0.16	0.02	0.09	0.01	720	
		Min.	0.05	0.01	0.02	0.01	590	
		Avg.	0.10±0.06	0.01±0.01	0.05±0.03	0.01	650±80	0.06
C-3, CRM 14.5	4	Max.	0.68	0.05	0.14	0.11	2,200	
		Min.	0.16	0.01	0.03	0.01	1,000	
		Avg.	0.40±0.31	0.02±0.02	0.08±0.05	0.05±0.05	1,400±700	0.15
C-5, CRM 4.5	4	Max.	0.37	0.05	0.23	0.05	1,800	
		Min.	0.14	0.01	0.02	0.02	1,400	
		Avg.	0.33±0.21	0.03±0.02	0.11±0.09	0.04±0.01	1,600±200	0.21

9

* Most restrictive MPC for each isotope used for calculating percent MPC. The method for calculating percent of MPC for a known mixture of radionuclides is given in NRC 10 CFR 20 Appendix B. 13

Evaporation and drift from the main mechanical draft wet-cooling tower will be released 55 feet above grade or at elevation 870 feet MSL. Release point for the emergency towers will be 40 feet above grade or at elevation 855 feet MSL. Locations and dimensions of liquid release points are described in Section 3.4. 9

Design release points for gaseous radiological effluents will be through the following exhausts:

1. Intermediate Bay (IB) H&V Exhaust, elevation 857 feet MSL;

2. Three Reactor Service Building (RSB) H&V Exhausts: two at elevation 884 feet MSL from the Service Area, and one at elevation 884 feet MSL, from the Radwaste Area; 13

3. Six Steam Generator Building (SGB) H&V Exhausts (one main for each SG cell at elevation 886 feet MSL, and one other exhaust for each SG cell at 874 feet MSL).

4. One Reactor Containment Building annulus H&V exhaust at elevation 987 feet MSL.

5. Twelve Turbine Generator Building (TGB) H&V Exhausts, one at elevation 878 feet MSL, three at elevation 862 feet MSL, five at elevation 910 feet 6 inches MSL, and three at elevation 921 feet MSL. 9

6. One Plant Service Building (PSB) H&V Exhaust, elevation 830 feet MSL.

7. Eight additional release points are provided at the top of the Reactor Containment Building, elevation 991 feet MSL, for events which are beyond the design basis.

The above-mentioned nuclear island and balance of plant design gaseous radiological effluent release points are described in Sections 3.5.2.5 and 3.5.2.7, respectively. 8

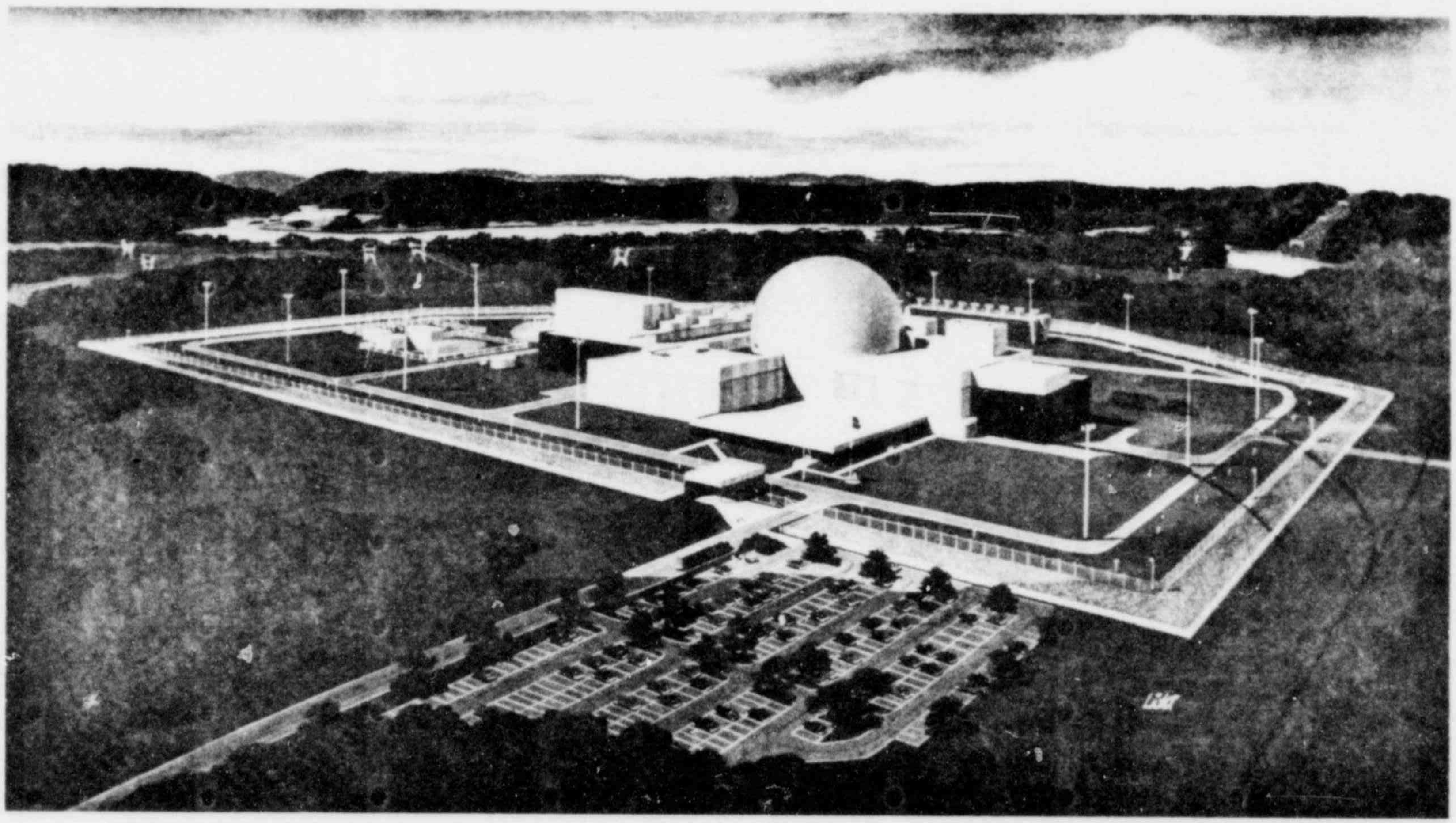


Figure 3.1-1 A CONCEPTUAL ARCHITECTURAL RENDERING OF THE CRPRP

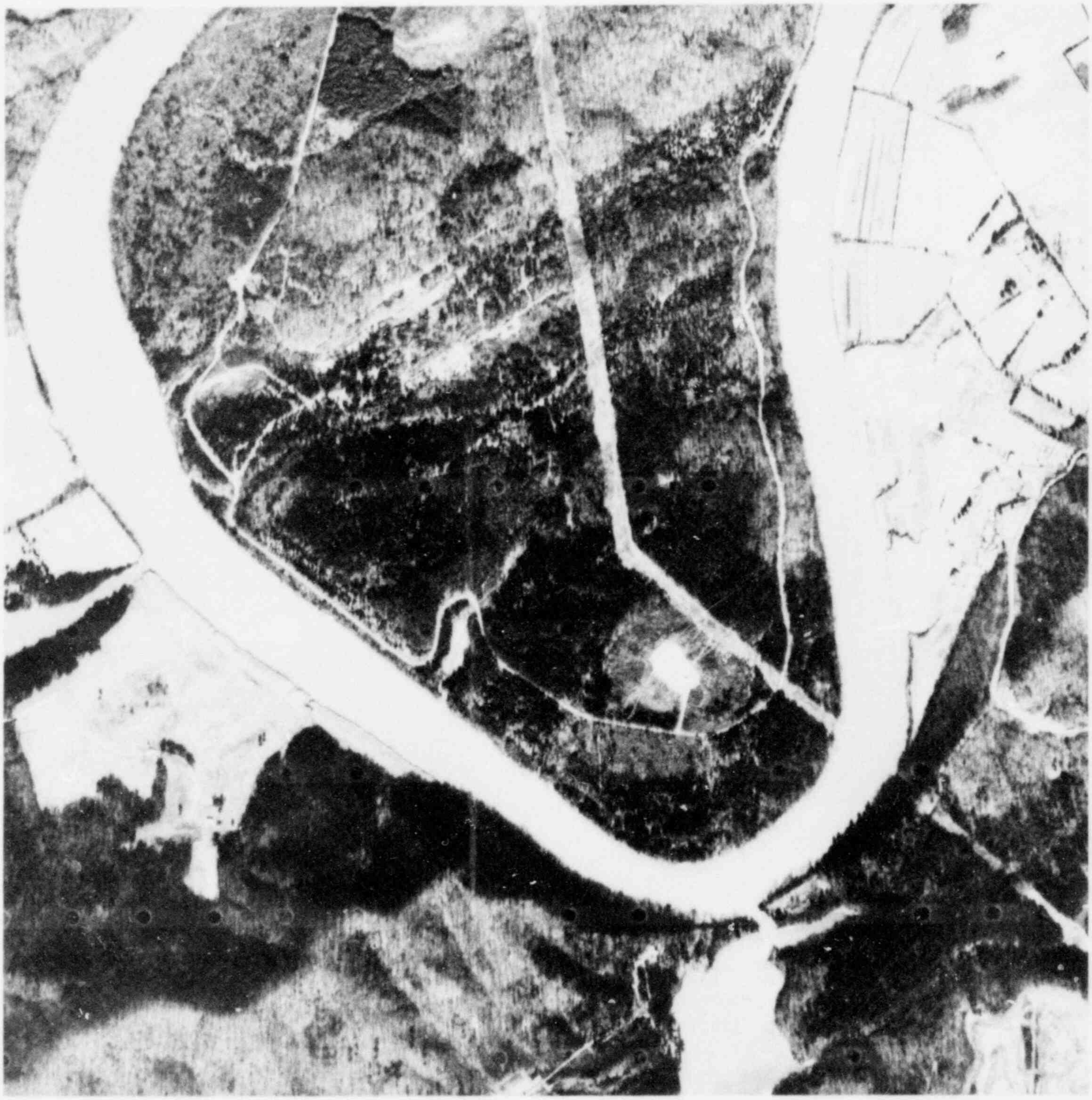


Figure 3.1-2 AERIAL PHOTOGRAPH OF THE CRBRP SITE

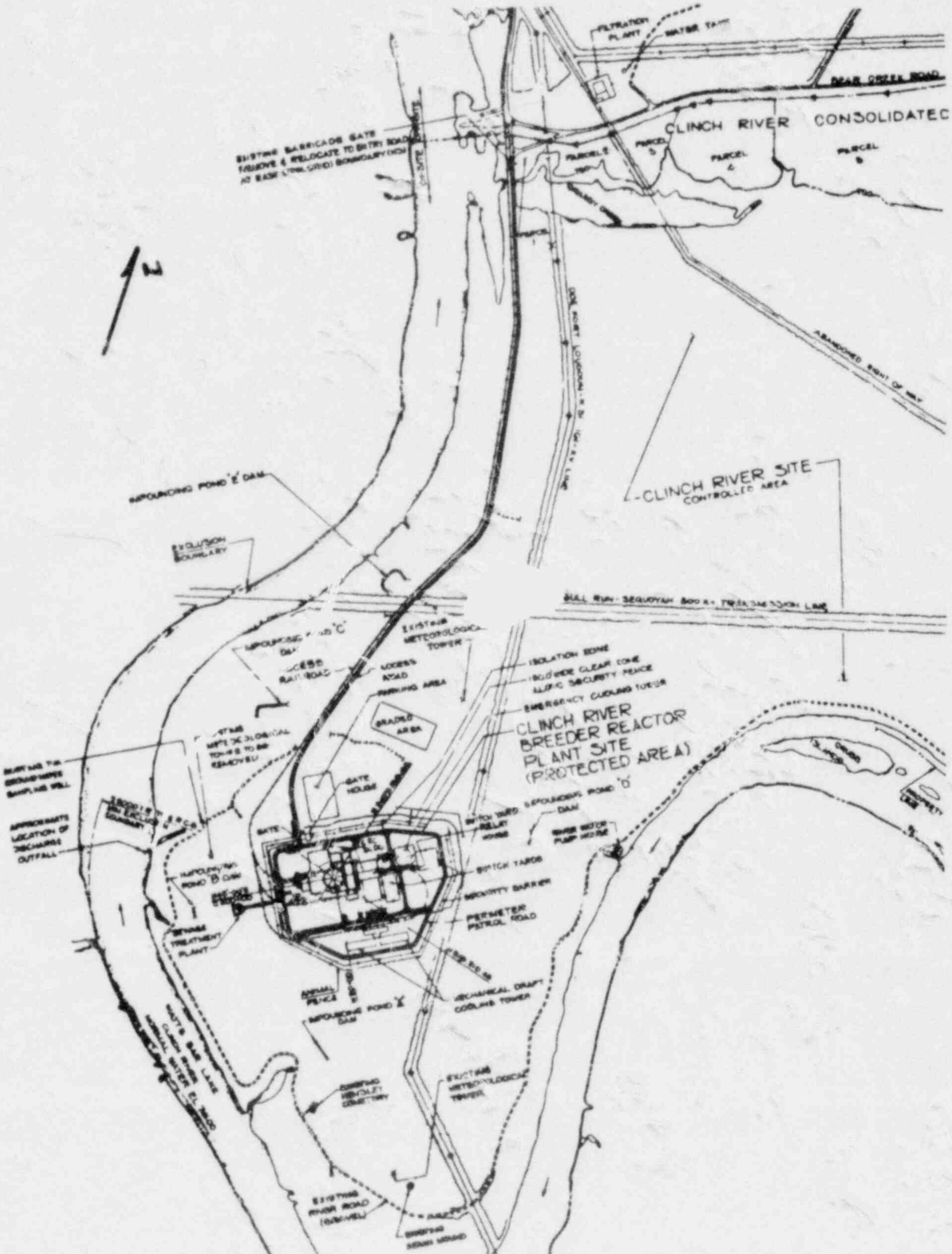
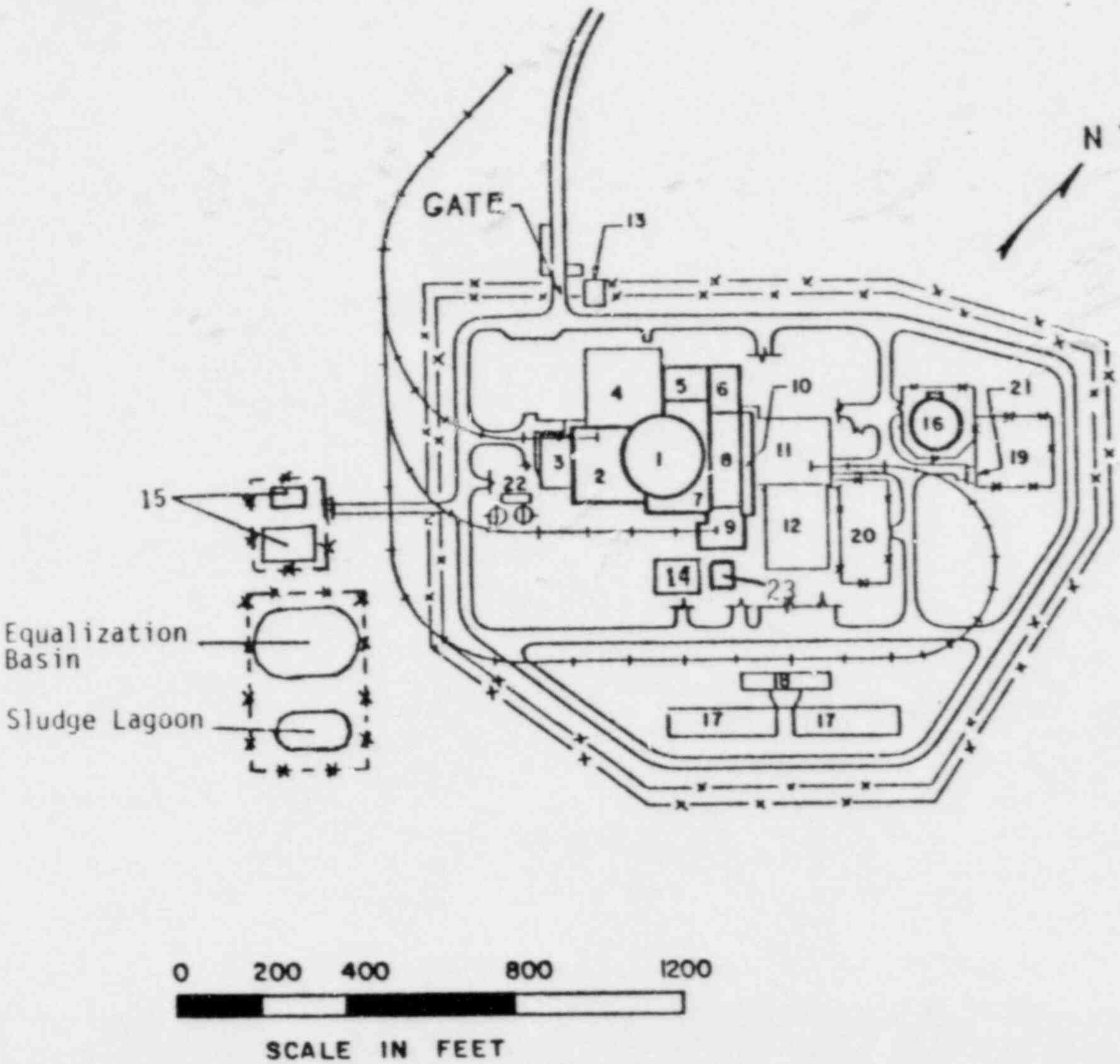


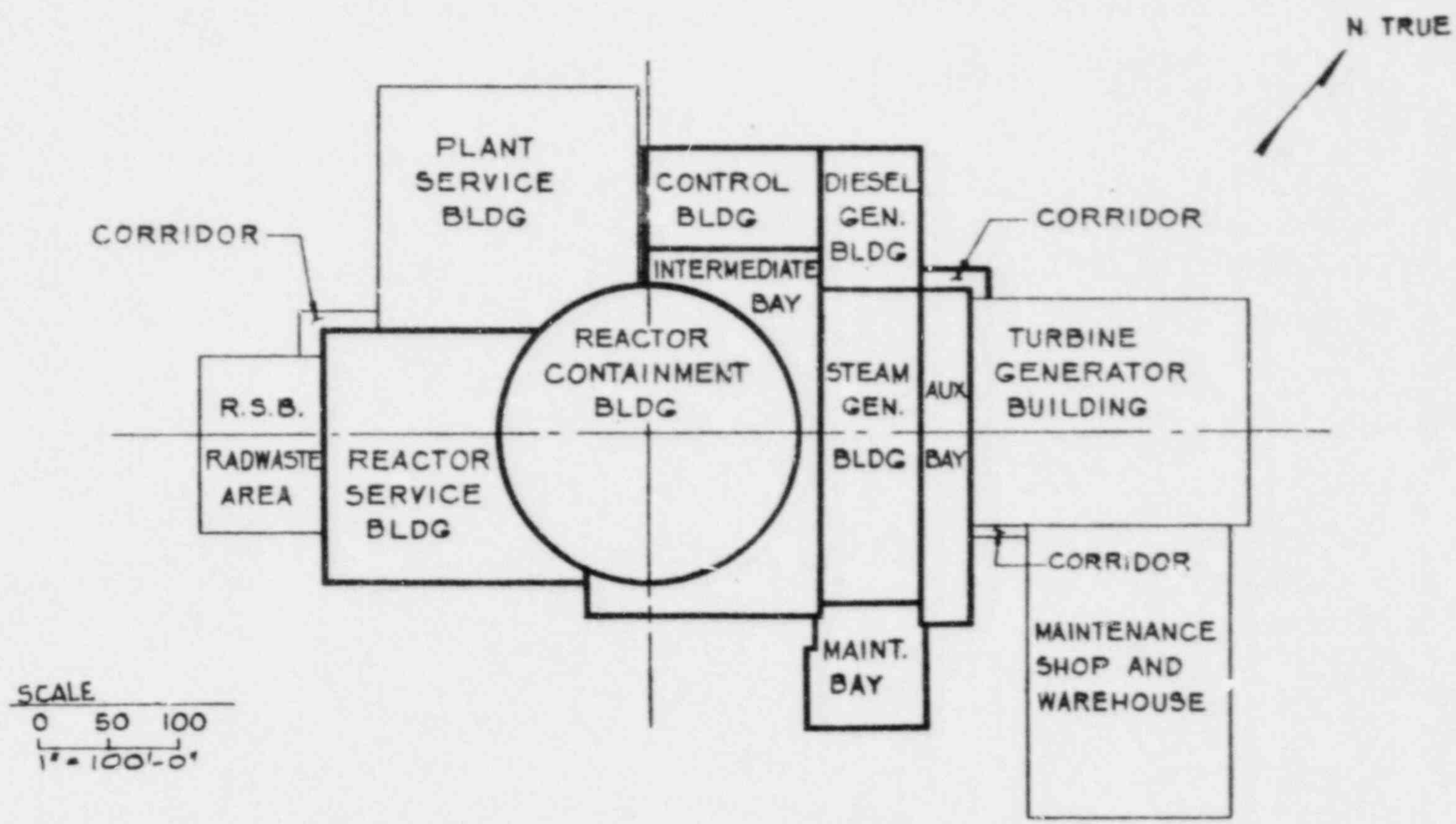
Figure 3.1-3 CRBRP IN RELATION TO SITE



1. REACTOR CONTAINMENT BUILDING
2. REACTOR SERVICE BUILDING
3. RADWASTE AREA
4. PLANT SERVICE BUILDING
5. CONTROL BUILDING
6. DIESEL GENERATOR BUILDING
7. INTERMEDIATE BAY
8. STEAM GENERATOR BUILDING
9. MAINTENANCE BAY
10. AUXILIARY BAY
11. TURBINE GENERATOR BUILDING
12. MAINTENANCE SHOP & WAREHOUSE
13. GATE HOUSE
14. Waste Water Treatment Area
15. Sewage Treatment Plant
16. EMERGENCY COOLING TOWERS
17. COOLING TOWER
18. C. W. PUMP HOUSE
19. GENERATING SWITCH YARD
20. STARTUP RESERVE YARD
21. SWITCHYARD RELAY HOUSE
22. FIRE PROTECTION PUMP HOUSE
23. Waste Disposal Building

13

Figure 3.1-4 LAYOUT OF PLANT STRUCTURES IN RELATION TO THE SECURITY BARRIER



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NOTE: HEAVY LINES INDICATE CATEGORY I STRUCTURES

Figure 3.1-5 MAIN BUILDING LAYOUT OF CRBRP a fixed percentage (0.05%) of the circulating water flow rate. This value is based on information provided for cooling towers equipped with standard drift eliminators by cooling tower vendors.[1]

Blowdown is provided to maintain the quality of the circulating water in a non-corrosive, non-scaling condition and, as shown in Figure 3.4-4, is a function of ambient wet bulb temperature. The annual average total dissolved solids (TDS) concentration in the circulating water is approximately 355 ppm. The makeup water compensates for the operational losses of the system and is also a function of ambient wet bulb temperature as shown in Figure 3.4-5.

9
4

3.4.2 INTAKE

The intake structure for the makeup water is located on the shore of the Clinch River at Site grid coordinates 2481.112 and 550.878, as shown in Figure 3.4-9 and will be designed in accordance with the requirements set by the U.S. Army Corps of Engineers and will be monitored in compliance with the NPDES requirements developed pursuant to the Federal Clean Water Act. 9

7

Screening of the withdrawn river water is accomplished by two 100-percent capacity perforated pipe inlets, Figures 3.4-6 and 3.4-7. The pipe inlets are positioned approximately 26 feet from the present shoreline (at elevation 741), supported above the river bottom and aligned parallel to the direction of flow in the river. The inlets will be recessed into the river bank such that they will lie below the existing river bed contour (see Figure 3.4-10) and, hence, will not present a navigation hazard. Final position of the perforated pipes is subject to hydraulic model tests to be performed on the perforated pipes and the river bottom in the vicinity of these pipes. Perforations in the pipes are 3/8-inch diameter maximum. Maximum average velocity of entering water measured 0.75 inch from the front of the perforated pipe is estimated to be less than 0.4 feet per second. Under normal operation, with both pipes in service, the maximum inlet water velocity is estimated to be less than 0.2 feet per second.

7

Due to the low inlet water velocity, no substantial accumulation of trash is expected on the perforated pipe, as discussed in Section 10.2;

therefore, trash racks and screens are not necessary. Redundancy, provisions for access and maintenance to the perforated pipe, as well as provisions for backwash have been incorporated in the perforated pipe intake design to insure reliability of the intake system during all plant operating modes.

The intake system includes, two, 100-percent capacity river water pumps with a design flow rate for the system of 9,000 gpm. The river water 9
system will operate between a flow rate of 2,500 gpm to 9,000 gpm during normal plant operation. The major makeup water demand of the plant results from cooling tower operating losses. Makeup water will be supplied to the cooling tower basin to control basin water level. A flow control valve in the cooling tower makeup line will modulate supply to the basin. A recirculation line is provided for the river water supply pumps. This line will open to prevent pump damage when the basin is at high level and the other plant demands are less than the minimum flow requirements of the pump. The recirculation line returns flow into the intake structure. 4

The annual average river flow rate is approximately 2,415,000 gpm and 4 8 9
the one day low flow rate is zero, as discussed in Section 2.5.

3.4.3 DISCHARGE

Blowdown from several plant streams is combined with the cooling tower blowdown and is discharged to the Clinch River by means of a submerged single port discharge, as shown in Figure 3.4-8. Discharge velocity to 13
the river, at 100 percent load factor, is approximately 15 feet per second, 9
based on an eight-inch diameter opening at the end of the single port diffuser. The discharge structure is designed to insure that the plant releases meet the thermal discharge limits given in the Draft National Pollutant Dis- 9
charge Elimination System (NPDES) Permit. Depth of the discharge is four feet below minimum river water level and extends approximately 25 feet into 7

TABLE 3.4-2
COMPONENT DESCRIPTION

<u>Condenser</u>

Tube Length	60 ft.	6
Tube Material	90-10 Cu-Ni (Main Section) 70-30 Cu-Ni (Peripheral & Air Cooler Section)	9
Number of Passes	1	
Number of Tubes	19,464	9
Tube Size	0.875 in., O.D. 20 BWG (Main Section) 18 BWG (Peripheral and Air Cooler Section)	9

<u>Cooling Tower</u>

Number of Towers	2	6
Cells per Tower	5	6, 13
Tower Size	247' x 76' x 41'	6, 13
Air Flow (Total)	16×10^6 ft^3/min	6, 13
Number of Concentrations	2.5	6
Total Dissolved Solids (Average)	355 ppm	4
Blowdown (Annual Average)	2,306 gpm	9
Drift (Annual Average)	106 gpm	9
Evaporation (Annual Average)	3,623 gpm	9
Makeup (Annual Average)	6,035 gpm	9

TABLE 3.4-3

ESTIMATED WET BULB TEMPERATURES BASED ON READILY AVAILABLE DRY BULB TEMPERATURES AND RELATIVE HUMIDITIES AT KNOXVILLE, TENNESSEE

	Dry Bulb Temperature* (°F)	Relative Humidity* (%)	Wet Bulb Temperature** (°F)
January	41.4	70.8	40.0
February	43.1	67.0	42.0
March	49.6	63.3	48.0
April	58.9	62.5	56.5
May	67.7	67.3	64.5
June	75.7	73.5	73.5
July	78.4	75.8	75.5
August	77.4	76.0	74.5
September	72.2	74.3	69.5
October	60.9	71.0	58.5
November	48.7	71.3	48.0
December	41.6	71.5	41.0

*Local Climate Copy Data, Annual Summary with Comparative Data, Knoxville, Tennessee, 1931-1960, No. AA, U.S. Department of Interior, 1971.

**Psychrometric chart conversion of columns 1 and 2

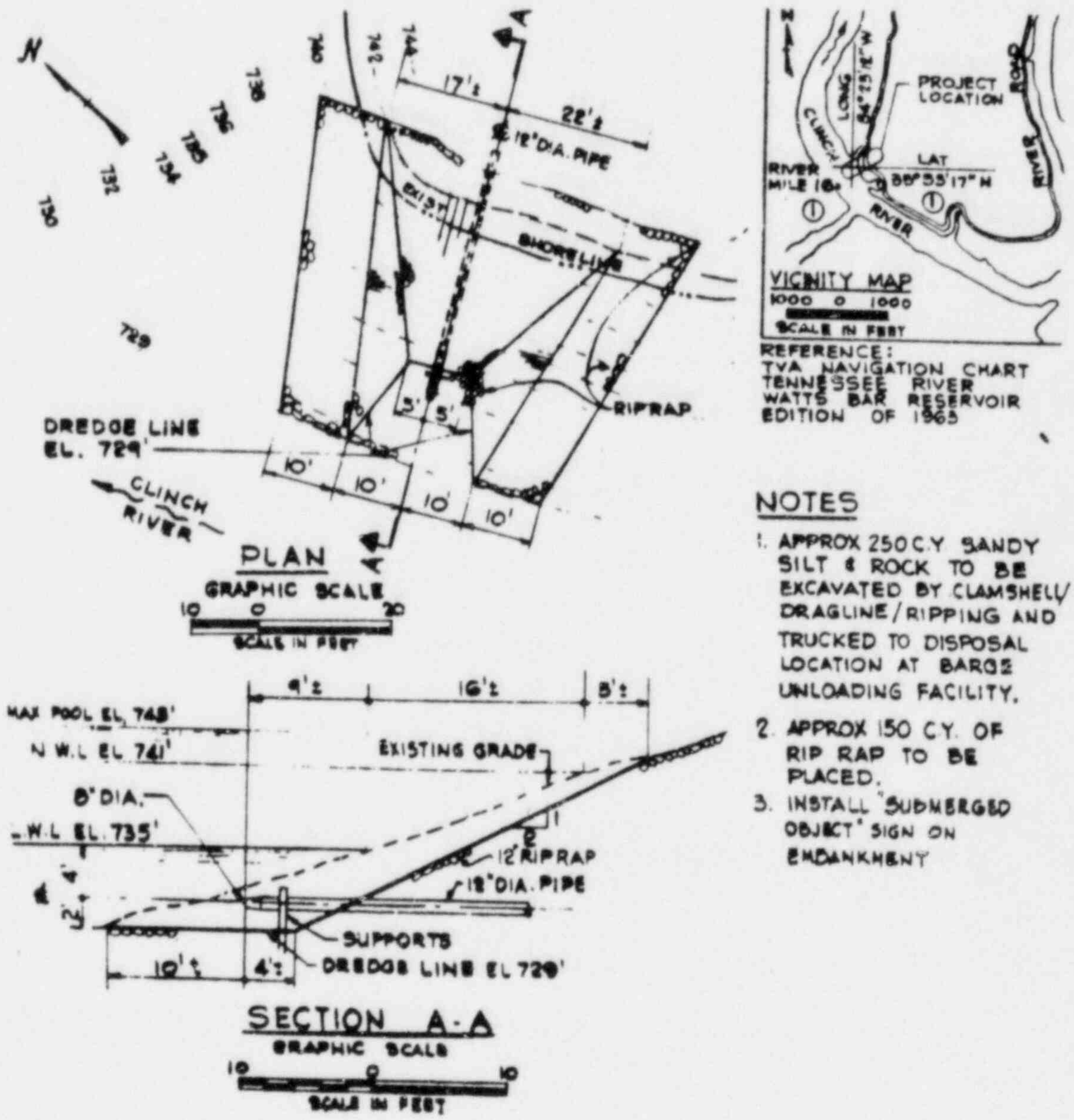

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Figure 3.4-8. DISCHARGE STRUCTURE

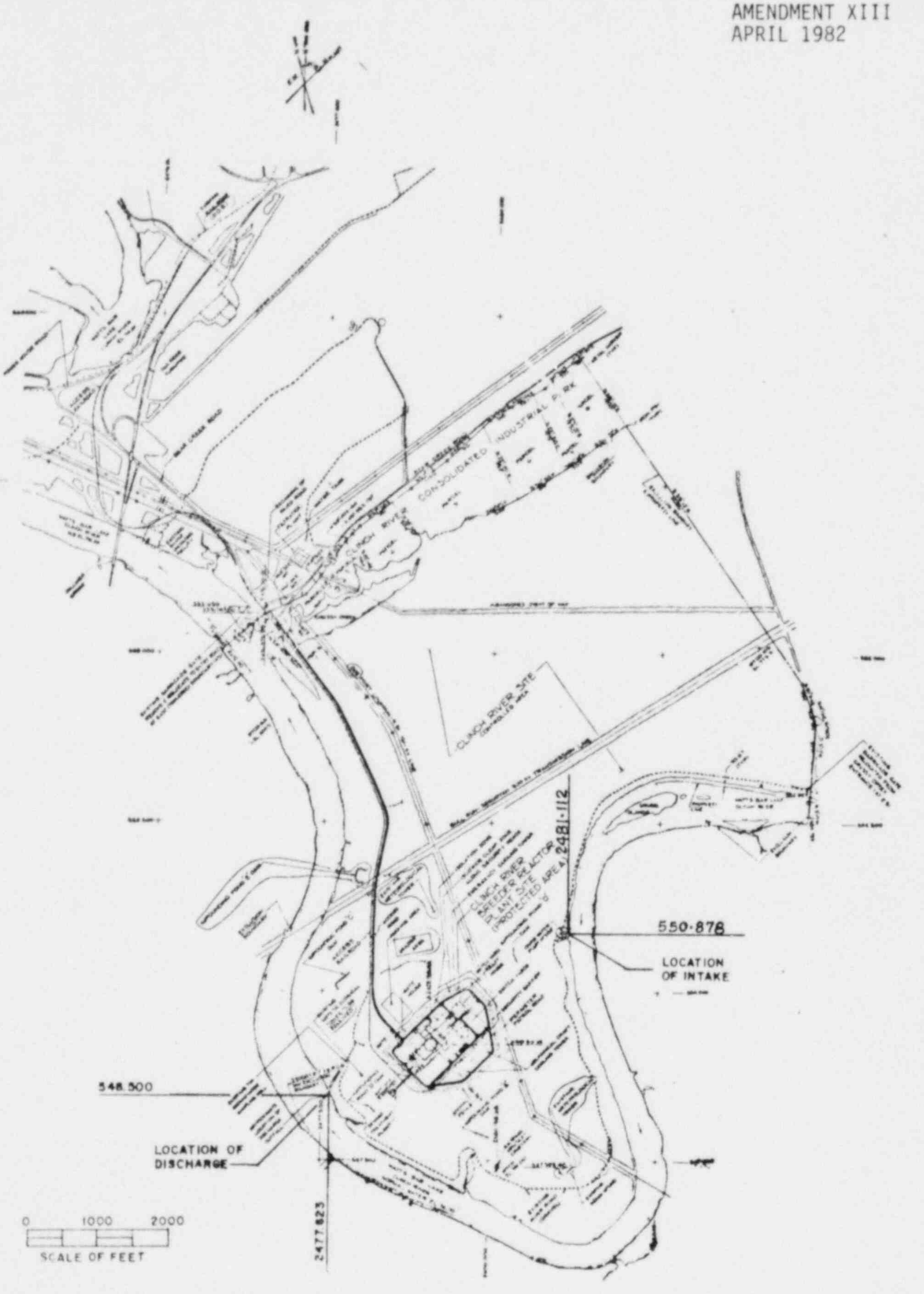

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Figure 3.4-9 SITE LOCATION

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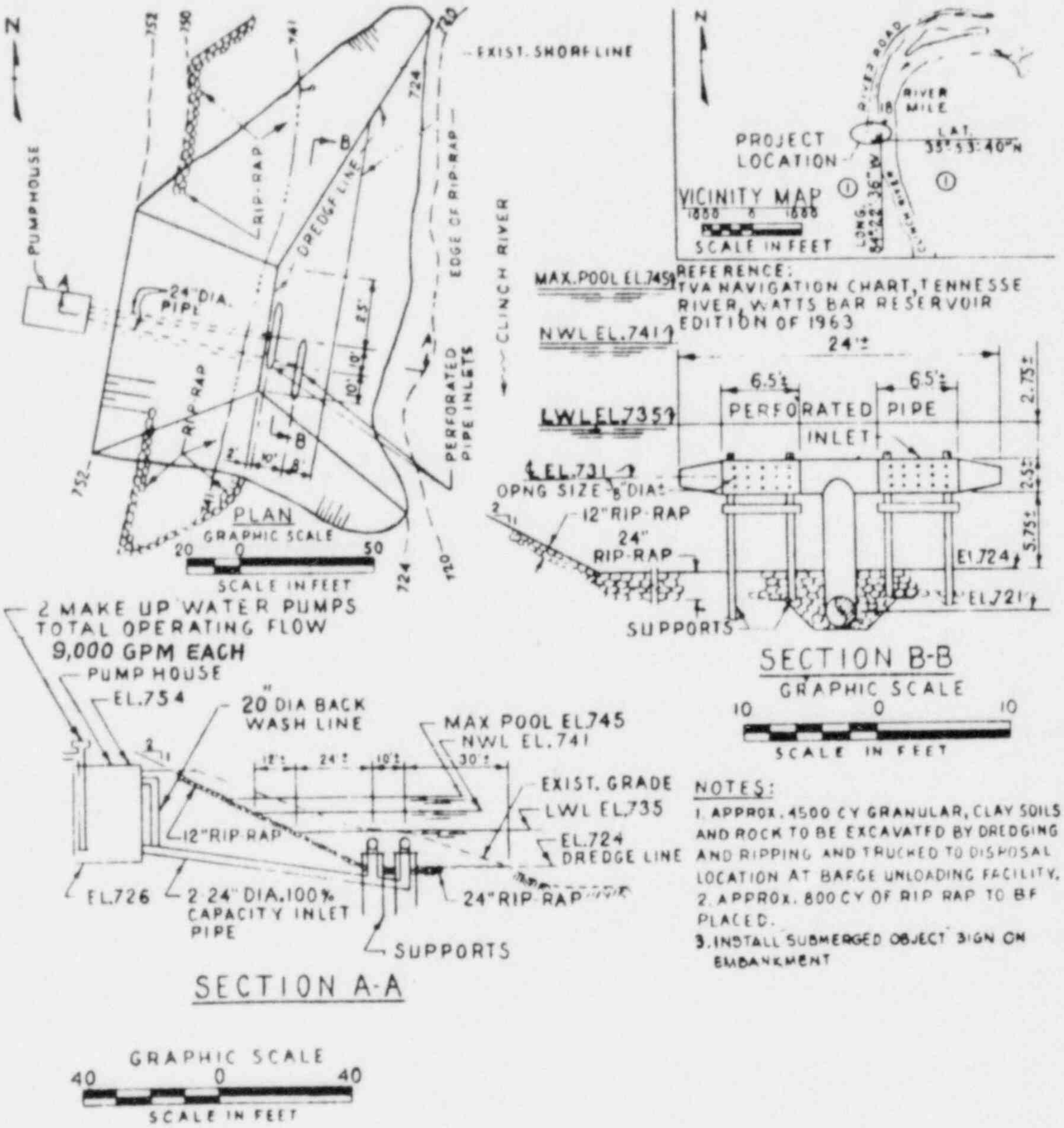

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Figure 3.4-10. PLANT INTAKE STRUCTURE

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3.5.2.4.2 BUFFERED-SEAL LEAKAGE

Buffered head seals are fed by recycled argon (processed in RAPS); a maximum seven standard cc/min of this gas is expected to leak into the Head Access Area. Cover-gas and buffered seal leakages both diffuse into the Head Access Area atmosphere and are vented into the RCB operating floor and to the RCB HVAC exhaust and discharged to the atmosphere without processing. 10

3.5.2.4.3 PRIMARY PIPING LEAKAGE

An estimation of the total leakage through piping connections, welds, valves and components of the PHTS and of the Reactor Cover Gas System indicates that the assumption of one standard cc/min 8 of cover gas is conservative regarding leakage into the corresponding Reactor Containment Building (RCB) cells. Small amounts of tritium will diffuse through the piping wall into the 10 PHTS and auxiliary Na cells. These gases will be vented to CAPS by the normal feed and bleed nitrogen gas cell-atmosphere inerting and pressure control system. 10

3.5.2.4.4 RAPS AND CAPS LEAKAGE

Similarly, a maximum of one standard cc/min of RAPS cold box 10 influent gas is assumed for the total leakage from RAPS and CAPS components into their respective cell atmospheres, which vent to the RCB HVAC, and RSB HVAC, respectively.

3.5.2.4.5 INTERMEDIATE CELLS

Tritium that diffuses from the primary into the Intermediate Heat Transport System will also diffuse at a small but finite rate through piping and components into the Steam Generator Building Intermediate Bay cell atmosphere. 10 In the cell atmosphere, it will reach an equilibrium concentration dependent upon natural-convection air turn-over in those cells. 10

3.5.2.5 RADIOLOGICAL RELEASE POINT DESCRIPTIONS

There are a total of nineteen Nuclear Island ventilation exhaust 8 13
air releasing points which are designed for monitoring/sampling
of exhaust air. These are: one located in the Intermediate Bay
(IB) of the Steam Generator Building, one located in the Radwaste
Area of the Reactor Service Building (RSB-RWA), two located in 10 13
the Fuel Handling Area of the Reactor Service Building (RSB-FHA), 8
six located in the Steam Generator Building (SGB) and nine 13
located in the Reactor Containment Building (RCB). Of these
release points, only two are expected to contain radioactivity in 13
their effluents during normal operation of the CRBRP. These are
the SGB-IB exhaust, and the RCB normal exhaust release point 13
located in the RSB.

The release point associated with the Intermediate Bay (IB) of
the SGB will exhaust air at 54,500 scfm at an elevation of 857' 8 10
with an exhaust air velocity of 1520 fpm. 13

Three release points are located in the RSB. One receives 10 13
ventilation exhaust air from the Radwaste Area of the RSB. A
ventilation exhaust air quantity of 46,000 scfm will be released 8 10
at an elevation of 884'-0". Exhaust air temperature will vary
from 55°F to 140°F. Exhaust air velocity is 940 fpm. 13

13

The second release point located in the RSB receives normal 13
exhaust from the Reactor Containment Building. A ventilation
exhaust air quantity of 14,000 scfm will be released at an 8
elevation of 884'-0". Exhaust air temperature will vary from 10
55°F to 120°F. Exhaust air velocity is 1750 fpm.

The third release point located in the RSB receives exhaust from
the RSB clean up filter unit. A ventilation exhaust air quantity 10
of 18,000 scfm during normal operation and 1700 scfm during

refueling will be released at an elevation of 884'-0". Exhaust
air velocity is 1800 fpm and 170 fpm, respectively. The 10
temperature will vary from 55^{o}F to 120^{o}F.

Six design radiological release points are located in the SGB. 8 13
Three, one in each of the steam generator loop cells, receive
ventilation exhaust air from their respective cells. Ventilation
exhaust air quantities of 65,000; 55,000 and 73,000 scfm will be 8 13
released from loop cells 1, 2 and 3, respectively, at an
elevation of 886'0", and the exhaust air velocity will be 1,350, 10 13
1,150 and 1,520 fpm for loop cells 1, 2 and 3, respectively.
Each loop cell has an additional release point which receives
ventilation exhaust air from the same area as stated above. A
ventilation exhaust air quantity of 16,000 cfm will be released 13
from each of the additional release points at elevation 874'-0".
Exhaust air velocity will be 1,600 fpm. 13

Located near the top of the Reactor Containment Building at
elevation 987'-0" is the combined exhaust of the Annulus Pressure
Maintenance System, the Annulus Filtration System, and the RCB
Containment Clean Up System. The exhaust air quantity and 8
exhaust velocity through this exhaust opening varies from 3,000
scfm and 425 fpm during normal and accident conditions, to 14,000 13
scfm and 1980 fpm during refueling, to a 21,770 scfm and 3,080
fpm which represents the RCB Clean Up System exhaust during the 10
TMBDB event (Thermal Margin Beyond Design Basis). The
temperature of the air varies from 55^{o}F to 200^{o}F.

An additional eight (8) release points associated with the
Thermal Margin Beyond Design Basis (TMBDB) event are located at
the top of the Reactor Containment Building for the Annulus Air
Cooling System at elevation 991'. A nominal total of 400,000
scfm or 50,000 scfm per exhaust point, will be exhausted at each

point with an outlet velocity of 780 fpm. This annulus cooling system is not required to operate during normal operation, or to mitigate the consequences of any design basis accidents.
Activity would only be released from these points in the event of 10
very low probability accidents beyond the design basis. No on-line radioactivity monitor will be provided for these exhausts and offsite/emergency monitoring techniques will be adopted.

The radiological discharge points described are sampled and/or 4 8
monitored. Section 6.2.1.1.1 describes the plant effluent monitoring system for gaseous effluents.

3.5.2.6 SYSTEM PERFORMANCE

Steady-State Inventory of a specific radionuclide in the reactor cover gas can be calculated from the formula:

$$I = \frac{\dot{I}}{\lambda + \varepsilon F/V}$$

where,

I = Inventory
$\dot{I}$ = Input rate (presented in Table 3.5-6)
λ = Decay constant (0.693 $\div$ half-life)
ε = Processing efficiency factor (typically taken as unity)
F = Purge rate
V = Cover-gas-space volume
F/V = Purge factor

Concentration of a radionuclide in the cover-gas space is its inventory divided by the total gas volume adjusted to standard temperature and pressure.

Description of disposal of additional materials is provided in Section 3.8, Radioactive Materials Inventory.

3.5.3.1 CONCENTRATED LIQUIDS

Concentrated liquids and spent bead-type resins from the liquid radwaste are solidified. The equipment in the solid radwaste system is shown schematically in Figure 3.5-5. 4 10

The equipment includes a cement filling station, a decanting station, a concentrated waste collection tank, a drumming station, a filter handling machine and a compactor. Equipment has been selected, arranged and shielded to permit operation, inspection and maintenance with minimal exposure to personnel. The solid radwaste system will process approximately one-hundred eighty-one 55 gallon drums of concentrated liquids per year as shown in Table 3.5-11. Total plutonium in 181 drums is expected to be less than 0.3 Ci or less than 2×10^{-3} Ci per drum, assuming that no plutonium is removed by the liquid radwaste filtration system. 10 4 13

3.5.3.2 COMPACTIBLE SOLIDS

Compactible solids such as rags, paper, and rubber seals, which can be potentially contaminated, will be collected at various points throughout the plant and transferred to the solid radwaste system. These types of solids, after compaction, are estimated to have an average activity of less than 9.5×10^{-5} Ci/ft^3 as shown in Table 3.5-10. Compactible solids will be placed in 55-gallon drums and compacted by a hydraulic compacting machine. It is estimated that a total of twenty-eight 55-gallon drums per year will be produced. Transport to a burial site by licensed burial contractors will be carried out after a suitable number of drums are accumulated. 8 10 8

3.5.3.3 NON-COMPACTIBLE SOLIDS 10

Low activity, non-compactible solids (less than 0.12 Ci/ft^3) 4 13 include used support tools, metal from cutting operations such as 10 an IHX tube bundle, valves and vapor traps. All components previously exposed to sodium will be cleaned of metallic sodium in the LCCV or the SCA.

The low activity non-compactible solids will be placed in 55-gallon drums, capped, decontaminated, monitored and placed into temporary storage. Other types of non-compactible solids such as spent cartridge filters, will be prepared for off-site 10 disposal in concrete-lined 55 gallon drums. It is estimated that there will be a total of one hundred and twelve (112) 55-gallon 4 8 drums per year containing non-compactible solids.

3.5.3.4 METALLIC SODIUM IN CONTAINERS

Radioactive sodium will be present in the Fuel Handling Cell as a result of fuel handling operations. This metallic sodium will be transferred to the radwaste system from the Fuel Handling Cell in 55-gallon drums. The number of drums of waste is estimated to be two per year, each containing about 20 Ci. Since no burial sites will accept sodium, the drums will either be placed in storage on 8 10 site or processed to a disposal form in a to-be-determined manner.

TABLE 3.5-7

(Sheet 1 of 2)
RADIONUCLIDE RELEASE RATES AND RELEASE PATHS FOR THE 0.1%
FAILED FUEL SERVICE CONDITION

Isotope	Cover Gas Leakage RCB H&V Exhaust (Ci/day)	Buffer Seal Leakage-RCB H&V Exhaust (Ci/day)	Primary Piping Leakage-RCB Cells to CAPS to RSB H&V Exhaust (Ci/day)	RAPS +++ Components Leakage - RCB Cells to RCB H&V Exhaust (Ci/day)	Noble Gas Effluent to CAPS to RSB H&V Exhaust (Ci/day)	Fuel Failure Monitoring System Effluent to CAPS to RSB H&V Exhaust (Ci/day)
Xe^{131m}	4.7E-7	1.8E-8	5.9E-11	3.9E-5	*	2.9E-9
Xe^{133m}	1.5E-5	4.9E-7	*	1.2E-3	*	*
Xe^{133}	2.7E-4	9.7E-6	*	2.2E-2	*	*
Xe^{135m}	7.0E-5	1.1E-9	*	4.5E-5	*	*
Xe^{135}	1.2E-3	1.7E-5	*	5.6E-2	*	*
Xe^{138}	1.1E-4	1.3E-9	*	6.0E-5	*	*
Kr^{83m}	4.1E-5	6.4E-8	3.7E-9	4.9E-4	*	8.9E-8
Kr^{85m}	9.5E-5	6.0E-7	4.3E-5	2.7E-3	*	1.5E-3
Kr^{85}	+	+	+	+	1.9E-1	+
Kr^{87}	1.1E-4	8.0E-8	1.1E-11	8.4E-4	*	2.0E-10
Kr^{88}	1.8E-4	5.8E-7	2.3E-6	3.5E-3	*	7.0E-5
Ar^{39}	5.0E-6	7.9E-3	1.1E-3	1.1E-3	7.8E-2	4.4E-2
Ar^{41}	1.3E-5	3.5E-4	1.1E-3	1.8E-4	*	3.0E-2
Ne^{23}	*	*	*	*	*	*
H^{3}++	9.5E-11	1.5E-7	1.9E-5	2.2E-8	≤ 1E-5	8.5E-9
Total	2.1E-3	8.1E-3	2.2	8.8E-2	0.27	7.6E-2

*Less than E-15

+Leakage of Kr-85 is not included, since it is removed by the cryostill and, therefore, is accounted for in the Noble Gas Effluent Column.

++BOP Tritium Release (6.3E-5 Ci/day for a plant capacity factor of 0.68) from T-G Building Exhaust not included. Also, allowance for 2 weeks per year bypass of the oxidizer unit (amounts to 0.04 curies of tritium exhausted to the RSB H&V exhaust) is not included.

+++CAPS components leakage is negligible.

TABLE 3.5-7

(Sheet 2 of 2)
RADIONUCLIDE RELEASE RATES AND RELEASE PATHS FOR THE 0.1%
FAILED FUEL SERVICE CONDITION

Isotope	Refueling Effluent to CAPS to RSB H&V Exhaust (Ci/day)	Maintenance Effluent to CAPS to RSB H&V Exhaust (Ci/day)	Aux. Liquid Metal Effluent to CAPS to RSB H&V Exhaust (Ci/day)	Impurity Monitoring & Analysis Effluent to CAPS to RSB H&V Exhaust (Ci/day)	Intermediate Bay Leakage (Ci/day)	Totals (Sheets 1 and 2) (Ci/day)
Xe^{131m}	1.2E-7	*	7.8E-9	2.9E-12	0	3.9E-5
Xe^{133m}	*	*	*	*	0	1.2E-3
Xe^{133}	4.8E-13	*	*	*	0	2.2E-2
Xe^{135m}	*	*	*	*	0	1.1E-4
Xe^{135}	*	*	*	*	0	5.7E-2
Xe^{138}	*	*	*	*	0	1.7E-4
Kr^{83m}	*	*	*	1.8E-10	0	5.3E-4
Kr^{85m}	*	*	*	2.2E-6	0	4.5E-3
Kr^{85}	1.4	*	*	9.7E-8	0	1.6
Kr^{87}	*	*	*	5.5E-13	0	9.5E-4
Kr^{88}	*	*	*	1.2E-7	0	3.7E-3
Ar^{39}	0.11	*	*	5.6E-5	0	0.24
Ar^{41}	*	*	*	3.4E-5	0	3.2E-2
Ne^{23}	*	*	*	*	0	*
H^{3}++	*	*	*	1.1E-11	1.6E-4	1.9E-4
Total	1.5	**	7.8E-8	9.2E-5	1.6E-4	1.9

4 10 13

*Less than E-15
++BOP Tritium Release (6.3E-5 Ci/day for a plant capacity factor of 0.68) from T-G Building Exhaust not included. Also, allowance for 2 weeks per year bypass of the oxidizer unit (amounts to 0.04 curies of tritium exhausted to the RSB H&V exhaust) is not included.

TABLE 3.5-10

ESTIMATES OF SOLID RADWASTE SHIPMENTS PER YEAR

IN TERMS OF ANNUAL QUANTITIES

	Volume (ft^3)	Weight (lbs.)	Estimated Activity (Ci)	Comments
Compactible Solids*	210	1.2E4	<0.02 Ci	Rags, paper, and seals
Non-Compactible Solids				
Scrapped Components	705	5.7E4	82	valves, vapor traps, small components cleaned of sodium
Resins	125	5.6E3	280	Activated corrosion and fission products
Filters	118	1.3E4	170	Activated corrosion and fission products
Solidified Liquid Radwaste	1000	1.4E5	2.8E3	Concentrated evaporator bottoms
Solidified Tritiated Water	67	1.0E4	0.7	RAPS and CAPS
Solidified Sodium Contaminated Ethyl Alcohol	140	2.1E4	1.2	Cleaning Solution from FHC
Total	2365	2.6E5	3.4E3	

*Assume compaction has decreased volume by factor of 10.

TABLE 3.5-11

SOLID RADWASTE SHIPMENTS PER YEAR

Material	Shipments Per Year	Volume (ft^3)	Containers Per Year*
Compactible Solids	0.3	210	28
Non-Compactible Solids			
Scrapped Components	1.5	705	96
Filters	1.1	118	16
Resins	1.2	125	17
Solidified Liquid Radwaste	3.5	1000	136
Solidified Tritiated Water	0.1	67	9
Solidified Sodium Contaminated Ethyl Alcohol	0.3	140	19

*55-gal Drums

10

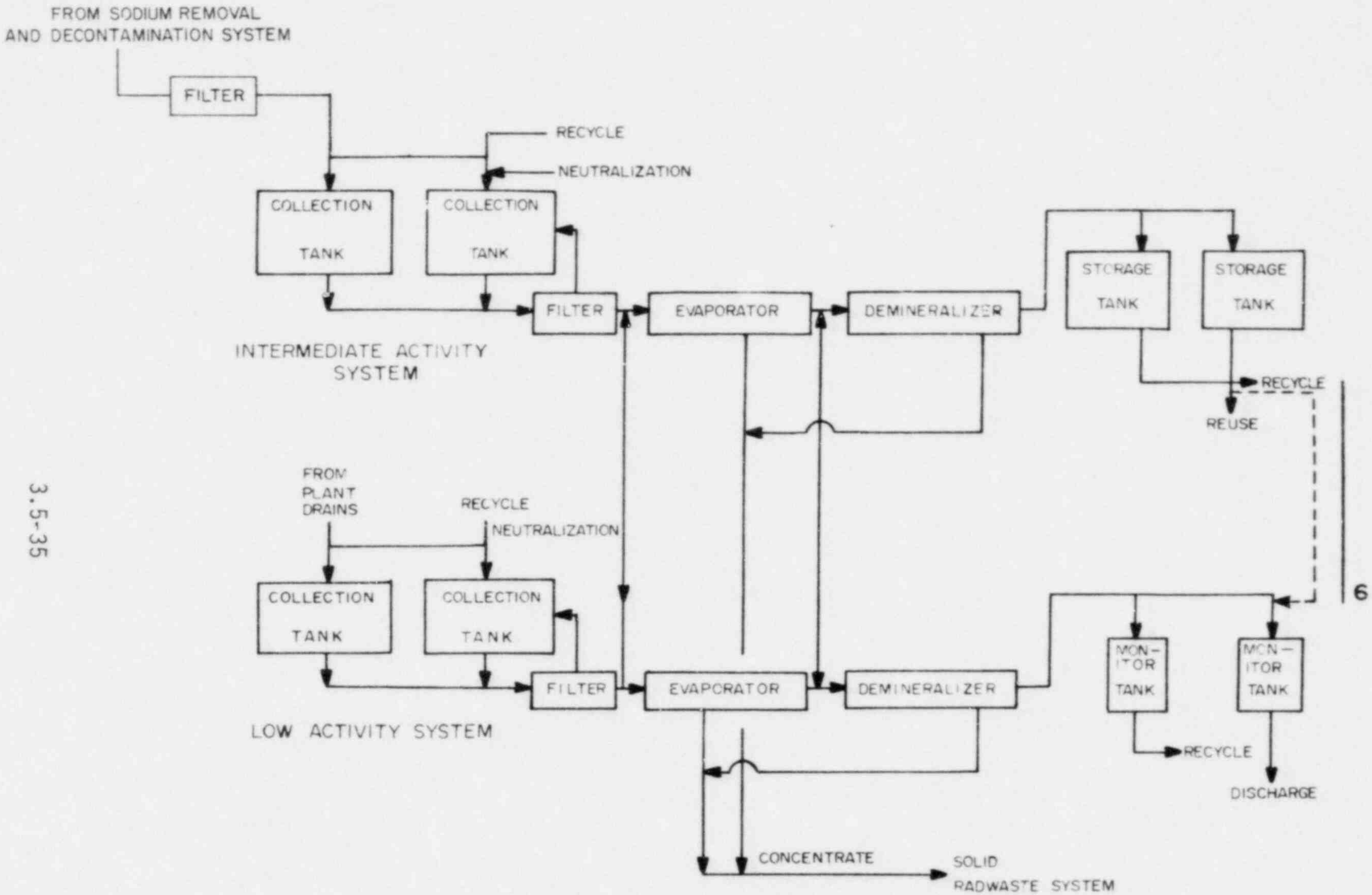

Figure 3.5-1 LIQUID RADWASTE SYSTEM FLOW DIAGRAM

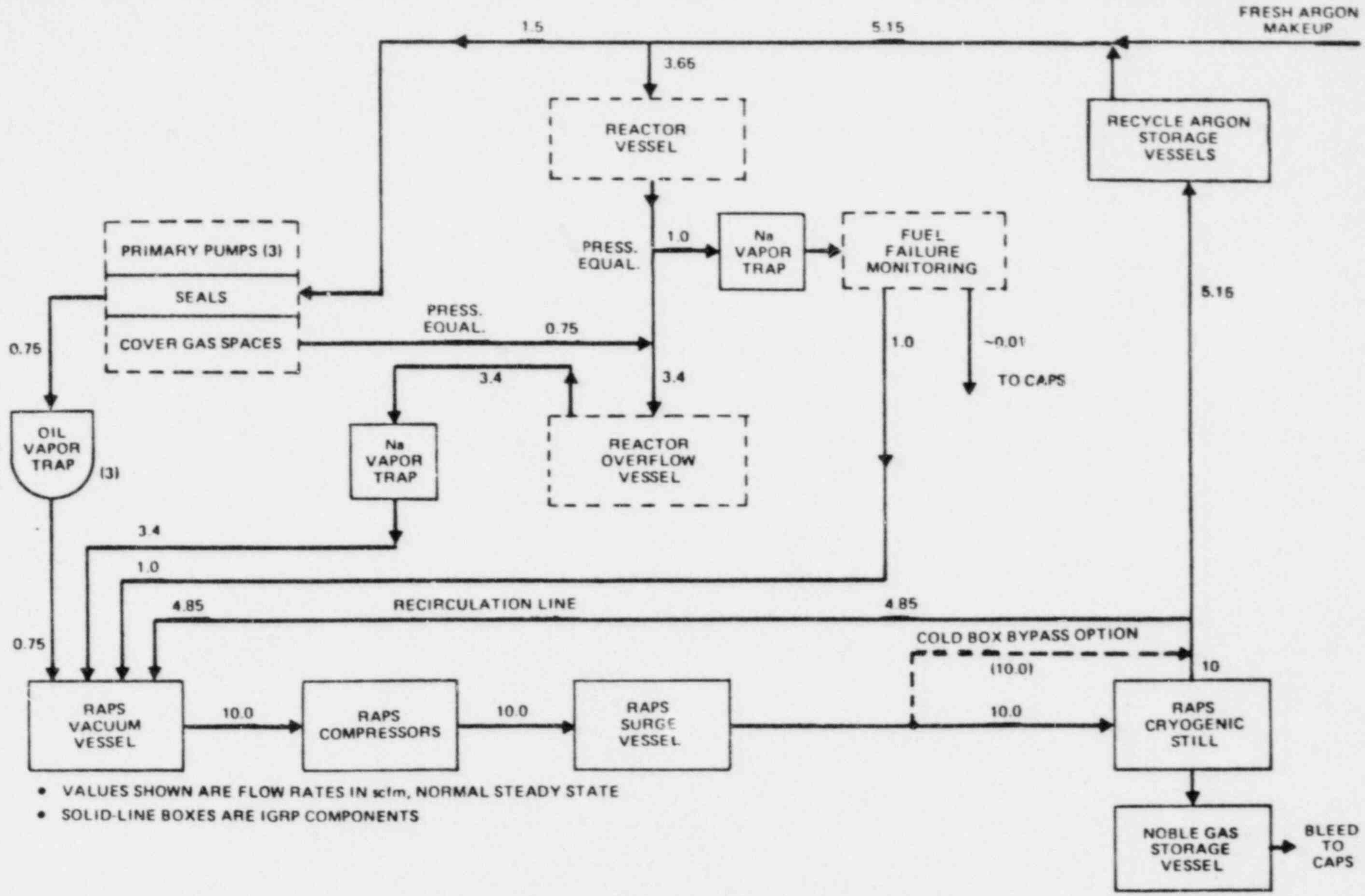

Figure 3.5-2. Schematic Diagram of the RAPS Recycle Argon Circuit

13

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TABLE 3.7-2

EXHAUST EFFLUENTS FROM PLANT DIESEL ENGINES OPERATION (DURING TESTING)

	DIVISION 1 & 2 DIESEL GENERATOR (DG) UNITS	DIVISION 3 DIESEL GENERATOR (DG) UNITS	DIESEL FIRE PUMPS (DFP)	TOTAL
1. Quantity	2	1	2	5
2. Test				
a. Frequency per Unit	1 start test per month & at least 1 full loading test every 18 months	Same as Division 1 & 2 DG units	1 start test per week	-
b. Duration, per Unit	2 hours & 24 hours, respectively	Same as Division 1 & 2 DG units	30 min.	-
3. Maximum pollutants released to atmosphere, lbs/year:				
a. Particulates	48*	8.9*	0.68#	57.58
b. Sulfur dioxide (SO_2)	3,446*	637*	49#	4,132
c. Nitrogen oxides (NO_X)	19,296*	3,570*	272#	23,138
d. Organic compounds	336*	62*	4.73#	402.73
e. Carbon monoxide (CO)	691*	128*	9.72#	828.72

*Based on 48 hours running time per year per DG Unit and the maximum emission rates given in TABLE 5.5-1.
#Based on 26 hours running time per year per DFP unit and the maximum emission rates given in TABLE 5.5-1.

13

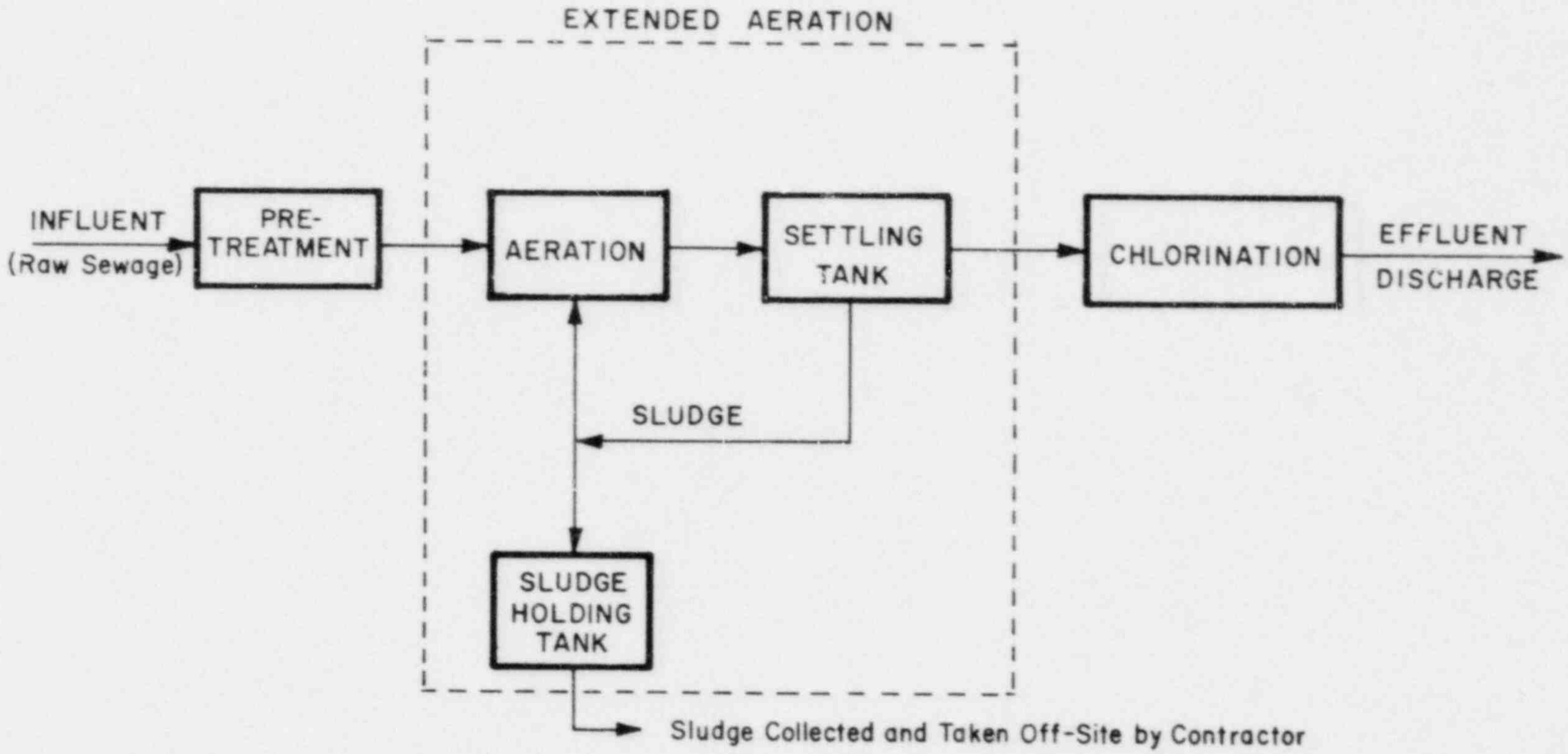

Figure 3.7-1 CONSTRUCTION SANITARY WASTE SYSTEM SCHEMATIC

9

By rotating these plugs in sequence, the In-Vessel Transfer Machine, which is a simple straight pull device, can be indexed over any core or transfer position in the reactor.

After the spent fuel assembly has been placed in the transfer position, the Ex-Vessel Transfer Machine (EVTM) withdraws the CCP container with the assembly and transfers it to the sodium-filled Ex-Vessel Storage Tank (EVST) located in the Reactor Service Building.

Fuel assemblies will remain in the EVST for at least 100 days prior to being loaded into a shipping cask for transportation. 9

Irradiated fuel assemblies will be transported and protected in 6
a cask approximately eight feet in diameter by 22 feet in
length. Irradiated fuel assemblies are inserted in removable
canisters. The approximate weight of the cask is 100 tons and 9
is designed for transportation on a standard high capacity 6
railroad flatcar. The cask and car combination is designed in accordance with NRC and DOT regulations and 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 the heat load limit of 6 9
the cask.

It is estimated that during the spent fuel shipping phase there will be 14 shipments per year. 9 12

3.8.2.2 INNER/RADIAL BLANKET ASSEMBLIES 9

Irradiated properties of the blanket assemblies were developed 9
based on the same reactor operation conditions as those used for

the core fuel assemblies. On the average, 70 blanket assemblies 6 9
will be discharged from the plant per year. The burnup averaged 9 9
over all the discharged blanket assemblies is approximately 8,000
MWD/Ton of heavy metal (depleted uranium). During irradiation,
neutron captures in the fertile material (U-238) of the radial
blanket breeds on the average 2.5-3.0 kg of fissile plutonium per 9
discharged blanket assembly.

The expected mode of protection for packaging of the discharged 9
blanket assemblies for shipment is the same as the core fuel
assemblies. One day after shutdown, the peak inner/radial
blanket assembly heat generation would be 19.7/12.0 kW. Thirty 9
days after shutdown, these heat generation values are 2.61/1.64 6
KW and 2.53/0.88 KW, respectively. This lower heat generation
rate would allow for shipment of blanket assemblies earlier than 13
the 100 days assumed for fuel assemblies. It is estimated that
the number of inner/radial blanket assemblies removed from the 6 9
reactor will require about 12 shipments per year. 12

3.8.3 Radioactive Waste Material

3.8.3.1 Replacement In-Vessel Components

3.8.3.1.1 Control Rod Assemblies and Drive Lines

Control rod assembly consists of a bundle of stainless steel
clad, boron carbide pins. The 9 primary control rod assemblies
have bundles of 37 pins while the 6 secondary control rod 9
assemblies have bundles of 31 pins each. The bundles of pins are
arranged in hexagonal inner ducts within outer ducts having the
same external geometry as the fuel assembly ducts. The 20
percent cold worked Type 316 stainless steel tubing is

Proven suitability of the casks for their use in shipment of spent fuel will assure the acceptability for shipping the radial shield assemblies, as well as control rod assemblies and radial blanket assemblies.

3.8.3.2 OTHER RADIOACTIVE WASTE MATERIAL

Processing procedures for radwaste are discussed in Section 3.5. Radioactive waste material will be shipped off-site and disposed of at an approved burial ground. The source of these radioactive wastes is 9
the solid radwaste described in Section 3.5.3. The estimated weight, volume and activity of solid radwaste shipments per year are shown in Table 3.5-10. Estimated number of shipments per year are shown in Table 3.5-11.

All drums and special containers being shipped off-site will be monitored for radioactivity to assure that the dose rates conform to the regulations set by the Department of Transportation and 10 CFR 71. Temporary storage space is provided on-site prior to shipment of the drums and containers. 9

The inert gas receiving and processing system has liquid radioactive waste in the form of tritiated water which is collected in a holding tank in 10
the Cell Atmosphere Processing System. It is periodically transferred to the Radioactive Waste Disposal System for processing and ultimate disposal. The routinely generated solid waste will consist of compressor diaphragms and spent filter-type vapor traps. These solid wastes will be transferred to the Radioactive Waste Systems for disposal and are included in Tables 3.5-10 and 3.5-11. 13

At the present time there are no plans for disposal of radioactive metallic sodium waste and sodium bearing cold traps. The quantity, activity and onsite storage of the metallic sodium and sodium bearing solids are described in Section 3.5.3. 13

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3.9 TRANSMISSION FACILITIES

3.9.1 LOCATION AND DESCRIPTION OF RIGHT-OF-WAY

The transmission route and related facilities are discussed in this section. Environmental impacts of construction are discussed in Section 4.2, the impacts of operation are discussed in Section 5.6 and alternatives are discussed in Section 10.9.

The proposed transmission line has been divided into two
segments, A-B Compartment-15 and B-C Compartment-13, for purpose 13
of description in this section and facilitation of the discussion of the alternate and proposed routes in Section 4.2, 5.6 and 10.9. Point A marks the beginning of the proposed route at the junction of the existing Sequoyah-Bull Run 500-kV transmission line and the TVA-owned Ft. Loudoun-Roane 161 kV transmission
line, as shown in Figures 3.9-1a and 3.9-1b. From this point, 13
the proposed route travels in an east-west direction parallel to
the existing 500-kV line to the DOE-owned Ft. Loudoun K-31 161-kV 9
transmission line which runs north and south. The proposed
corridor then veers south, parallel to this DOE-owned line, into 9
the proposed switchyard of the CRBRP at point C. Segments A-B and B-C are 1.4 and 1.8 miles long, respectively.

3.9.2 PHYSICAL DESCRIPTION OF CORRIDOR

The transmission line route is situated between two major ridges of the Site area, Chestnut Ridge and Haw Ridge. Within the proposed corridor, the topography consists of rolling hills which range between elevations of 800 and 960 feet. Between the crests of these hills, two streams which drain into the Clinch River near CRM 18 will be crossed by the proposed transmission system. Due to the drainage pattern of the area, intermittent streams of lesser importance are also found along the proposed route.

Soils found within the proposed corridor are quite variable as shown in Figure 2.7-1. A detailed discussion of all soil types for the CRBRP Site is given in Section 2.7. The following discussion of soil types is taken from the 1942 Soil Survey of Roane County.(1)

Clarksville, Upshur, Fullerton and Colbert are the major soil types found within the proposed transmission corridor.(1) Of these four major types, Clarksville is the predominant (34%) soil type found. Clarksville soils are low in fertility, contain little organic matter and are highly acid. This soil responds only slightly to management as a result of low moisture-supplying capacity and low natural fertility. The next most abundant soil type is the Upshur series (27%), which is highly susceptible to accelerated erosion because of the prevailingly rolling topography. Crops are unsuited for this soil, but grass grows very well. The Fullerton Series (20%) consists of deep well-drained soils developed on broad rounded hills and ridges in residuum, weathered from cherty dolomitic limestone. It is found on all slopes. Productivity is influenced by the amount of chert, slope and degree of erosion on this soil. Lack of proper management by the agricultural families who inhabited the area prior to 1942 caused a high degree of erosion on all the soils named above.

Remaining soils are of minor importance compared with those already discussed. For details concerning description and impact on these soils, see Sections 2.7 and 4.2, respectively.

3.9.3 LAND USE

The area through which the proposed transmission line will pass is presently composed of pine plantations and second growth | 13
hardwoods. Prior to 1942, this land was used for various | 13
agricultural and forestry practices by resident farmers. It has reverted back to forest or reforested under the Doe Forest | 13

Management Program. No land in the proposed transmission line area is presently under agriculture cultivation. One half acre 13 of cottonwood is being cultivated under the Forest Management Program. Recent Forest Management has consisted of harvesting about five percent of the trees. Loblolly pine plantations are being selectively cut and short leaf pine plantations will be clear cut.

No part of the area through which the proposed line will pass has been developed for recreational use. There are no wildlife refuges in the vicinity and the general Site area is closed to hunting. There are no homes in the area nor do any public roads cross the proposed corridor route.

An underground gas pipeline owned and maintained by the East Tennessee Natural Gas Company crosses the proposed corridor. The pipeline presently crosses the existing 500-kV right-of-way (ROW) just west of point B, as shown in Figure 3.9-1b. It is a six 13 inch spur pipe-line serving Lenoir City. An underground Bell 13 Telephone crossing at New Zion Road provides service to K-25.

3.9.4 TERRESTRIAL ECOLOGY

3.9.4.1 SEGMENT A-B (COMPARTMENT 15) 13

Hardwood and hardwood-successional pine-cedar communities predominate along this segment of the proposed ROW, as shown in Table 3.9-1. The dominant overstory trees are species of oak and hickory with tulip poplar and sweetgum found on the moister sites. Within this ROW, these communities cover 21.5 acres or 13 nearly 69 percent of the corridor.

The coniferous forests consist of successional stands of Virginia and shortleaf pine and plantations of loblolly, and shortleaf 13 pine. These coniferous forests cover approximately 9 acres or nearly 29 percent. Approximately 2 percent of this segment or 13

1/2 acre is unforested. These areas characteristically have shrubby growth and herbaceous species mixed with hardwood and cedar seedlings. 13

3.9.4.2 SEGMENT B-C (COMPARTMENT 13) 13

Plantations of white and loblolly pine are the major overstory types along segment B-C, comprising 63 percent of the total acreage. 13 13

Hardwood areas along this segment of the transmission line corridor are generally fingerlike extensions of larger stands. Communities of tulip poplar, sycamore, sweetgum and northern red oak comprise approximately 28 percent of the total acreage along this corridor. These hardwood communities are found just west of point B and east of point C with the coniferous forest concentrated in the central portion of the segment.

In areas that have been disturbed, eastern red cedar is also present. As in segment A-B, 20 percent of the corridor has been cut-over or disturbed and has been forested with loblolly and Cottonwood plantations. Harvested portions of short leaf pine and thinned portions of loblolly and white pine plantations border the transmission line. 13 13

3.9.4.3 WILDLIFE

A variety of game and non-game species inhabit the vegetative communities along the corridor.

White-tailed deer, probably the only big game species in the area, prefer hardwood-pine forests and shrub-grown areas. Eastern cottontails and eastern gray squirrels are the two major small game species present. Cottontails prefer open fields and edge areas of the transmission line corridor while gray squirrels reside in deciduous forests.

Probable access availability to the various line segments has been identified along the proposed corridor route by numerical designation or reference points, as shown in Figure 3.9-2. Access availability at these reference points is discussed below.

3.9.5.1 POINTS 1 AND 2

The transmission route will utilize the existing cleared right-of-way for construction and maintenance access. Entry would be provided by use of the existing access roads at points "1" and "2".

3.9.5.2 POINTS 3, 4 AND 5

Existing right-of-way access will be used with entry at point "2" and by previous routes, points "3", "4" and "5", developed for the parallel Bull Run-Sequoyah 500-kV line.

3.9.5.3 POINTS 5 AND 6

The right-of-way will be used for access with entry at the proposed switchyard, point "6", and previously identified point "5".

3.9.5.4 POINTS 6 AND 7

The parallel River Road will be used for access at point "7" as well as entry to the right-of-way from the proposed switchyard, point "6".

3.9.6 AREAS OF HISTORICAL AND ARCHAEOLOGICAL INTEREST

In developing the route for the proposed transmission line corridor, the National Register of Historic Places, published by the National Park Service, was consulted to determine if the proposed corridor would conflict with any previously identified significant historical or archaeological sites. This review failed to reveal any conflicts. For the CRBRP Site, which would include approximately one half of the proposed transmission line corridor, an extensive historical and archaeological investigation was conducted by personnel from the Department of Anthropology, University of Tennessee. The results of these studies are given in Section 2.3, Regional Historic, Scenic, Cultural and Natural Landmarks. Figure 2.3-1a shows the archaeological and historical sites within the CRBRP area and the existing transmission line corridors. The proposed corridor does not pass through or near any areas of known significance.

Prior to off-site transmission corridor clearing and tower line construction additional archaeological investigations will be 13
performed. Should these investigations reveal the presence of any significant archaeological site on or in close proximity to the proposed corridor, an evaluation will be made to determine if the transmission line route or if specific towers should be relocated. For archaeological sites, the possibility of recovering the artifacts will be studied. In the event a structure or other prominent historical property is identified, a determination will be made in conjunction with State and Federal agencies as to its eligibility for nomination to the National Register.

3.9.7 DESCRIPTION OF RIGHT-OF-WAY

The location of the CRBRP on the Clinch River will allow the introduction of generated electricity from the CRBRP into the TVA power system with a minimum of new transmission line construction. The existing TVA 161-kV power system in this area has been developed to supply relatively large quantities of power to the DOE complex from several generating plants and is capable 9
of receiving the power generated by or of supplying power to the CRBRP. The system is also capable of experiencing a total loss

of output from the plant without serious effects to the system. Off-site power requirements for the CRBRP dictate development of 13
a redundant power supply system that guarantees, under single contingency emergency conditions, sufficient quantities of electric power for the orderly shutdown of the CRBRP. Therefore, the plant will utilize transmission line connections for station service requirements which are distinctly separate and remote from the plant power circuit connections.

The DOE-owned Ft. Loudoun K-31 161-kV Transmission Line crosses 9
the proposed Site and will be utilized to provide emergency shutdown power. The DOE-owned line crosses the eastern edge of 9
the 161-kV switchyard. This permits the line to be opened and the two resulting sections to be connected to the station service switchyard by the installation of two short spans of conductor. This will provide reliable and independent power sources for station service in accordance with applicable NRC guides, 9
standards and criteria. The conductor will be removed from existing structures along the 0.5 mile of right-of-way (ROW) to its juncture with the Bull Run-Sequoyah 500-kV line and transferred to new structures on the eastern side of the expanded 0.5 mile ROW. One of the line connections will be from Kingston 13
and Bull Run Steam Plants via the K-31 switchyard and the other connection will be from the Ft. Loudoun Hydro Plant. At the juncture with the 500-kV line ROW. the DOE owned line will cross 9
under to two 161kV lines looped to TVA's power circuits through a protective safety structure engineered so that physical failure of either circuit would not endanger the station service line.

To connect the CRBRP generation into the area power system, TVA will utilize the TVA-owned Ft. Loudoun-Roane 161-kV Transmission Line which is located approximately 2.7 miles northeast of the CRBRP Site. This transmission line will be opened and the ends reconnected as shown on Figure 3.9-2, to two separate single- 13
circuit lines which will be constructed to the plant switchyard.

The proposed access utilizes right-of-way common with the Sequoyah-Bull Run 500-kV line. To accommodate the two 161-kV circuits along this 2.7 mile section, the existing 200-foot-wide right-of-way will be expanded an additional 160 feet. This will 13
provide 100 feet separation between the 161-kV circuits with 110 feet separation between the 500-kV circuit and the inside 161-kV circuit and 50 feet from the outer 161-kV circuit to the edge of the right-of-way. This corridor will require 62 acres of new right-of-way easement.

At the intersection of the 500-kV and the DOE-owned 161-kV, the
route turns southeastward and parallels the existing DOE-owned 9 13
161-kV Transmission Line to the CRBRP switchyard at point C, a
distance of approximately 0.5 mile. This section of parallel 9
line will be constructed so that the northern loop line will be
suspended on the existing DOE owned Fort Loudoun K-31 towers 13
while the southern loop line will be placed on new towers. The separation of the lines will be such that the northern loop will be on existing towers, the southern loop on towers 100 feet away, and the existing DOE circuit transferred to new structures 100 feet further away with the ROW edge 50 feet east of the third line. This 0.5 mile section will require approximately 10.6 acres of new rights-of-way.

The bases for determining the amount of horizontal separation that is provided for various voltage transmission lines are reliability, safety, good engineering practice, and past
experience. The proposed 100-foot separation between the 13
centerline location of the existing 161-kV line and the centerline of proposed 161-kV loop connection will provide the necessary reliability and operating safety required for the emergency shutdown power requirements of the Clinch River project.

3.9.8 DESIGN DESCRIPTION OF PROPOSED TRANSMISSION LINE

To connect the CRBRP generation into the area power system, a new loop connection will be constructed connecting the existing TVA-owned Ft. Loudoun-Roane 161-kV Transmission Line located approximately 2.8 miles northeast of the plant site. The loop connection will be constructed on separate rows of structures with adequate lateral separation to assure that the structural failure of one of the circuits would not jeopardize the integrity of the other circuit. |13

These transmission line connections will be designed to meet the medium design loading requirements of the National Electrical Safety code. In addition, TVA design cases provide for wind loadings of approximately 85 mile per hour winds on bare conductor and vertical loading strength based on one inch of radial ice. These loading conditions assure adequate strength even under extreme weather conditions.

Structures proposed for this loop connection will be compact, narrow based steel towers approximately 85 feet high with epoxy fiberglass crossarms six to eight feet long. Insulators will be gray in color and will blend with the gray epoxy fiberglass crossarms and galvanized steel used in fabrication of the towers. This combination of steel and epoxy fiberglass will assure minimum maintenance and maximum structural reliability. Foundations for these towers will be precast concrete sections designed for installation in an augered hole. The structures will be installed with approximately a 600-foot ruling span.

Each circuit of the loop connection will consist of three 2,034,500 C mil (1.68-inch diameter), 72/7 stranding ACSR conductors, one conductor per phase and one 7 No. 9 alumoweld shield wire. Wire tensions for the conductors and shield wire will be selected to assure that vibration damage will not occur. Long experience with transmission lines in the Tennessee Valley area have verified that where everyday tensions are kept below 18 percent of the ultimate strength of the cable, vibration will not be a problem.

Galloping of conductors is a condition that has never been observed on lines in the eastern portion of the TVA system. TVA has had only minor reports of galloping in its entire operating experience; these have occurred only on short span lines in the central and western portions of TVA's service area.

As stated earlier, shield wires will be installed on the loop connections to provide lightning protection for the circuits. Even though the lines are located in an area with an isokeraunic level of 50, TVA's experience has shown that the outages on similar type lines in this area varies from zero to three flashover interruptions annually per 100 miles of line. The use of circuit breakers with high speed reclosing relays results in the majority of these interruptions being momentary.

3.9.9 EXISTING SUBSTATIONS AFFECTED

No existing substation will be affected by the construction of the proposed CRBRP with the possible exception of some possible adjustments in switching facilities. The need for these facilities will be determined as the Clinch River Project develops. If such adjustments are deemed necessary, they will be very minor in nature.

TABLE 3.9-1

COMMUNITY TYPES OF THE PROPOSED TRANSMISSION LINE ROUTE

OF THE CRBRP SITE AREA

Segment A-B, Compartment-15 13

Stratum #	Forest Cover Type	Acreage %	On Site	13
	Hardwood:			
10	White oak - Northern and Southern Red oak	4.0		
18	Red oak - White oak	6.0		
	Pine:			
2	Shortleaf Plantation - 1948	1.5		
3	Loblolly Plantation - 1950	2.0		
5	Loblolly Plantation - 1951	4.5		
23	Loblolly Plantation - 1979	1.0		
	Hardwood - Pine - Cedar:			
9	Cedar - Virginia Pine - Red oak	3.5		
	Hardwood - Pine:			
12	Red oak - Shortleaf Pine	5.0		
20	Shortleaf Pine - Hickory - Yellow Poplar	3.0		
27	Woods - Roads	0.5		
		31.0		

TABLE 3.9-1
(Continued)

Segment B-C, Compartment-13 13

Stratum #	Forest Cover Type	Acreage %	On Site
	Hardwood:		
12	Cottonwood Plantation - 1979	0.5	
23	Red oak - White oak - Yellow Poplar	5.5	2.5
26	Red oak - Yellow Poplar	2.0	
31	Yellow Poplar - Red oak	2.5	2.5
37	Ash - Sycamore	0.5	
	Pine:		
1	Loblolly Plantation - 1951	7.0	
2	White Pine Plantation - 1951	4.5	
3	White Pine Plantation - 1952	1.5	0.5
10	Loblolly Plantation - 1979	6.5	3.0
43	Woods - Roads	0.5	—
		31.0	8.5

13

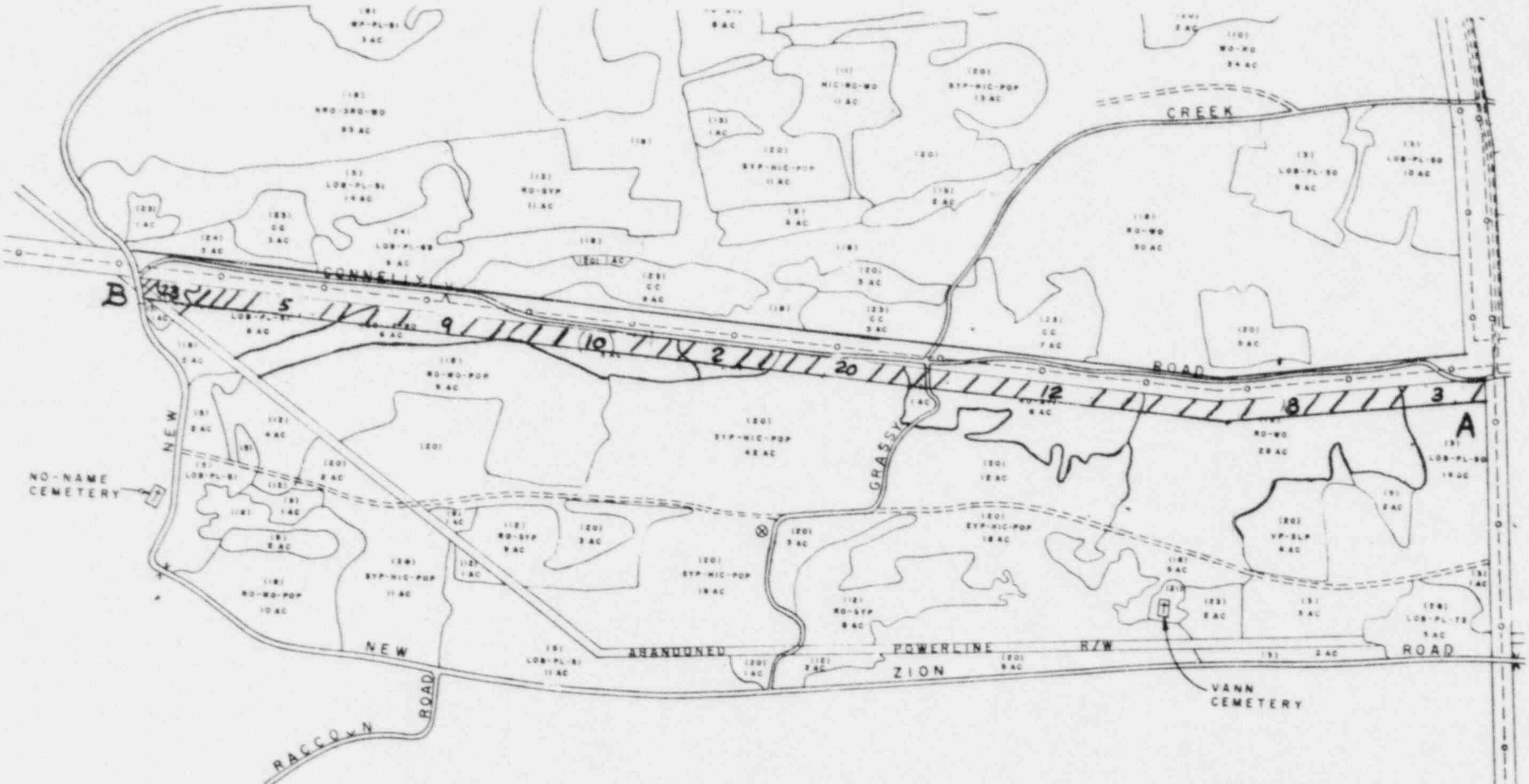

FIGURE 3.9-1a. Proposed Transmission Line Route of the CRBRP Area, Segment A-B, Compartment #14.

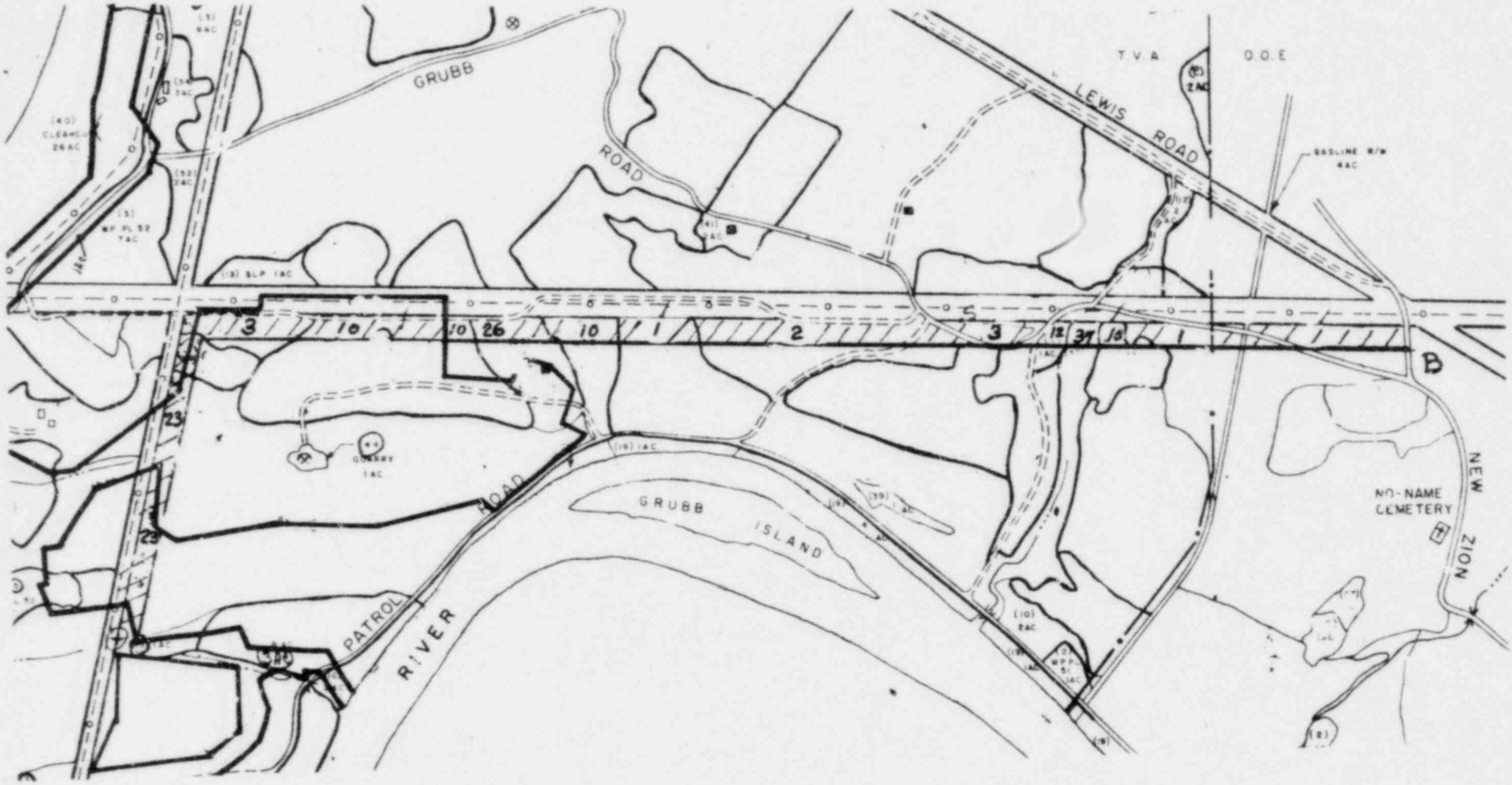

FIGURE 3.9-1b. Proposed Transmission Line Route of the CRBRP Site Area Segment B-C, Compartment #13.

13

9

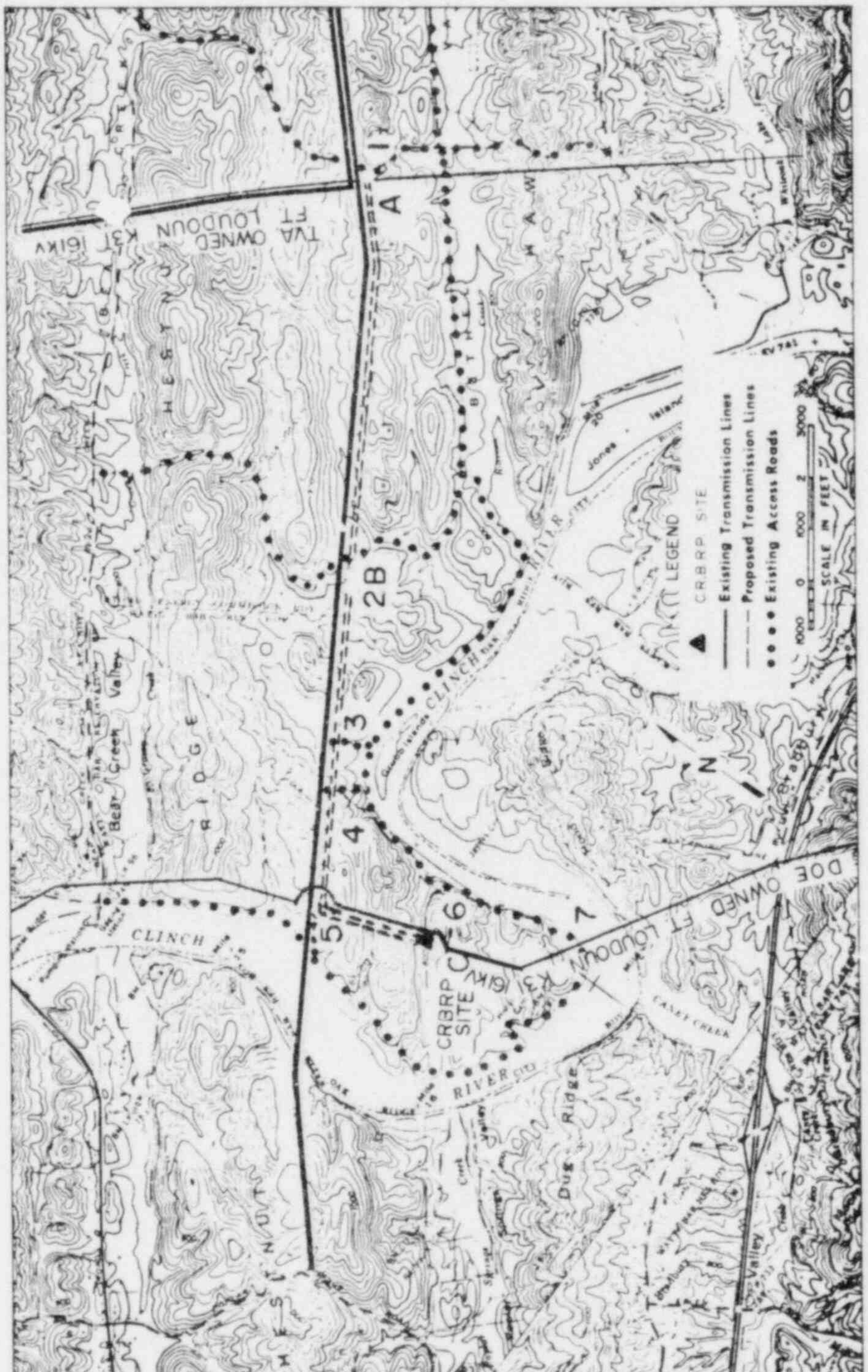

Figure 3.9-2 EXISTING ACCESS ROADS OF THE CRBRP SITE AREA

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4.0 ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

Discussion of the environmental effects that may be associated with site preparation and plant construction is divided into two general categories: (1) effect on land use and (2) effect on water use. Potential environmental effects from operation of the Clinch River Breeder Reactor Plant (CRBRP) are discussed in Section 5. Effects which are primarily social or economic in character are discussed in Section 8.

Site preparation will consist of clearing and grubbing,
excavation and backfilling, and construction of access roads, 9
rail lines, laydown and storage facilities, on-site quarry and
crusher facilities, and barge unloading facilities. Site 9
preparation and construction activities for the plant will cover
a period of approximately six years. The environmental 8 9
monitoring program as described in Section 6.1 will be employed
to monitor the impact of site preparation and plant construction.
This monitoring program will determine whether methods being
employed to mitigate impact are effective. 8

The Clinch River Site consists of approximately 1,364 acres,
nearly all in woodland. Of this total acreage, approximately 292 9 13
acres will be required for the CRBRP and related facilities, as
shown in Figure 4.1-1. Main plant buildings and surrounding land
within the security barrier, shown in Figure 4.1-2, will occupy
approximately 37 acres. Approximate amount of land area to be 9
affected by the various construction activities is shown in Table
4.1-1. Locations of temporary structures are shown in Figure 9
4.1-3.

Major impact on the terrestrial ecology from construction activities at the Site will be within the plant complex area of

approximately 37 acres and the quarry stockpile and crushing area 9 13
which may be as large as 60 acres. An additional security area
required for a 150' line of sight beyond the security barrier 13
will occupy approximately 19 acres. This area will be grassed
and mowed. The impact of the quarry, concrete batching and 9
mixing activity will be temporary, whereas the impact of the
plant complex will continue during the life of the plant. Other
smaller impacts of a temporary nature will arise from 9
construction of the barge unloading facilities, discharge pipes,
inlet pipes, river water pumphouse and lay-down areas. Permanent
impact consists of land area that contains facility buildings,
roads or railroads that will be disturbed repeatedly during the 9
life of the plant. Temporary impact consists of land area that
will be revegetated and is not expected to be repeatedly
disturbed during the life of the plant.

4.1.1 EFFECTS ON LAND USE

4.1.1.1 CLEARING AND EXCAVATION

Areas of the Site will first be cleared, grubbed and stripped
during the site-preparation phase. The plant area will undergo a
major land use change from woodland to industrial use. Trees of
commercial value will be harvested and removed from the Site in
accordance with the DOE Forest Management Program. 8 9

Open burning will be employed for disposal of forest slash 9
cleared from the Site in accordance with State and Federal air
pollution regulations. Burning will result in some releases of
particulates and gases into the atmosphere; however, these
releases will be local and generally short-lived. Non-
combustible waste and residue from burning will be buried on-site
and the disturbed area will be graded and seeded with appropriate 8
ground cover species to minimize soil erosion. 9

Topsoils in the areas to be excavated will be removed and stockpiled separately for subsequent use in landscaping. Topsoil thickness varies from 0 to approximately 12 inches. Subsequent to the removal of topsoil, the excavated material (except for the 4
on-site quarry), which will include residual overburden, 8
weathered and sound rock, will be utilized by direct placement methods to establish the required plant area grade elevation of 815 feet and to bring the main access roads and the railroad to the design gradient. 13

Depending on the degree of rippability of weathered siltstone and limestone, a pre-drilling and blasting pattern will be established to permit excavation to the required elevation for the Reactor Containment Building and its auxiliary buildings and 13
excavation of the quarry. For the Reactor Containment Building, 13
average excavation depths are expected to range from approximately 40 to 104 feet below the existing grade elevation. An average depth of excavation into sound siltstone of approximately 20 feet is anticipated. The quarry will be excavated from the side of an existing hill, with average 8 9
excavation depths expected to range from 40 to 100 feet below the existing grade. Multiple small blasts of dynamite will be used to facilitate removal of the material. Explosives will be used intermittently starting shortly after initial clearing and 6
grubbing and extending through the construction period. Raw water for aggregate washing and dust control will be recirculated through the aggregate wash settling pond which is designed for 13
total recirculation with no discharges of water required. Quarry operation will last approximately 4 years and will involve removal of between 1.0 and 1.7 million cubic yards depending on the quality of rock found. Disturbance from explosives will be 9 13
limited by use of small multiple charges to minimize noise, dust and vibration effects in the vicinity of the plant and quarry sites. Topsoil in the quarry will be scraped off, separately stockpiled and replaced over the quarry when excavating 9
activities have ceased. After quarrying operations have been

completed, all temporary facilities will be dismantled, excess materials will be hauled off-site for disposal and disturbed areas will be reshaped and replanted. The quarry floor will be covered in sequence with waste rock first, subsoil second and topsoil on top, such that each layer is shaped for drainage 9 before the next is evenly spread. Reclamation of the quarry will consist of loosening the topsoil and then planting a mixture of native grasses and forbs such as broomsedge, purpletop, aster, goldenrod, plume-grass and Lespedeza.

A concrete batch plant will consist of two identical central mix concrete plants, each rated at 100 cubic yards per hour, each with cement, flyash and aggregate storage and handling facilities with a common ice plant and boiler plant, all complete with parts and equipment for automatic operation. The cement and flyash handling facilities will be equipped with a reverse-air-flow pollution control system. All cement and aggregate from the wash out of transit-mix trucks will be processed through a waste water/concrete separator to reclaim waste cement and aggregate. Wash water will be recirculated, eliminating the need for an 13 impounding pond. Dust control will be maintained for truck traffic by sprinkling with water.

The site storm drainage system will be developed along with permanent site access roads, temporary construction roads, spoil and laydown areas to assure that construction activities will not interfere with natural watercourse runoff. Impounding ponds will be constructed to protect the river from suspended solids. These ponds will effectively contain most of the suspended solids and ensure that discharges into the river will be in accordance with the NPDES permit.

4.1.1.2 CONSTRUCTION FACILITIES

Because the CRBRP will be located in an undeveloped area, temporary construction facilities will be essential. Temporary construction buildings and facilities are to be arranged in an orderly manner to minimize the impact on terrestrial ecology, reduce land use requirements, expedite construction operations and facilitate routine groundskeeping. Acreage required for the temporary facilities are listed in Table 4.1-1. Following completion of the plant and termination of quarry operations, all 8
temporary facilities will be dismantled, excess materials will be hauled off-site for disposal and all disturbed areas will be reshaped and replanted. Utilization facilities such as laydown 13
areas, parking areas, plant site railroad spurs, concrete batch plant areas and areas assigned to various contractors are time sequenced to minimize requirements. They are indicated in 9
Figures 4.1-1 and 4.1-3.

4.1.1.3 ACCESS FACILITIES

No off-site construction of new roads is planned, however, some 8
off-site road improvements may be necessary. Bear Creek Road which parallels the northern boundary of the Site is a paved two-lane road with little traffic in the vicinity of the Site. A gravel road, River Road, parallels the river on the Site property. Plans call for improving and paving that portion of River road from its junction with Bear Creek Road to the plant as shown in Figure 4.1-1. Access to the quarry will be provided by a gravel road of approximately 0.3 mile connecting with the 8
Concrete Batch Plant. The quarry haul road will be built along natural contours to minimize erosion. 9

Railroad access to the Site will consist of a spur line from the existing rail facilities at the Oak Ridge Gaseous Diffusion Plant north of the Site. The railroad will enter the Site on the northwest corner and will run parallel to River Road and connect to the various plant buildings as shown in Figure 4.1-3. Total on-site land area required for construction of access roads and railroad is estimated to be approximately 30 acres. In addition, approximately four acres will be required for the off-site portion of the railroad. 13 9 13

The improvement of the existing road and the construction of the railroad spur will require an existing culvert passing beneath them at Grassy Creek and another adjacent to Bear Creek Road to be extended to accommodate the granular fill on which the access road and railroad will be constructed. A new culvert will be installed in an existing ditch near Gallaher Bridge and an existing box culvert at Grassy Creek will be replaced with a corrugated metal pipe. Embankment slopes below maximum pool elevation (745 feet) will be protected by riprap. 13

The barge-unloading facility, indicated on Figure 4.1-1, will be constructed on the right bank facing downstream of the Clinch River for the purpose of unloading large construction equipment or large plant components such as the reactor vessel and guard vessel, turbine generator, stator, diesel generator, etc. The concrete slab on piling type of barge unloading facility will occupy a 185 by 125 foot area recessed into the river bank at latitude 35° 54' 11"N and longitude 84° 23' 16"W. One one side and one end of the area, steel sheet piling will be driven to form two sides of the area to be excavated. Approximately 11,000 cubic yards (5,000 cubic yards below minimum water level, elevation 735 feet) of sandy silt material will be removed from the river bank using clam-shell and/or dragline, deposited, and spread at the adjacent disposal location. Except for the dredging, all work will be accomplished without disturbing the river. In order to control turbidity and preclude dredged material from returning to the river, a dike will be constructed around the disposal area. Approximately 700 cubic yards of sand will be placed on the bottom of the slip to cushion grounded barges during unloading of the major nuclear components. The 13 7 13 9 sequence of construction will be as follows: (1) drive piling; (2) construct concrete slab; (3) excavate bottom and (4) place sand as required. Approximately 600 linear feet of shoreline will be disturbed during barge-unloading facility construction. 9

Telephone lines needed during construction and operation will be installed along the site access road. Electric power will be taken from existing transmission lines (1) following completion 8 of the construction substation. Prior to this time, electric power will be supplied by the City of Oak Ridge or by portable 13 generators.

4.1.1.4 CHEMICAL WASTES

Major chemicals used on-site during the construction period include soaps, detergents, paints, cleaning fluids, concrete admixtures, chemical fire extinguishers, sweeping compounds, oils and fuels such as propane, gasolines and diesel oil. The dissemination, release, or spillage of such materials on the Site will be controlled in accordance with applicable State and 9 Federal regulations. Spill prevention control plans will be developed and submitted per EPA requirements.

Used oil will be hauled off-site and disposed of. The use of 9 fire extinguishers is expected to be minimal, but, if they are 8 used, the waste will be cleaned up and buried off-site. Soaps and detergents will be directed to the construction sanitary 13 system. Sweeping compounds will be disposed of off-site or buried on-site. All potentially hazardous materials will be transported and/or disposed in accordance with appropriate 9 13 Federal and State requirements.

4.1.1.5 SANITARY AND OTHER WASTES

The sanitary system for the construction period is designed to accommodate 2450 persons. Average daily sanitary waste water 6
design flow will be 61,250 gallons or 25 gal/person/day. 13
Sanitary wastewater will be treated in packaged sewage treatment systems prior to discharge into the Clinch River. All wastewater discharged into the Clinch River will comply with NPDES Permit conditions. If necessary, chemical toilets will be used in 13
isolated or remote areas. Further details of the sanitary system 9
may be found in Section 3.7.

Conventional garbage will be generated during construction. This waste will be collected by an outside contractor and disposed of off-site in a local disposal facility. No incineration of garbage will be allowed on the Site.

4.1.1.6 IMPACTS ON TERRESTRIAL ECOLOGY

The most significant effects of the CRBRP on the terrestrial ecology of the area will occur in connection with site-preparation activities and with plant construction. A smaller impact will result from construction of the railroad and access road. Impacts associated with transmission line construction are discussed in Section 4.2. Site biota will be affected by construction, but the effects are expected to be minor. 9

Approximately 292 acres (on-site plus off-site excluding the 13
transmission line discussed in Section 4.2) of land surface will be disturbed by construction of the CRBRP. Community types, acreages and percentages of each are listed in Table 4.1-2 based on disturbance locations shown in Figure 4.1-1 and vegetation 9
types shown in Figure 2.7-6. Approximately 203 acres (70 13
percent) of disturbance land is covered with four communities including hardwood, pine plantation, cedar-pine and hardwood-cedar. Three community types will have more than 20 acres 13

disturbed representing approximately 171 acres (59 percent of disturbance land). Approximately 89 acres of non-forested including clear cut areas, powerlines, quarry area and inundated 13 land will be disturbed by construction activities. The 292 acres of disturbance land constitutes only 0.7 percent of all land on the 36,993 acre Oak Ridge Reservation (ORR). 13

Construction activities will disturb terrestrial biological survey sampling locations in communities D, E, F, G and I, shown in Figures 2.7-7, 2.7-A and 2.7-B. Community C was harvested in 1975 and converted to a shortleaf pine plantation in 1976 and will be partly disturbed by the quarry. Maintenance of the terrestrial biological survey sampling locations is not required. 10

Planned forest management activities on the CRBRP Site from 1974 through 1976 included thinning hardwood forests on Chestnut Ridge and all pine plantations, limited harvest cutting, southern pine beetle control cuttings and pitch canker fungus control cuttings.[2,3] Approximately 500 acres were affected by pine thinning and by cuttings to control southern pine beetle and pitch canker.[3] Approximately 25 acres of shortleaf-Virginia pine successional forest (Community C of Figure 2.7-6) was clearcut and replanted to shortleaf pine in 1976.[3] Hardwood thinning on Chestnut Ridge disturbed approximately 50 acres.[3] Seventy-seven acres of shortleaf pine plantation-1954 were clearcut to control pitch canker.[2] This included all of the shortleaf pine-1954 plantation listed in Table 4.1-2. Forest tree growth and reproduction are expected to increase following these thinnings. Timber on disturbance land will be harvested as part of site cleaning activities.

Construction activities have been planned to avoid all rare community types and rare plant species discussed in Sections 2.7.1.3.3 and 2.7.1.3.4. 9

Wildlife will be affected in proportion to effective habitat loss. White-tailed deer (Odocoileus virginianus) utilize the relatively open cedar-pine and mixed hardwood communities where browse and cover are available. Forest thinning provided additional relatively open habitat and additional browse and cover. Construction clearing and other activities are expected to decrease deer habitat and populations on the site by approximately 20 percent. Population reductions of gray squirrel, raccoon, gray fox, opossum and bobcat are also expected to be approximately 20 percent since they occupy forestland. Wildlife residing in open

to motorists crossing the Gallaher Bridge. Construction of facilities
associated with the main plant (e.g., water intake and discharge, railroad
extension and barge unloading area) involves only low height equipment 6
and structures. Approximately 10 homes on the southern side of the Clinch
River will have a limited view of some portion of plant construction.

No provision for living quarters will be made for workers or their
families on the Site. Housing and school facilities will be available
in nearby communities as discussed in Section 8. The peak construction
force is estimated to be approximately 5,400 persons. 10 6 8

Full compliance with fire laws and regulations will be considered a
necessity and a fire plan will be proposed that will set forth in detail
the plan for prevention, control and extinction of fires on and in the
vicinity of the project area and quarry site. 8

Several archaeological sites have been investigated in the area as
described in Section 2.3; however, all field work at these sites was
completed as of April 30, 1975. The Hensley family cemetery, described 8
in Section 2.3, is located on the tip of the peninsula and is to be
preserved with the family retaining the right of access. The cemetery
is not in the immediate construction area. Care will be exercised
to insure that the cemetery remains intact. 9

4.1.1.8 MITIGATION OR REVERSAL MEASURES

Mitigation or reversal measures will include erosion control by regular
leveling of rutted areas and maintenance of present gradients or contours
where possible. Potential erosion due to rain, run-off or seepage and
dewatering activities during excavation will be controlled by the construc-
tion of drainage ditches around the periphery of all stockpile areas and 8
at the base of designated excavation slopes. Drainage water will then be
collected in sumps and either pumped or permitted to flow under gravity

to settling basins prior to discharging into the Clinch River.
Land erosion control and slope protection followed during
construction will complement the landscaping which will be 8
initiated as soon as the construction schedule permits. The 9
quarry area will be reclaimed as discussed in Section 4.1.1.1.

During the construction period, train and barge arrivals are
expected to average less than one per day. Truck traffic will be
confined to established roads (Bear Creek Road or Oak Ridge
Turnpike) leading to the Site. Normal state highway regulations
will apply to the highways leading into the Site. Control of 9
truck traffic will be exercised by the applicant with on-site
truck traffic strictly controlled by a security force.(1)
Traffic regulations on-site will be in accordance with guidelines
established by the constructor. On-site roads will be repaired, 8
upgraded or paved to handle construction traffic.

Dust will be stabilized by water sprinkling on roads and in the construction area. Airborne dust, smoke from burning forest slash, diesel fumes and chemical odors will create only a temporary nuisance in the area with no long-term detrimental effects.

A Site storm drainage system will be developed in the vicinity of Site access roads, temporary construction roads and spoil laydown areas to insure minimal effect from natural water course runoff.

Rainfall runoff will flow to impoundment ponds for control of
settlable solids and be discharged through a sand filter. To
meet NPDES conditions five impoundment ponds and a quarry pond
will be designed to process the 10 year, 24 hour storm in 13
addition to anticipated dewatering flows. Rainfall runoff from
storms greater than the design event will be discharged by means
of a riser overflow pipe. Pond outlets will be provided with an
energy dissipation structure to minimize potential erosion caused
by the discharge to the river.

Scrap combustible materials are planned to be removed from the Site by contractors or disposed of on-site in accordance with applicable regulations. A demolition fill area (spoil area 6 on Figure 4.1-1) for scrap, non-combustible materials such as broken 9
concrete, miscellaneous metal, boulders or concrete blocks will be established on-site.

4.1.2 EFFECTS ON WATER USE

4.1.2.1 WATER USE

Water used during the site preparation, plant construction and quarry preparation and operation will come from two sources; raw water from the Clinch River and potable water from the Bear Creek Water Filtration Plant. 8

Raw water will be used in dust control, compaction of fill material and aggregate crushing and washing, with a peak demand of less than 60,000 gallons per day. Water for the quarry operations will be initially pumped from the Clinch River and then recycled through a settling basin, with makeup from the river required only for losses and evaporation. The intake for water drawn from the Clinch River will be floated to insure sediment is not disturbed. 13

Potable water will be used in fire protection, sanitary facilities and production of concrete with a peak demand of 150,000 gallons per day. It is presently planned that potable water from the Bear Creek Filtration Plant will be piped to the site along existing roadways. Further into the construction period, the supply system will consist of a yard storage tank with make-up water coming from the potable water supply.

4.1.2.2 GROUNDWATER

Movement of groundwater at the Site is from groundwater highs to adjacent groundwater lows and hence to the Clinch River which serves as a ground water sink to the Site area. Thus, the Clinch River acts as a barrier to the movement of groundwater from the Site to the wells and springs presently in use south of the Clinch River, as discussed in Section 2.5.

During excavation, perched water tables and seep areas may be encountered and will be controlled by installing drainage ditches at the bottom of designated slopes and by installing drain pipes into the rock foundation. 8

Water will be collected in sump pits located at the periphery of the 8
excavated slopes to permit pumping to a holding basin for settlement of
suspended solids prior to discharging into the river. Since the normal
river water elevation is 741 feet, it is anticipated that additional
dewatering control and rock treatment may be required from elevation 741
to the base of excavation at 712.5 feet, primarily in the weathered lime- 8
stone on the east side of the excavation (plant north as reference).
The normal pattern of groundwater movement to the river will be restored
after the plant has been constructed and backfill has been placed around
the structures.

4.1.2.3 IMPACT ON AQUATIC ECOLOGY

Construction of the River Water Intake Facility, Plant Discharge Structure and Barge Unloading Facility on the Clinch River will necessitate excavation and dredging, fill placements (including riprap) and other construction activities below normal water level, elevation 741 feet. In addition, limited dredging and placement of fill (including riprap) below elevation 741 feet will be required for improvement of the access road and construction of the railroad spur. Impact of these construction
activities on various forms of aquatic life, benthic habitat and other 7
aquatic uses is expected to be minor and of short duration.

During construction of the barge unloading facility, the proposed construction sequence, described in Section 4.1.1.3, will tend to minimize siltation in the Clinch River. Only 0.4 acre of river bottom below the 741-foot elevation will be disturbed during construction. Dredging will be from the river bank near river mile 15.0 and the dredged material (as will all dredged material resulting from the intake and discharge structures, access road and railroad construction) will be deposited and spread in an existing depression at a disposal site located adjacent to the barge unloading facility. Precautions, such as perimeter retention mounds, will be taken as required to control turbidity and preclude dredged material from returning to the river.

Revised positioning of the barge unloading facility results in an estimated dredging of 11,000 cubic yards of material, and filling with 700 cubic yards 9 of sand. This disturbed area is more limited than that previously planned, so adverse impacts are expected to be correspond'ngly reduced.

Construction of the intake and discharge facilities will impact approximately 0.22 and 0.06 acres, respectively, of river and shoreline below elevation 741 feet. A cofferdam will be constructed near the location of the river water pumphouse to permit work to proceed "in the dry." This cofferdam will eliminate siltation in the river during construction of the pumphouse. However, some turbid water will enter the river during cofferdam construction.

7 The limited dredging and placement of granular fill and riprap associated with the access road and railroad will impact less than 0.8 acre of existing river bottom below normal water level. Dredging and excavation activities, in summary then, will be limited to several small areas of the right bank and river bottom of the Clinch River between CRM 9 14 and 18, amounting to less than 1.5 acres. The impact of these construction activities is minimal and is expected to be of relatively short duration. Impacted aquatic organisms are expected to recover within a relatively short period.

A baseline survey, as described in Section 2.7.2, was conducted on the Clinch River at the Site to identify and characterize the existing biological communities. The results of this survey indicate that communities in areas where construction impact may occur are dominated by common chironomid and oligochaete species. These species will recover rapidly in the construction area. Fish species are expected to avoid areas of high turbidity and will not be impacted by construction activities.

TABLE 4.1-1

APPROXIMATE LAND AREAS AFFECTED BY CRBRP
CONSTRUCTION ACTIVITIES 10

Category	Acres Disturbed Temporary	Acres Disturbed Permanent	
Access Roads and Railroads (on-site)	30	30	
Access Railroad (off-site)	4	4	
Parking Area	19	2	
Barge Unloading Area	4	4	
Impounding Ponds	7	7	9 13
Quarry Including Stock Pile Area, Crusher and Facility	60*	-	
Concrete Batch Plant	5	-	
Riverwater Intake, Pumphouse, Discharge Line	6	.5	
Spoil Areas and Sanitary Land Fill Area	43*	-	
Storage and Other Work Areas	67	-	
Permanent Plant Buildings and All Land within Security Barrier	37	37	
Meterorological Tower Areas	10	10	
Additional Security Areas Required For 150 foot line of sight beyond security barrier - to be grassed, mowed - not restored to original condition	-	19	
TOTAL	292	113.5	9

*All May Not Be Required 13

TABLE 4.1-2

PLANT COMMUNITY TYPES AFFECTED BY CRBRP CONSTRUCTION*

Stratum #	Community Type	Acreage	Percent Of Disturbed Land
	Hardwood		
23	Red Oak-White Oak-Yellow Poplar	29	
24	Red Oak-Hickory-Yellow Poplar	11	
26	Red Oak-Yellow Poplar	3	
28	White Oak-Red Oak-Yellow Poplar	17	
31	Yellow Poplar-Red Oak	2	
33	Sweetgum-Virginia Pine-Sycamore	1	
35	Elm Boxelder-Ash	4	
Total Hardwoods		67	23%
	Pine Plantation		
3	White Pine Plantation	15	
5	Virginia Pine-Plantation	3	
7	Loblolly Plantation 1954	8	
10	Loblolly Plantation 1979	16	
13	Natural Pine	3	
Total Pine Plantation		45	15%

13

TABLE 4.1-2 (Continued)

Stratum #	Community Type	Acreage	Percent Of Disturbed Land
	Successional Pine		
6	Short Leaf Pine-Virginia Pine-Plantation	6	
9	Virginia Pine-Short Leaf Pine-Plantation	7	
	Total Successional Pine	13	5%
	Cedar Pine		
15	Cedar	49	
16	Cedar Natural Pine	10	
	Total Cedar-Pine	59	20%
	Hardwood Cedar		
18	Cedar-White Oak-Red Oak	13	
19	Cedar-Ash-Hackberry	2	
21	Red Oak-Cedar-Yellow Poplar	2	
	Total Hardwood-Cedar	15	6%
	Hardwood Pine		
20	Red Oak-Short Leaf Pine	3	
	Total Hardwood-Pine	3	1%

13

TABLE 4.1-2 (Continued)

Stratum #	Community Type	Acreage	Percent Of Disturbed Land
	Hardwood-Cedar-Pine		
27	Southern Red Oak-Poplar-Short Leak Pine	1	
	Total Hardwood-Cedar-Pine	1	<1%
	Non-Forested		
39	Non-Forested	5	
40	Clearcut	54	
42	Powerlines	11	
43	Roads	16	
44	Quarry	1	
45	Inundated Land	2	
	Total Non-Forested	89	30%
	TOTAL	292	

* On-site plus off-site excluding transmission line.

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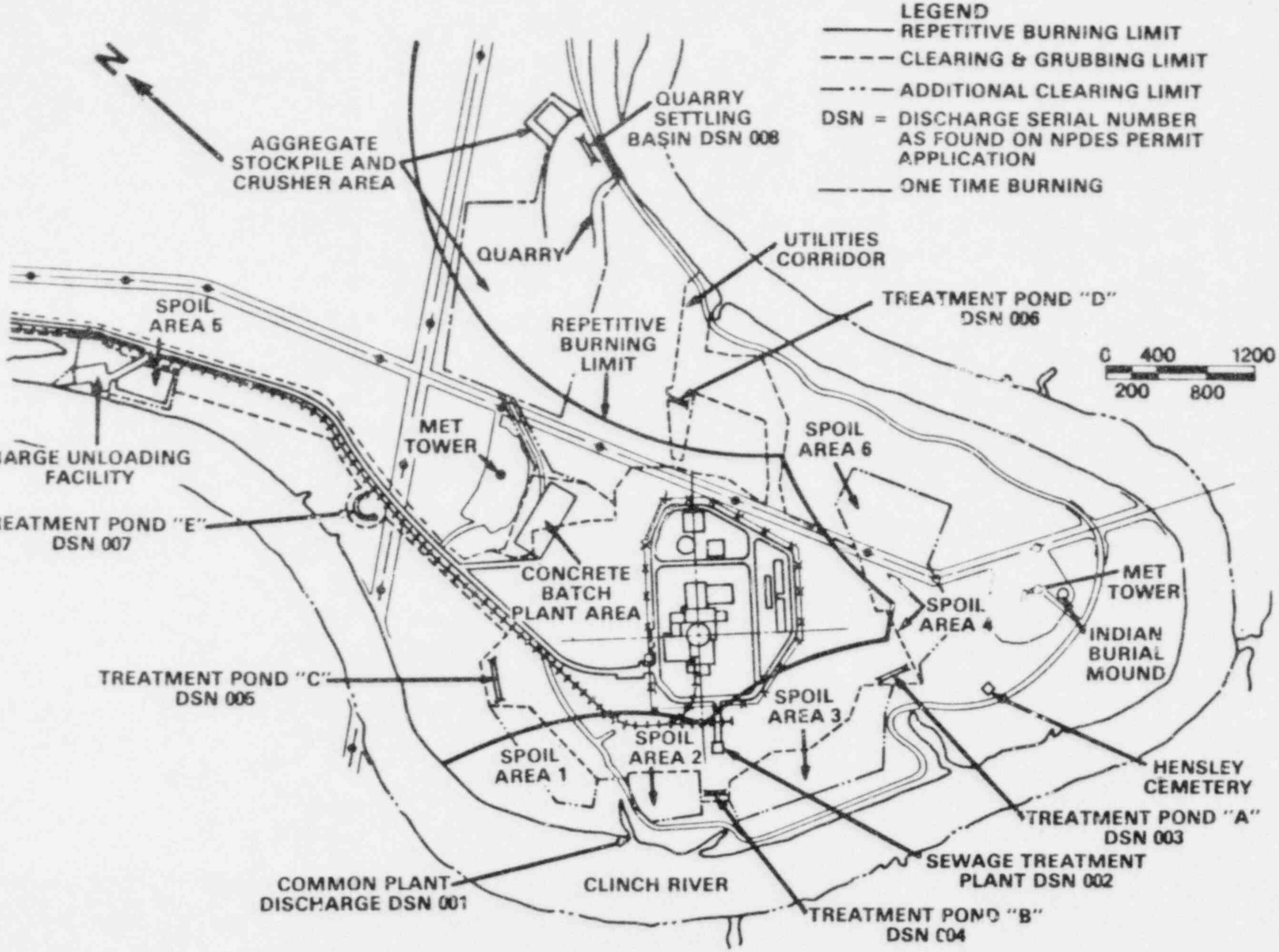

FIGURE 4.1-1. **Site Construction Layout**

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AMENDMENT XIII
APRIL 1982

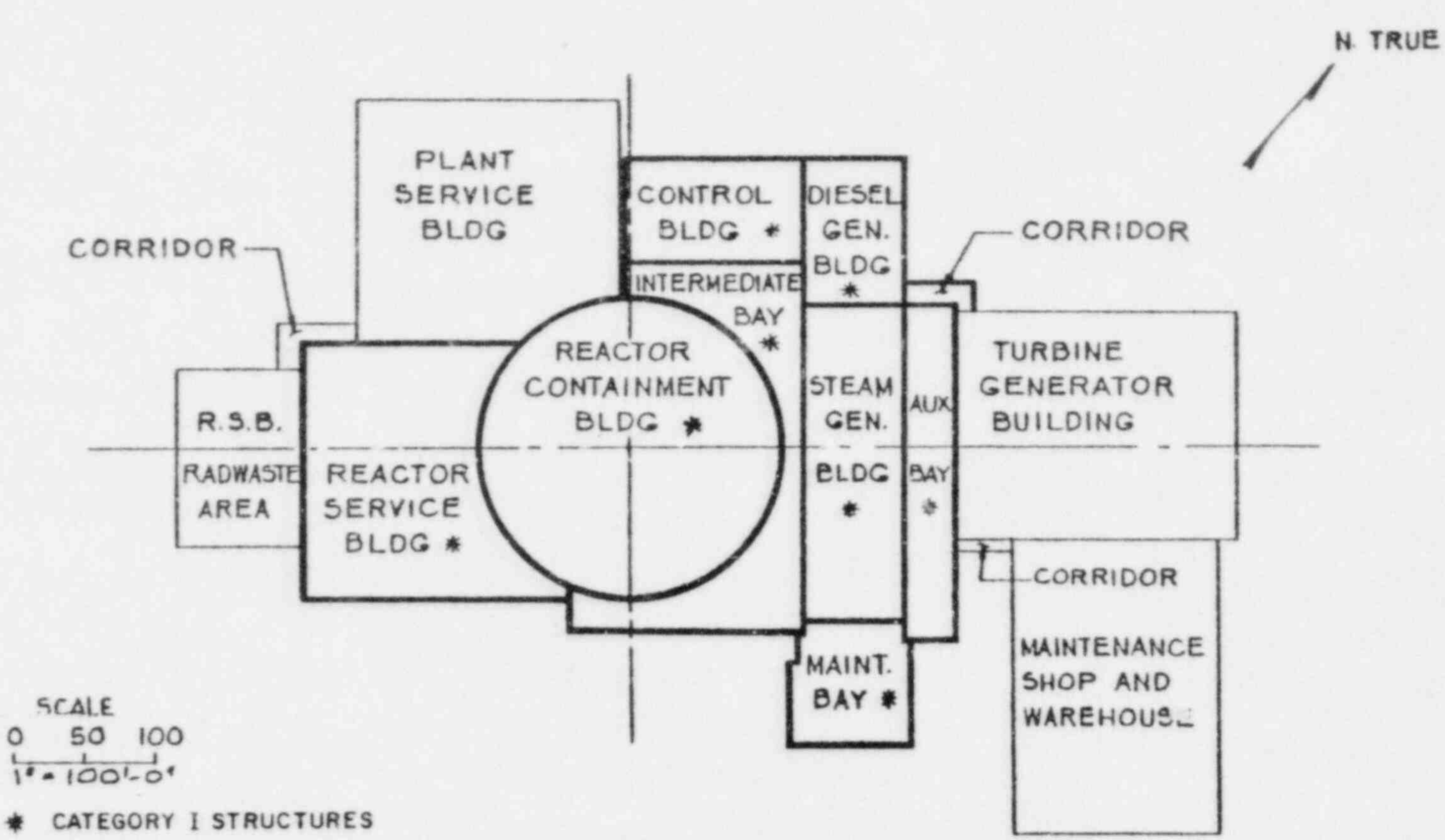

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Figure 4.1-2 ARRANGEMENT OF PLANT STRUCTURES

AMEND. IX
OCT. 1981

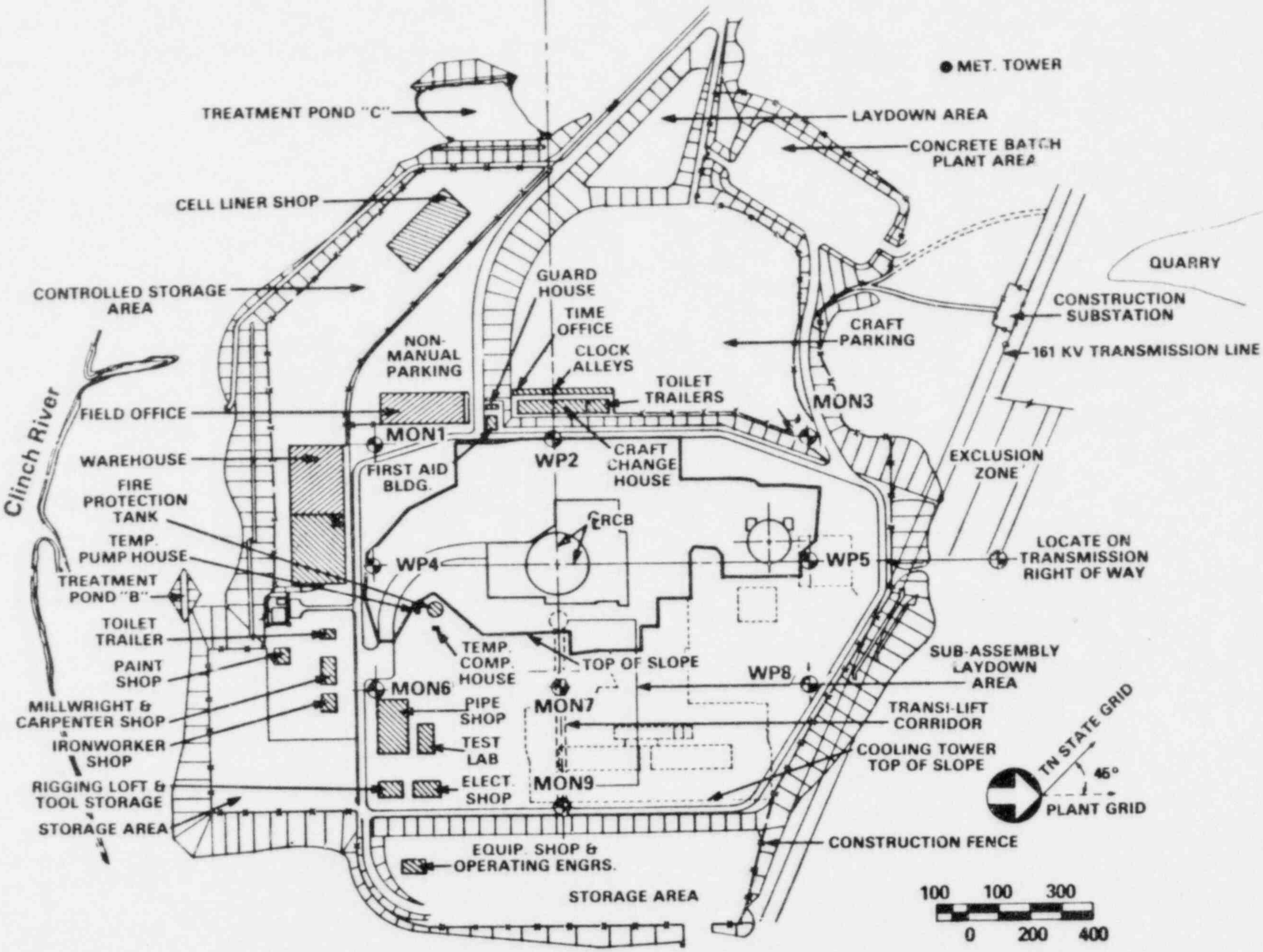

Figure 4.1-3 **Temporary Construction Facility Layout**

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4.1-25

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4.2 TRANSMISSION FACILITIES CONSTRUCTION

The proposed transmission line will connect the CRBRP switchyard with a TVA-owned Ft. Loudoun-k31 161-kV line located approximately 2.7 miles northeast of the plant site as shown in Figure 3.9-1. Two separate single-circuit 161-kV transmission lines on 2.7 miles of a 160-foot wide and 0.5 mile of a 150-foot wide right of way (ROW) will be cleared 13
parallel and adjacent to existing right-of-way (ROW). A detailed description of the proposed transmission line and structure design is contained in Section 3.9.

Environmental effects as a result of transmission line construction are unavoidable. The corridors for constructing these transmission lines have been located so that no private property owners are involved. Approximately one-half of the required line construction will be located on TVA's Watts Bar Reservation and the remainder on DOE property. 9
The conversion of woodland to open habitat destroys a large amount of vegetation and the habitats of numerous forest-dwelling species. It creates habitats for fewer species which are adaptable or originally suited to brushy and open conditions.

Clearing the acreage, moving heavy equipment along the ROW and access roads and installation procedures will mean some soil erosion and possible stream siltation. Such effects will be minor and short-lived; care will be taken and revegetation will be carried out quickly.

Open burning to dispose of forest slash cleared from the ROW will result in the release of some particulates and gases to the atmosphere. These effects on air quality will be local and short-lived. All construction waste and other trash will be transported to a designated land fill or dump.

In general, both the transmission lines and the cleared ROW's can have a visual impact on the environment. However, the Clinch River Site is in a secluded area that has been inaccessible to the general public for many years. The topographic features which provide natural screening and the continuation of a limited access policy for the area will minimize visual impact of the transmission lines.

4.2.1 ACCESS ROADS

Although specific access routes will not be selected until line structure locations are finalized, it is anticipated that existing roads, portions of the Bull Run-Sequoyah 500-kV transmission line ROW now used for maintenance access and the proposed transmission line ROW will satisfy future construction and maintenance access requirements. The majority of these roads have restricted access, are gravel surfaced and are regularly maintained. Locations of these roads are shown in Figure 3.9-2. Moving construction equipment onto the ROW will likely cause some rutting on existing roads. Temporary drainage ditches, to direct rain water off the roadways, terracing and ground cover will be provided as needed to prevent excessive soil erosion.

Following construction, access and maintenance roads will be restored or upgraded to equal or better than original condition. Rutted gravel roads will be leveled and resurfaced with gravel.

4.2.2 RIGHT-OF-WAY CLEARING METHODS

Construction of the proposed lines on the preferred route will involve clearing of approximately 58.2 acres of woodland and old field communities for which "shear clearing" methods (clearing of trees and other vegetation to the ground level) will be employed. On steeper slopes or rocky outcrops, conditions may necessitate hand-clearing with power saws and piling brush in scattered brush piles along the edge of the ROW. It is expected, however, that nearly all clearing will be done by bulldozers with cutter blades which mechanically cut all vegetation off at ground level.

the ROW for an extended period of time. The small amount of soil and smaller rocks that are not replaced in the hole will be leveled around the base of the tower.

Whenever stream crossing is necessary, construction vehicles will use established bridges, construct temporary bridges or perform the work on each side of the stream rather than disturb the existing channels.

4.2.5 SOLID WASTE DISPOSAL

In compliance with State and Federal air pollution guidelines, open burning will be employed for disposal of all cleared vegetation. This will result in particulate and gas releases into the atmosphere. However, these effects will be local and short-lived. The use of a chipper was explored but found to be prohibitively expensive along the transmission line.

In general, other solid waste generated by transmission line construction will be very small. These minor construction waste items consist of protective wood cribbing attached to conductor reels, cardboard shipping cartons and steel bands used to bind structural items and other line hardware. All waste material which accumulates will be transported to approved dumps or landfill sites. All trash and garbage will also be regularly carried out of the area. Portable sanitary facilities will be provided for construction workers.

4.2.6 RESTORATION

The ROW will be restored by grading (where necessary) and soil will be cultivated, fertilized at the rate of 400 pounds of Triple 13 fertilizer per acre and seeded with Kentucky 31 fescue. Reseeding will be accomplished as quickly as possible to control erosion and enhance appearance. Revegetation potential of the CRBRP area is shown in Figure 4.2-3. Following the initial seeding, native herbs, shrubs and tree seedlings will be allowed to invade.

4.2.7 VEGETATION

Construction of the proposed transmission line necessitates the clearing
of approximately 60.5 acres of forest land and approximately one acre of
existing woods roads. Acreages of forest types to be cleared 13
are listed in Table 4.2-1. The open shrubby areas are being invaded
by seedlings and sapling hardwood species. More detailed descriptions
of these vegetation types can be found in Sections 2.7 and 3.9. None
of the acreages in question is under cultivation.

Clearing of the wooded and old field communities on the proposed corridor will produce approximately 58 acres of new open shrubby habitat.

4.2.8 WILDLIFE

Hardwood (especially mixed oak) and hardwood-conifer community types
were found to have the highest species diversity for mammals, avifauna
and herpetofauna, as shown in Section 2.7. Approximately 60.5 acres or
98 percent of the total cleared area consists of these cover types. 13
In contrast, pine plantations and other predominately pine forest types
support relatively few species except that winter avifauna populations
in conifer habitats were much higher than in deciduous habitats as shown
in Table 2.7-18.

The removal of wooded acreage means a loss of habitat available to forest-
dwelling species. The gray squirrel and the Eastern chipmunk live in
hardwood forests and the squirrel, especially, depends on nuts for food.
Ruffed grouse inhabit deciduous woodlands in summer and coniferous stands
in winter. All three species will probably emigrate to surrounding hab-
itats as the transmsission corridor is cleared. The unsuitability of
some habitats, population pressures in suitable ones and increased sus-
ceptibility to predators will eventually decrease these animal populations.
Raccoons will also lose preferred habitat. They are generally a species 9
found in wooded areas near lakes or streams, although they may forage in

open areas; acorns are a main fall and winter food. Opposums may also experience a loss in numbers as they are woodland animals which may, like the raccoon, forage in open fields. Skunks, which prefer forest edge and open meadow, may increase slightly in numbers with the creation of new fields.

Although deer need woodlands for food and cover, they may browse the vegetation in open fields. Rabbits and woodchucks may increase in numbers with the development of shrubby field areas. The short tail shrew is a species with no restricted habitat requirements and will probably not change in numbers with the conversion of woods to fields. The effect of clearing on white-footed mouse populations will probably be minor as these species will inhabit brushy and open areas. The golden mouse, however, is mainly a forest species and will lose habitat.

Hawks, owls and foxes may experience no number change. They will probably search the open areas for prey.

Other species will gain preferred habitat as a result of corridor construction. Bobwhite quail, especially, may increase in numbers with the expansion of their favored open field habitat. Mourning doves may forage in the weedy areas and several species of songbirds may utilize the ROW for nesting and feeding. In general, however, the number of bird species utilizing the area will decrease with the conversion to open fields.

The number and variety of herpetofauna in the area will also decrease as the acres of mixed oak forest are eliminated. Construction will cause destruction of habitats in the ROW and the loss of some animals which depended on those specific environmental conditions. Different species and species with less specific habitat requirements will invade the ROW only after sufficient cover has developed. For a more detailed discussion of habitat requirements of fauna in the transmission line area, see Section 2.7.

4.2.9 AESTHETIC EFFECTS OF CONSTRUCTION 9

The proposed corridor will pass through an area that is approximately 95 percent forested. No construction will be done in sensitive areas such as the following: marshlands; wildlife refuges; parks; National and State momuments; scenic, recreational, or historical areas; or national forests.

Access to the area is controlled by security patrols and/or locked barriers. 8
There are no houses within the controlled area. Therefore, most of the
clearing and construction operations will not be witnessed by the general
public. The exception to this is in the area where the proposed corridor
meets White Wing Road, as shown in Figure 3.9-1. Motorists on this road
will see the clearing operations for the 160 foot wide ROW and the con-
struction of transmission line facilities for a few hundred feet of the rights
of way; however, a hill prevents a direct view down the transmission 13
ROW. The corridor is perpendicular to White Wing Road where the road
makes a sharp curve and consequently, viewing time will consist of only
a few seconds and the motorist will not have a direct line of sight. The
additional aesthetic impact of new pole structures will also be minor
compared to the visual impact of the existing towers and lines.

TABLE 4.2-1

WOODY PLANT COMMUNITIES AFFECTED BY THE PROPOSED CRBRP TRANSMISSION ROUTE

Community Type	Acreage Compartment-13	Acreage Compartment-15	%	
Hardwood	11	10	34	
Pine	19	9	46	9
Hardwood Pine Cedar		3.5	6	
Hardwood Pine		8.5	14	
	30	31	100	13

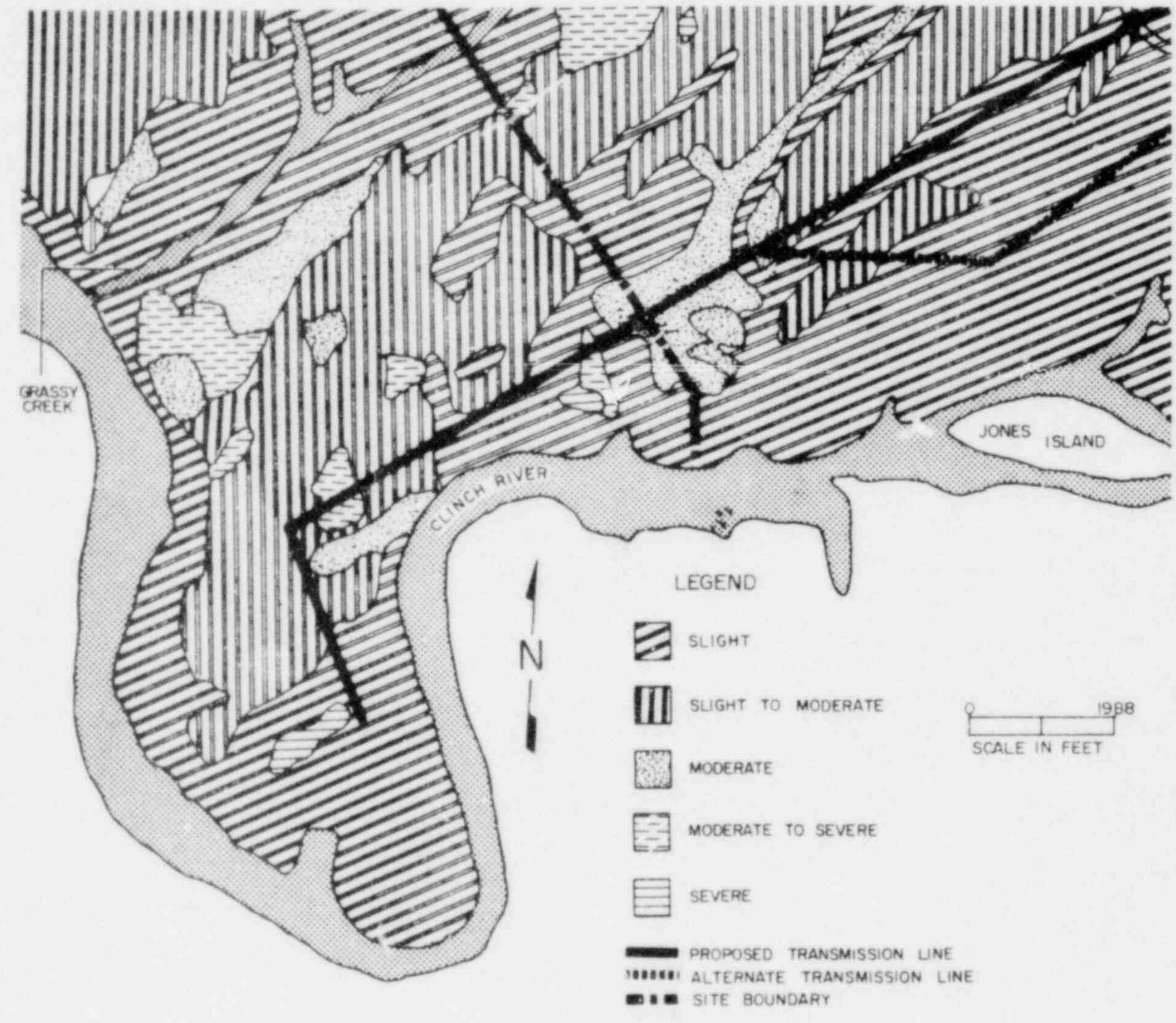

Figure 4.2-1 SOIL ERODIBILITY OF THE CRBRP AREA

total average flow. Hence, the potential quantity of plankton, fish eggs and larvae lost in transit through the plant will not be significant.

Estimates of the fish eggs and larvae which may be entrained by the CRBRP have been made during the aquatic baseline survey. Results of this sampling are shown in Table 5.1-12. Eggs were most abundant in collections from mid-May through early June and were evenly distributed among the transects. Most of the dominant fish at the Site lay adhesive demersal eggs in shallow water and these eggs would not normally be 7
entrained. Field observations and sampling results do not indicate that important concentrations of eggs or larvae occur in the area of the proposed plant intake.

Though entrainment may have only sublethal effects on plankton organisms, the most conservative estimate of 100 percent entrainment mortality is considered in this section. Using this estimate the quantity of plank- 7
ton lost would be proportional to their concentration in the makeup water. Based on the design flow presented above, entrainment would effect $\leq$0.5 percent of the population at any time during the year. This is such a small portion of the total population, it can be assumed that entrainment of plankton, fish eggs and larvae through the condenser will have negligible effects on the river populations.

Additional information on the effects of entrainment are presented in Section 10.2.4.1.

5.1.6 IMPACTS FROM INDUCED CIRCULATION EFFECTS

Potential environmental effects resulting from the motion and displacement of water in conjunction with the operation of power plant intake and discharge systems include scouring and sedimentation, alteration of dissolved oxygen and nutrient contents and disruption of thermal stratification.

Scouring and sedimentation will not occur to any substantial degree as a result of the water flows of the CRBRP intake and discharge systems. Approach velocity of water at 0.75 inch from the surface of the perforated pipe intake is less than 0.2 fps when both pipes are operating. As the minimum distance from the pipe surface to the river bottom is 5 feet and 9 inches, no 13
induced movement of bottom material will occur. Although the discharge structure is supported on piles and elevated above the bottom, maximum discharge velocities may exceed 20 fps, as shown 6
in Table 10.3A-4, and some bottom scouring will occur. Benthic populations will be reduced in the small area of scouring but the dominant benthic organisms in the river community will not be altered.

Initial scouring of bottom material may suspend organic material from sediments that will reduce dissolved oxygen and increase nutrient levels in a small area downstream from the discharge. After the initial removal of bottom sediment, scouring will only resuspend those sediments that have been transported into the discharge area by the river and will not cause alteration of the downstream dissolved oxygen or nutrient content.

The Clinch River is requlated stream and experiences daily and seasonal fluctuations in flow and pool elevation as a result of the operational procedures of various upstream and downstream TVA dams. The intake and discharge flows at full power (13.0 and 5.0 6
cfs, respectively, based on Table 3.3-4) are small in relation to the typical seasonal flows of the river. Further, the discharge

rapidly mixes with ambient water and jet momentum is reduced quickly so that induced circulation effects will be confined to a very small area directly in front of the discharge structure.

As the Clinch River is not characterized by stable, seasonal stratification patterns, no adverse temperature effects will be produced by the displacement of water from the intake to discharge areas.

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TABLE 5.1-13

OLD AND NEW DESIGN PARAMETERS FOR THE COOLING SYSTEM

Parameter	Old Design	New Design	
Total No. of Towers	1	2	
Total No. of Cells	10	10	
Tower Size	400 ft x 60 ft x 55 ft	247 ft x 76 ft x 41 ft	
Heat Rejection	2.650×10^9 Btu/hr	2.26×10^9 Btu/hr	13
Circulating Water Flow Rate	212,000 gpm	212,200 gpm	
Approach to Wet Bulb	15°F	11°F	
Range	25°F	21.34°F	
Total Air Flow	17.0×10^6 ft^3/min	16×10^6 ft^3/min	13
No. of Concentrations	2.5	2.5	
Total Dissolved Solids (Avg)	375 gpm	355 gpm	
Blowdown (Annual Avg)	2700 gpm	2306 gpm	
Drift (Annual Avg)	110 gpm	106 gpm	13
Evaporation (Annual Avg)	4240 gpm	3623 gpm	
Makeup (Annual Avg)	7050 gpm	6035 gpm	

TABLE 5.1-14

MEAN LENGTH OF VISIBLE PLUME* FOR CRBRP COOLING TOWER**

Stability Class	Relative Humidity (percent) 100	95	85	75
A	1.6	0.6	0.4	0.2
B	3.4	1.1	0.8	0.7
C	5.1	1.8	1.3	0.9
D	6.0	3.7	2.9	2.2
E	8.3	5.5	5.0	4.1
F	10.3	8.0	6.9	6.4

*Plume length in miles

**From Table 10.1A-5

5.2 RADIOLOGICAL IMPACT FROM ROUTINE OPERATION

This section includes both the Radiological impact on biota other than man and the Radiological impact on man which had previously been discussed separately in Sections 5.2 and 5.3, respectively. The radiological impact from routine releases, previously discussed in Section 14.4, is also presented in this section.

5.2.1 EXPOSURE PATHWAYS

Extensive waste treatment systems included in the CRBRP design will assure that the amounts of radioactivity released to the environs during normal operation of the plant will be as low as reasonably achievable. Potential doses to man, and biota other than man, from both external and internal sources have been estimated for routine releases and are presented in this Section.

5.2.1.1 EXPOSURE PATHWAYS FOR ORGANISMS OTHER THAN MAN

13

These pathways originate with either liquid or gaseous effluent release and result in doses from external and internal routes. External pathways include submersion in air and water and exposure to soil and sediment. Internal exposure results from the ingestion of food or water and the inhalation of air. The primary exposure pathways for organisms other than man are shown in Figure 5.2-1.

Doses to aquatic organisms from radionuclides deposited internally are generally of greater magnitude than the doses they receive from external sources of radiation. Radionuclides are incorporated into tissues of aquatic organisms either through the assimilation of food or through the direct penetration of dermal tissue. External radiation exposures to aquatic organisms are due primarily to radioactivity in solution or associated with suspended particulates. Benthos receive an additional external dose from radionuclides adsorbed onto or concentrated in the benthic substrate.

Internal doses to terrestrial animals are generally of greater magnitude than the doses they receive from external sources. These internal exposures result primarily from radionuclides ingested with food and water and from the inhalation of airborne radioactivity. Terrestrial organisms and plants receive an external exposure from submersion in air containing concentrations of radionuclides. Radionuclide concentrations in soil and vegetation, due to deposition from the atmosphere and to radionuclides entering through the water supply, are minor contributors to the external dose. An additional external exposure is attributable to direct radiation from radioactivity contained within the plant.

5.2.1.2 EXPOSURE PATHWAYS TO MAN 13

The most significant exposure pathways to man are diagrammed in Figure 5.2-2.

5.2.1.2.1 LIQUID EFFLUENTS

Radiation exposures from liquid effluents generally arise from recreational activities or dietary intake. External exposures occur as a result of swimming, boating, and fishing in waters containing radioactivity; and persons involved in shoreline activities may be exposed from radionuclides accumulated in sediment. These external doses are proportional to radiouclide concentrations in water and sediment. Internal doses result from the ingestion of water, the consumption of fish that contain radionuclides, and ingestion of waterfowl which feed on aquatic organisms. Swimmers receive an internal dose from tritium accumulated in the body as a result of exchange processes.

5.2.1.2.2 GASEOUS EFFLUENTS

Individuals are exposed to gaseous effluents via the following pathways: (1) external radiation from radioactivity in the air and on the ground; (2) inhalation; (3) ingestion of beef, vegetables, and milk; and (4) tritium transpiration. No other additional exposure pathway has been identified which would contribute ten percent or more to either individual or population doses.

External air exposures are evaluated at points of potential maximum exposure (i.e., points at the site boundary and sector peaks given in Table 5.2-1). External skin exposure, total body exposure and the internal dose from tritium are calculated at the site boundary and sector peak locations.

13

The contribution to the internal dose from tritium includes inhalation, milk ingestion (with cow assumed to obtain 100% of feed from pasture), beef ingestion and vegetable ingestion.

It is assumed that enough fresh vegetables are produced at each residence to provide for annual consumption by all members of that household. Data on annual meat production are not available for a 50-mile radius from the plant center. It is assumed that enough milk and meat is produced in each sector annulus to supply the needs of that region. The CRBRP population distribution is given in Table 5.2-2.

5.2.1.2.3 DIRECT RADIATION

The shielding design criteria for the CRBRP specifies that, during normal operation, the dose rate at the surface of that part of the containment vessel which is above grade will be no more than 0.2 mrem/hr. An estimated 90 percent of the containment building that is above grade is shielded from the Site boundary by buildings and is enclosed by the Reactor Confinement Structure consisting of four feet of concrete.

Radwaste tanks are housed in buldings protected with concrete walls. In addition, sodium storage tanks, the Radioactive Argon Processing System (RAPS) and the Cell Atmosphere Processing System (CAPS) are located below grade.

As described in Section 3.2, the probability of radioactive sodium leaking from the primary to the intermediate loop of the Heat Transport System is very small.

Because of the above design and shielding characteristics, direct 13
radiation doses at the site boundary are calculated to be much less than 1% of natural background. Therefore, these doses have not been included in the summary tables.

5.2.2 RADIOACTIVITY IN THE ENVIRONMENT

5.2.2.1 LIQUID EFFLUENTS

Estimated average annual quantities of radionuclides released in liquid effluents are listed in Section 3.5. The assumption is made that aquatic biota are exposed to radionuclide concentrations in the river near the liquid effluent discharge port. These concentrations are calculated assuming one part of liquid effluent is diluted by nineteen equal parts of river water. The average blowdown rate from the plant is assumed to be 2,306 gallons per minute. To calculate the exposure to man, the assumption is made that the liquid effluents from the plant are mixed with 1/5 of the river flow in the section of the Clinch River between the CRBRP and the Clinch River mouth. Water from the Clinch River is assumed to be mixed with 1/5 of the Tennessee River flow for a 10 mile reach of the Tennessee River starting at the mouth of the Clinch River. Downstream from this section of the river, the effluent is assumed to be mixed into the entire Tennessee River flow. Dilution of the radionuclide concentrations in the Clinch and Tennessee Rivers is calculated using mean flow data (see Table 5.2-3). The resulting average annual concentrations of radionuclides which would be contributed by the CRBRP plant at locations on the Clinch and Tennessee Rivers are listed in Table 5.2-4. For comparison purposes, average annual radionuclide concentrations in the plant effluent prior to mixing in the Clinch River are also listed.

As discussed in Section 2.5, the area of the Clinch River encompassing the point of the CRBRP discharge acts as a groundwater sink. Therefore exposure to liquid containments through seepage into aquifers is highly unlikely. 13

The assumptions and equations used to calculate the cumulative buildup of radionuclides in sediment are listed in NRC Regulatory Guide 1.109.

5.2.2.2 GASEOUS EFFLUENTS

Calculations of atmospheric transport, dispersion, and ground deposition are based on the straight-line airflow model discussed in NRC Regulatory Guide 1.111 (Revision 1, July 1977). Because of the small magnitude of doses predicted from routine operation of the facility, it was not considered appropriate to use a more sophisticated model. Therefore terrain correction factors as applied in Section 2.6 were not used in this assessment. All releases are assumed to be continuous.

All gaseous releases from the plant are treated as ground-level releases. The joint frequency distribution (JFD) used in the assessment may be found in Section 2.6.2.2 (Tables 2.6-5 through 2.6-11).

Air concentrations and deposition rates were calculated considering radioactive decay and buildup during transit. Plume depletion was calculated using the figures provided in Regulatory Guide 1.111.

Estimates of normalized concentration (X/Q) and normalized deposition rates (D/Q) for releases from the plant at points where potential dose pathways exist are listed in Tables 5.2-1 and 5.2-6.

5.2.3 DOSE RATE ESTIMATES FOR BIOTA OTHER THAN MAN

13

Analyses for the following representative organisms and pathways are performed to determine the potential radiological impact of the CRBRP.

Aquatic Organisms
- external exposure from water
- external exposure from sediment
- internal exposure

Terrestrial

Vertebrates
- external exposure from air
- external exposure from ground or water
- external exposure from direct radiation
- internal exposure from ingestion or inhalation

Plants
- external exposure from air
- external exposure from ground
- external exposure from direct radiation

Because of the complexity of biological functions and the interrelationships between organisms and their environment, simplified dose models have been developed to predict doses resulting from the more significant exposure pathways. Conservative assumptions are chosen because these models cannot predict the detailed variances of a system and because the results of an analysis cannot be applied equally to all members of a population. A brief outline of the models, methods of calculation, and basic assumptions is provided in this section. Dose estimates are based on the average annual activities of radionuclides expected to be released during normal operation of the CRBRP (Section 3.5). 13

5.2.3.1 LIQUID EFFLUENTS

The assumption is made that aquatic biota are exposed to radionuclide concentrations in the river near the liquid effluent discharge port. Dilution in the river near the plant is calculated using an average plant blowdown rate of 2,306 gpm and mixing with nineteen parts river water. Average annual radionuclide concentrations in the plant effluent prior to mixing in the Clinch River are listed in Table 5.2-4.

TERRESTRIAL VE' 'BRATES

Waterfowl and muskrats feed on aquatic plants which concentrate trace elements to a greater extent than do fish and invertebrates.[1] Therefore, maximum potential internal dose estimates for terrestrial mammals are computed for muskrats with diets consisting entirely of green algae from algal masses growing near the water discharge structure. This same analysis is also performed for ducks as a pathway to man. Equation 5.2-1 is used for estimating the annual internal total body dose to ducks and muskrats.

$$D_i = \frac{51.2 \times 10^3}{m} I_i f_{wi} \epsilon_i (1 - \exp(-\lambda_i T))/\lambda_i \text{ , mrad} \quad (5.2\text{-}1)$$

where 13

$51.2 \times 10^3 = (1.6 \times 10^{-8}$ g-rad/meV) $(3.20 \times 10^9$ dis/Ci-d) $(10^3$ mrad/rad),

I_i = 330 g/d x C_{wi} x F_{pi} x 365 d,μCi,

C_{wi} = water concentration,μCi/g,

F_{pi} = concentration factor for aquatic plants, dimensionless,

f_{wi} = fractional uptake, dimensionless,

ϵ_i = effective energy absorbed per disintegration of the i^{th} radionuclide including daughter products, MeV/dis,

λ_i = effective decay constant, $days^{-1}$,

T = 1,825 days,

m = 1,000 g.

The duck and muskrat are assumed to have a mass of 1,000 g, an effective radius of 10 cm, and a daily intake of 330 g of green algae. Long-lived radionuclides such as Cs-137 can deliver significant portions of the total dose commitment long after the time of ingestion. Therefore, a life span of five years is assumed for the integration interval T. In the absence of data applicable specifically to ducks and muskrats, International Committee on Radiation Protection and Measurement (ICRP) data[2] are used for the fractional uptake and for the biological half-life of parent radionuclides. The use of human data for biological half-lives is considered to be conservative because warm-blooded vertebrates smaller than man exhibit more rapid elimination rates.[3]

The duck and muskrat are assumed to be exposed continuously by full immersion in the water. External dose rates are estimated using the equation:

$$R_i = 51.2 \times 10^3 \; C_{wi} E_i, \text{ mrad/d}, \qquad (5.2\text{-}2)$$ 13

where

E_i = average effective energy emitted by the i^{th} radionuclide per disintegration, MeV/dis.

Doses to this hypothetical mammal (muskrat) are given in Table 5.2-9.

AQUATIC PLANTS, INVERTEBRATES, AND FISH

Radioactivity desposited internally in these organisms is estimated by multiplying the average water concentration contributed from the CRBRP releases in the Clinch River near the point of discharge by the applicable concentration factors[1, 3, 4, 12, 13] listed in Table 5.2-7. Internal doses are estimated (Table 5.2-8) for organisms having effective radii of 3 cm and 30 cm. In the absence of detailed knowledge of the dynamic behavior of radioactive daughter products that are produced internally, all daughter products are assumed to be bound permanently in the organisms; and every daughter in a decay chain is assumed to decay at an equilibrium disintegration rate equal to the disintegration rate of the parent nuclide. The annual dose from i^{th} radionuclide is calculated using the equation:

$$D_i = 51.2 \times 10^3 \, C_{fi} \, \varepsilon_i \times 365, \text{ mrad/yr} \qquad (5.2\text{-}3)$$

where 13

C_{fi} = radioactivity concentration in the organism
= $C_{wi} \times F_i$, μCi/g,
F_i = concentration factor, dimensionless.
ε_i = effective energy absorbed per disintegration of the i^{th} radionuclide including daughter product, Mev/dis.

External doses for organisms immersed in water (Table 5.2-7) are calculated using Equation 5.2-2. Benthic organisms such as mussels, worms, and fish eggs receive additional external doses from radioactivity associated with bottom sediments. Accurate prediction of the accumulation of radioactivity in sediment and the resultant doses to benthic organisms requires detailed knowledge of a number of factors, including mineralogy, particle size, exchangeable calcium in the sediment, channel geometry, waterflow patterns, chemical form of the radiocompounds, and behavioral characteristics of the organism. In the absence of this detailed knowledge, external doses from radioactivity associated with bottom sediment are calculated assuming a 4-π geometry for beta doses and a 2-π geometry for gamma doses.

5.2.3.2 GASEOUS EFFLUENTS

In the evaluation of the potential impact of gaseous effluents on terrestrial organisms, biota are assumed to be located at the point of maximum offsite exposure. External doses to terrestrial organisms from air submersion and ground contamination are estimated using dose factors derived for humans. It is assumed that total body dose factors for humans are applicable to terrestrial vertebrates and that skin dose factors for humans are 13
applicable to terrestrial plants and small fauna.

Internal exposures vary for each type of organism and tissue. For this estimate, biota are assumed to be located at the point of maximum offsite exposure. The equation used to calculate the annual total body dose to an animal from the inhalation and ingestion exposure pathway is:

$$D_i = (C_{ai} \times DF_{ai}) + (C_{gi} \times DF_{gi}), \text{ mrad/yr} \qquad (5.2\text{-}4)$$

where

C_{ai} = average air concentration, $\mu Ci/cm^3$,
C_{gi} = average ground concentration, $\mu Ci/m^2$, S.
DF_{ai} = dose factor for inhalation, mrad per year per $\mu Ci/cm^3$,
DF_{gi} = dose factor for ingestion, mrad per year per $\mu Ci/m^2$,S.

Dose estimates for biota which could result from CRBRP plant released radioactivity are listed in Table 5.2-9. These estimated doses are less than the dose limits established for occupational workers in the nuclear industry.[5,6] In the "BEIR" report,[7] it is stated that ". . . probably no other living organisms are very much more radiosensitive than man, so that if man as an individual is protected, then other organisms as populations would be most unlikely to suffer harm."

5.2.4 DOSE RATE ESTIMATES FOR MAN

5.2.4.1 LIQUID PATHWAYS

Estimated average annual activities of radionuclides released in
liquid effluents are listed in Section 3.5. Data listed in Table
5.2-5 for potable water supply systems [17] and appropriate 13
ingestion dose factors [11,12,13] are combined to calculate dose
commitments from the ingestion of Tennessee River water (Table
5.2.10). Dilution of the radionuclide concentrations in the
Clinch and Tennessee Rivers is calculated using flow data listed
in Table 5.2-3. The plant effluent is assumed to be mixed with
one-fifth of the Clinch River flow in the reach between the CRBRP
plant and the river mouth. Water from the Clinch River is

assumed to mix with 1/5 of the Tennessee River flow in a 10 mile reach of the Tennessee River starting at the mouth of the Clinch River. Beyond this section, mixing into the entire Tennessee River flow is assumed.

Fish harvest data[14, 15] provided in Table 5.2-11 are used to calculate population doses resulting from the ingestion of fish.[1, 2, 11, 12, 13] Maximum expected population and individual doses resulting from fish consumption are presented in Table 5.2-10. The types of fish in the Clinch and Tennessee Rivers are discussed in Section 2.7.

Data[16] provided in Table 5.2-12 and appropriate dose factors[11, 12, 13] are used to calculate population doses resulting from recreation activities on or near the Tennessee River. Maximum individual doses for above-water use of the river are estimated for a fisherman exposed for 100 days per year at 5 hours per day. The maximum individual doses for in-water activities are estimated for a person who swims 500 hours per year at a location in the river just below the CRBRP site. Maximum tritium doses to a swimmer are calculated for continuous immersion for 5 months in the Clinch River just below the CRBRP site. The visitation data listed in Table 5.2-11 were developed by multiplying the actual above-water, in-water, and shoreline visits to each stream reach by the average length of stay (in hours) along each reach and then dividing the resultant total visitor hours by the assumed lengths of stay. This process of extrapolation does not change the total visitor-hour values for each reach but simply puts the recreation use data in a comparable and suitable form for application of dosimetric analyses. 13

An individual adult is assumed to participate in shoreline activities for 500 hours per year. Population doses can be calculated using the recreational data provided in Table 5.2-12 and assuming an average recreational visit lasts 5 hours. The maximum annual individual and population doses expected from the use of the Clinch and the Tennessee Rivers for water sports during operation of the CRBRP are shown in Table 5.2-10.

It is assumed that the maximum exposed individual consumes one duck each year which has been contaminated as outlined in Section 5.2.3.1. The predicted doses are given in Table 5.2-10.

5.2.4.2 GASEOUS PATHWAYS

Doses are calculated using the dose factors and methodology contained in NRC Regulatory Guide 1.109 with certain exceptions as follows: 13

1. Inhalation doses are based on average individual inhalation rates[8] of 1,400; 5,500; 8,000; and 8,100 m^3/year for infant, child, teen, and adult respectively.

2. Doses to air are calculated using average beta and gamma energies per decay from the TVA nuclide data library.

3. The milk ingestion pathway has been modeled to include the assumption of 100% pasture grazing by milk animals.

4. The stored vegetable and beef ingestion pathways have been modeled to reflect more accurately the actual dietary characteristics of individuals. For stored vegetables the assumption is made that home grown stored vegetables are consumed when fresh vegetables are not available, i.e., during the 9 months of fall, winter, and spring. Rather than use a constant storage period of 60 days, radioactive decay is accounted for explicitly during the 275-day consumption period. The radioactive decay correction is calculated by:

$$\frac{1}{275}\int_{0}^{275} \exp(-\lambda_i t)dt = \frac{1 - \exp(-\lambda_i 275)}{275 \lambda_i}$$ 13

   This replaces the term exp $(-\lambda_i t_h)$ in equation C-7 of Regulatory guide 1.109.

5. The beef consumption pathways can be divided into either commercial sales or home use pathways. Dose calculations are made for individuals consuming meat produced for home use.

The normal processing route is for an individual to slaughter the beef animal, package and freeze the meat, and then consume the meat during the next 3-month period by

$$\frac{1}{90} \int_0^{90} \exp(-\lambda_i t)dt = \frac{1 - \exp(-\lambda_i 90)}{90 \lambda_i}$$

This term is multiplied into equation C-14 in Regulatory Guide 1.109. If the beef animals are sold commercially, then individuals would not be exposed continuously to meat containing radioactivitiy from the same farm. It is expected that this pathway will not cause significant individual exposures. 13

Calculations of wet deposition based c a washout model and recommendations of Engelmann[9] indicate that wet deposition is not a significant portion of total deposition. All doses related to deposition pathways (ground exposure and food ingestion) are estimated using dry deposition.

The basic data for individual and population dose calculations are contained in Tables 5.2-1 and 5.2-2. Included are distances and elevations at the site boundary and sector peaks; and population distribution and maximum elevations. Population doses were based on a U.S. population distribution of:

Category	Ages(A)*	Fraction
Infant	A<2	.034
Child	2≤A<13	.211
Teen	13≤A<19	.134
Adult	19≤A	.621

*e.g., someone who is 1 year, 11 months is an infant, while someone who is exactly two years old is a child.

Tables 5.2-13 and 5.2-14 provide the doses estimated for individuals and the resident population within 50 miles of the plant site. 13

5.2.4.3 DOSES VIA EXPOSURE TO RADIOACTIVE MATERIALS IN TRANSIT

5.2.4.3.1 NEW FUEL

Dose estimates have been made based upon transportation of fuel and blanket assemblies to the plant from the Hanford Site. These doses have been calculated based upon NUREG-0170[10].

Assuming an average of 14 shipments of fresh fuel for the core and axial blankets per year and 12 shipments of fresh fuel for the inner and radial blankets per year over a distance of 2500 miles per shipment, the annual dose to the general public is estimated and presented in Table 5.2-15.

5.2.4.3.2 IRRADIATED FUEL

Population doses from transport of irradiated fuel to fuel reprocessing plants have also been estimated based upon NUREG 0170[10] with shipment by rail. Assuming 14 shipments per year for spent fuel plus axial blanket assemblies and 12 shipments per year for inner and radial blankets assemblies and a transit distance of 2500 miles for each shipment, the population dose presented in Table 5.2-15 was calculated. 13

5.2.4.3.3 RADIOACTIVE WASTES

Approximately one-hundred eighty-one (181) 55-gallon drums of solidified liquid wastes will be shipped from the Site to an NRC-licensed burial ground each year. An estimated 112 drums of non-compactible solids and 28 drums of compactible solids will also be shipped from the Site each year. An estimated four shipments per year will be made for irradiated control assemblies and radial shield assemblies. The estimated population dose to the general population would be 0.43 man-rem/yr, as shown in Table 5.2-15. These estimates assume a shipping distance of 2500 miles per shipment.

5.2.5 SUMMARY OF ANNUAL RADIATION DOSES

The radiological impact to regional population groups in the year
2020 from the normal operation of the CRBRP are estimated. Table
5.2-15 summarizes these population doses. The total body dose
from background to individuals within the United States ranges
from approximately 100 mrem to 250 mrem per year. The annual
total body dose due to background for a population of 921,200
persons expected to live within a 50-mile radius of the CRBRP in
the year 2020 is calculated to be approximately 128,968 man-rem 13
assuming 140 mrem/year/individual. By comparison, the same
population (excluding onsite radiation workers) will receive a
total body dose of approximately 0.03 man-rem from effluents
released from the CRBRP. Based on these results, it is concluded
that the normal operation of the CRBRP will present minimal risk
to the health and safety of the public.

TABLE 5.2-1

DATA ON POINTS OF INTEREST NEAR THE CRBRP

	POINT	SECTOR	DISTANCE (m)	ELEVATION* (m)	CHI-OVER-Q** (s/m^3)	D-OVER-Q** (1/m^2)
1	LAND SITE BOUNDARY	N	2060.	87.	1.01E-06	1.31E-09
2	LAND SITE BOUNDARY	NNE	2440.	87.	6.43E-07	8.11E-10
3	LAND SITE BOUNDARY	NE	880.	-5.	5.06E-06	1.25E-08
4	LAND SITE BOUNDARY	ENE	820.	20.	8.33E-06	1.80E-08
5	LAND SITE BOUNDARY	E	820.	2.	9.69E-06	1.46E-08
6	LAND SITE BOUNDARY	ESE	980.	-5.	7.45E-06	1.42E-08
7	LAND SITE BOUNDARY	SE	1200.	-23.	3.83E-06	6.20E-09
8	LAND SITE BOUNDARY	SSE	820.	-23.	5.65E-06	7.35E-09
9	LAND SITE BOUNDARY	S	700.	-23.	6.08E-06	8.04E-09
10	LAND SITE BOUNDARY	SSW	670.	-23.	6.66E-06	9.38E-09
11	LAND SITE BOUNDARY	SW	670.	-23.	8.10E-06	1.34E-08
12	LAND SITE BOUNDARY	WSW	700.	-23.	1.10E-05	1.71E-08
13	LAND SITE BOUNDARY	W	750.	-23.	1.57E-05	1.57E-08
14	LAND SITE BOUNDARY	WNW	810.	-23.	9.77E-06	8.38E-09
15	LAND SITE BOUNDARY	NW	820.	-23.	1.80E-05	1.31E-08
16	LAND SITE BOUNDARY	NNW	1000.	-23.	1.00E-05	1.10E-08
17	SECTOR PEAK	N	1900.	93.	1.14E-06	1.51E-09
18	SECTOR PEAK	NNE	1900.	93.	9.16E-07	1.24E-09
19	SECTOR PEAK	NE	6500.	123.	2.78E-07	4.20E-10
20	SECTOR PEAK	ENE	6500.	166.	4.24E-07	5.39E-10
21	SECTOR PEAK	E	1700.	99.	3.20E-06	4.45E-09
22	SECTOR PEAK	ESE	2700.	93.	1.71E-06	2.65E-09
23	SECTOR PEAK	SE	3300.	117.	9.07E-07	1.14E-09
24	SECTOR PEAK	SSE	1000.	75.	4.14E-06	5.31E-09
25	SECTOR PEAK	S	1200.	93.	2.70E-06	3.33E-09
26	SECTOR PEAK	SSW	1300.	105.	2.40E-06	3.17E-09
27	SECTOR PEAK	SW	2700.	93.	9.95E-07	1.34E-09
28	SECTOR PEAK	WSW	1400.	69.	3.77E-06	5.53E-09
29	SECTOR PEAK	W	1400.	75.	5.85E-06	5.68E-09
30	SECTOR PEAK	WNW	1200.	69.	5.25E-06	4.41E-09
31	SECTOR PEAK	NW	7500.	93.	8.22E-07	3.02E-10
32	SECTOR PEAK	NNW	6900.	81.	6.87E-07	4.09E-10

* reference with respect to plant grade (Plant grade has been established at 816 feet above mean sea level)

** normalized air concentrations and deposition rates were generated using a constant wind direction model and the joint frequency distributions of meteorological data given in Section 2.6.2.2 (Tables 2.6-5 through 2.6-11)

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TABLE 5.2-2

CRBRP - POPULATION DISTRIBUTION AND SECTOR ELEVATIONS (Year 2020)*

POPULATION WITHIN EACH SECTOR ELEMENT

SECTOR**	1305.	2414.	4023.	5633.	7242.	12070.	24140.	40234.	56327.	72420.
N	0.	0.	0.	0.	0.	2100.	3600.	1100.	4300.	8400.
NNE	0.	0.	0.	0.	0.	8300.	10800.	4000.	20700.	7400.
NE	0.	0.	0.	0.	0.	5900.	26200.	1900.	10400.	5500.
ENE	20.	20.	0.	0.	0.	5100.	21000.	124100.	44600.	14900.
E	50.	80.	140.	30.	40.	3400.	33000.	125800.	29500.	22200.
ESE	20.	30.	70.	170.	150.	1500.	7600.	73200.	5500.	5700.
SE	0.	30.	70.	170.	70.	11500.	4700.	4700.	2400.	2400.
SSE	0.	30.	50.	110.	210.	1300.	4900.	1800.	2500.	5700.
S	0.	70.	60.	150.	200.	900.	5200.	10500.	4300.	4300.
SSW	10.	40.	70.	100.	110.	900.	1500.	2900.	6100.	12700.
SW	30.	100.	100.	130.	170.	800.	3300.	12800.	32900.	11700.
WSW	20.	80.	100.	170.	410.	5500.	2300.	4000.	4900.	5600.
W	0.	150.	120.	130.	620.	6600.	8700.	1600.	22500.	4700.
WNW	10.	100.	210.	10.	50.	3400.	6000.	2100.	3400.	3700.
NW	30.	30.	0.	10.	40.	1400.	2100.	1800.	3300.	8200.
NNW	10.	0.	0.	0.	100.	900.	3700.	1300.	4100.	3700.

MAXIMUM ELEVATIONS ABOVE PLANT GRADE (Meters)

SECTOR**	1305.	2414.	4023.	5633.	7242.	12070.	24140.	40234.	56327.	72420.
N	56.	93.	69.	99.	93.	239.	727.	635.	514.	514.
NNE	38.	93.	93.	93.	99.	56.	696.	818.	605.	666.
NE	26.	38.	56.	123.	123.	117.	117.	148.	239.	666.
ENE	20.	99.	56.	117.	166.	87.	148.	148.	392.	483.
E	62.	99.	38.	117.	111.	117.	56.	148.	635.	696.
ESE	50.	93.	87.	99.	99.	87.	56.	209.	818.	1428.
SE	-5.	117.	123.	75.	133.	87.	148.	575.	1245.	1306.
SSE	75.	105.	123.	105.	123.	87.	117.	148.	1062.	1336.
S	99.	87.	93.	123.	117.	56.	87.	209.	361.	514.
SSW	99.	93.	105.	99.	130.	87.	87.	87.	56.	56.
SW	14.	93.	111.	111.	105.	87.	117.	87.	87.	270.
WSW	69.	62.	75.	87.	87.	87.	87.	239.	681.	529.
W	81.	56.	81.	62.	87.	87.	331.	453.	635.	361.
WNW	69.	44.	38.	93.	93.	87.	422.	453.	361.	544.
NW	38.	44.	38.	87.	117.	209.	514.	514.	270.	300.
NNW	26.	50.	14.	56.	93.	209.	696.	696.	300.	239.

* Resident population distribution 0-10 and 10-50 miles from the CRBRP site for the year 2020 are taken from ER tables 2.2-2E and 2.2-3E

** Distance in meters from the center of the plant site to the center of the sector annulus

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TABLE 5.2-3

MEAN RIVER FLOW

Location* (River Mile)	Mean Flow (ft^3/sec)
585.7	4580
568.0	20,500
568.0	27,500
500.0	28,800
500.0	34,200
469.0	35,100
469.0	35,800
423.0	36,600
423.0	37,700
361.0	39,700
361.0	40,500
344.0	40,800
344.0	41,800
339.0	41,800
339.0	42,700
333.0	42,800
284.0	45,200
284.0	49,000
264.0	50,100
264.0	50,900
256.0	51,100
225.0	52,100
225.0	53,500
189.0	54,300
136.0	55,600
136.0	56,000
110.0	56,400
110.0	61,800
100.0	62,000
67.0	62,700
67.0	63,500
22.0	64,000
4.0	64,100
4.0	64,700
0.0	64,800

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* River mile locations are for the Clinch - Tennessee River System. (River mile 585.7 is at CRBRP site.) A repeated river mile location indicates tributary inflow.

TABLE 5.2-4

AVERAGE RADIONUCLIDE CONCENTRATIONS IN WATERS FROM CRBRP RELEASES (μ Ci/ml)

NUCLIDE	PLANT EFFLUENT AT DIFFUSER	CLINCH RIVER BELOW CRBRP	TENNESSEE RIVER ABOVE KINGSTON	TENNESSEE RIVER BELOW KINGSTON
H-3	2.85E-9	1.46E-11	3.60E-12	5.27E-13
Na-22	4.48E-14	2.29E-16	5.66E-17	8.26E-18
Na-24	6.74E-16	2.89E-17	8.51E-19	0.0
Cr-51	1.69E-13	9.07E-16	2.14E-16	2.90E-17
Mn-54	1.27E-12	6.50E-15	1.60E-15	2.33E-16
Co-58	1.14E-11	5.90E-14	1.43E-14	2.04E-15
Co-60	3.24E-12	1.66E-14	4.10E-15	5.99E-16
Fe-59	8.18E-14	4.31E-16	1.04E-16	1.45E-17
Sr-89	3.39E-15	1.78E-17	4.29E-18	6.03E-19
Sr-90	2.61E-15	1.33E-17	3.30E-18	4.83E-19
Y-90	2.61E-15	1.33E-17	3.30E-18	4.83E-19
Y-91	1.00E-15	5.22E-18	1.26E-18	1.78E-19
Zr-95	8.32E-13	4.34E-15	1.05E-15	1.49E-16
Nb-95	8.46E-13	4.34E-15	1.07E-15	1.56E-16
Mo-99	1.29E-16	1.07E-18	1.63E-19	1.12E-20
Ru-103	1.09E-12	5.74E-15	1.37E-15	1.90E-16
Ru-106	1.72E-14	8.78E-17	2.17E-17	3.15E-18
Rh-106	1.72E-14	8.78E-17	2.17E-17	3.15E-18
Ag-111	5.67E-17	3.47E-19	7.17E-20	0.0
Sb-125	6.09E-16	3.11E-18	7.69E-19	1.12E-19
Te-127m	7.10E-15	3.67E-17	8.97E-18	1.29E-18
Te-127	7.10E-15	3.67E-17	8.93E-18	1.28E-18
Te-129m	2.06E-14	1.09E-16	2.59E-17	3.56E-18
Te-129	1.32E-14	1.09E-16	1.66E-17	2.28E-18
Te-132	1.09E-14	8.45E-17	1.38E-17	1.05E-18
I-131	3.96E-13	2.39E-15	5.00E-16	5.63E-17
I-132	1.12E-14	2.61E-16	1.42E-17	1.08E-18
Cs-134	2.15E-14	1.10E-16	2.72E-17	3.97E-18
Cs-136	1.98E-14	1.11E-16	2.49E-17	3.13E-18
Cs-137	7.37E-13	3.77E-15	9.33E-16	1.36E-16
Ba-140	5.54E-13	3.13E-15	6.98E-16	8.66E-17
La-140	5.95E-13	3.13E-15	7.51E-16	9.75E-17
Ce-141	2.30E-15	1.22E-17	2.90E-18	3.98E-19
Ce-143	1.47E-15	2.00E-17	1.87E-18	5.90E-20
Pr-143	3.78E-15	2.00E-17	4.78E-18	6.18E-19
Ce-144	1.73E-15	8.89E-18	2.19E-18	3.18E-19

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TABLE 5.2-4 (continued)

AVERAGE RADIONUCLIDE CONCENTRATIONS IN WATERS FROM CRBRP RELEASES (μCi/ml)

NUCLIDE	PLANT EFFLUENT AT DIFFUSER	CLINCH RIVER BELOW CRBRP	TENNESSEE RIVER ABOVE KINGSTON	TENNESSEE RIVER BELOW KINGSTON
Pr-144	1.73E-15	8.89E-18	2.19E-18	3.18E-19
Nd-147	3.86E-16	2.22E-18	4.87E-19	5.89E-20
Pm-147	4.36E-16	2.22E-18	5.50E-19	8.04E-20
Eu-155	8.86E-17	4.54E-19	1.12E-19	1.63E-20
Ta-182	5.43E-13	2.80E-15	6.85E-16	9.84E-17
Pu-238	1.30E-16	6.60E-19	1.63E-19	2.39E-20
Pu-239	3.45E-17	1.76E-19	4.35E-20	0.0
Pu-240	5.08E-17	2.59E-19	6.41E-20	0.0
Pu-241	3.71E-15	1.89E-17	4.68E-18	6.84E-19
Pu-242	9.81E-18	5.00E-20	1.24E-20	0.0
Np-238	0.0	0.0	0.0	0.0
Np-239	4.08E-18	3.48E-20	0.0	0.0
Am-241	1.34E-17	6.81E-20	1.69E-20	0.0
Am-242	1.40E-19	0.0	0.0	0.0
Am-243	5.32E-19	0.0	0.0	0.0
Cm-242	9.40E-18	4.82E-20	1.18E-20	0.0
Cm-243	1.31E-19	0.0	0.0	0.0
Cm-244	2.73E-18	1.39E-20	0.0	0.0
Nb-95m	5.08E-15	0.0	6.41E-18	1.84E-18
Tc-99m	1.41E-16	0.0	1.78E-19	1.23E-20
Rh-103m	1.09E-12	0.0	1.37E-15	1.91E-16
I-129	0.0	0.0	0.0	0.0
Ba-137m	7.37E-13	0.0	9.33E-16	1.36E-16
Sm-147	0.0	0.0	0.0	0.0

An entry of 0.0 indicates a concentration of less than 1 x 10^{-20} μCi/ml.

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TABLE 5.2-5

POTABLE WATER SUPPLIES DOWNSTREAM FROM THE CLINCH RIVER BREEDER REACTOR PLANT PROJECT (ref 17)

Public Water Supply	Location (TRM)	2020 Population Served
CRBRP Discharge	585.7 (a)	
Bear Creek Water Supply	584.2 (b)	5,600
Kingston Steam Plant	572.3 (c)	790
Kingston	568.2	7,900
Harriman	561.2 (c)	6,800
Camp John Knox	553.0	200
Watts Bar Resort	529.9	300
Dayton	503.8	12,300
ICI America, Inc (VAAP)	473.0	2,000
C.F. Industries	473.0	900
E.I. DuPont, Co.	470.5	4,000
Chattanooga	465.3	610,700
South Pittsburg	418.0	4,400
Bridge Port	413.6	3,400
Widows Creek Steam Plant	407.6	500
Mead Paper Board	405.2	500
Scottsboro	385.8	38,700
Sand Mountain Water Authority	382.1	18,600
Christian Youth Camp	368.2	125
Guntersville	358.0	14,900
N.E. Morgan Co. Water & Fire	334.5	4,500
Huntsville	334.2	168,600
Redstone Arsenal	330.2	10,000
Decatur	306.0	84,600
U.S. Plywood-Champion Paper	283.0	500
Wheeler Dam	274.9	50
Muscle Shoals	259.6	14,100
TVA-NFDC	259.5	2,700
Sheffield	254.3	21,100
Colbert Steam Plant	245.0	520
Cherokee	239.3	3,900
U.S. Steel AGRI-Chemicals, Inc.	238.7	350
Hardin County Water District	206.8	2,400
Tri-County Utility District	193.5	1,900
Clifton	158.0	1,100
Foote Mineral Company	101.9	170
New Johnsonville	100.5	6,100
Camden	100.4	13,300
Johnsonville Steam Plant	100.0	375
E.I. DuPont Co.	98.5	900

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TABLE 5.2-5 (continued)

POTABLE WATER SUPPLIES DOWNSTREAM FROM THE CLINCH RIVER BREEDER REACTOR PLANT PROJECT (ref 17)

Public Water Supply	Location (TRM)	2020 Population Served
Consolidated Aluminum Corp.	95.5	700
Inland Container Corporation	94.5	250
Bass Bay Resort	79.5	120
Johnathan Creek Water District	39.3	4,300
North Marshall Water District	28.5	9,100
Grand Rivers	23.6	650
B.F. Goodrich Chemical Co.	17.8	600
AIRCO Carbide	17.4	106
AIRCO Alloys	16.8	592
Air Products and Chemicals	16.7	510
Paducah	0.1	69,800

(a) Clinch River Mile (CRM) 16.0

(b) CRM 14.5

(c) Water intake on the Emory River, a tributary of the Clinch River. Included to account for the possibility of water from the Clinch River backing up the Emory River.

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TABLE 5.2-6

CRBRP - NORMALIZED CONCENTRATIONS AND DEPOSITION RATES AT SECTOR ANNULI+

AVERAGE ANNUAL CHI-OVER-Q VALUES (s/m^3)

SECTOR*	1305.	2414.	4023.	5633.	7242.	12070.	24140.	40234.	56327.	72420.
N	2.03E-6	8.10E-7	4.07E-7	2.60E-7	1.87E-7	9.51E-8	3.87E-8	2.01E-8	1.31E-8	9.53E-9
NNE	1.61E-6	6.52E-7	3.29E-7	2.10E-7	1.51E-7	7.73E-8	3.15E-8	1.64E-8	1.07E-8	7.83E-9
NE	2.76E-6	1.09E-6	5.36E-7	3.37E-7	2.40E-7	1.20E-7	4.80E-8	2.46E-8	1.60E-8	1.16E-9
ENE	4.09E-6	1.64E-6	8.10E-7	5.13E-7	3.66E-7	1.85E-7	7.43E-8	3.83E-8	2.49E-8	1.81E-8
E	4.76E-6	1.93E-6	9.71E-7	6.20E-7	4.46E-7	2.27E-7	9.27E-8	4.82E-8	3.15E-8	2.30E-8
ESE	4.89E-6	1.99E-6	9.93E-7	6.31E-7	4.52E-7	2.29E-7	9.28E-8	4.81E-8	3.14E-8	2.29E-8
SE	3.40E-6	1.40E-6	6.93E-7	4.40E-7	3.14E-7	1.59E-7	6.43E-8	3.33E-8	2.17E-8	1.58E-8
SSE	2.80E-6	1.14E-6	5.69E-7	3.62E-7	2.59E-7	1.31E-7	5.33E-8	2.76E-8	1.80E-8	1.31E-8
S	2.39E-6	9.79E-7	4.81E-7	3.03E-7	2.16E-7	1.08E-7	4.33E-8	2.23E-8	1.45E-8	1.05E-8
SSW	2.39E-6	9.63E-7	4.80E-7	3.05E-7	2.18E-7	1.10E-7	4.47E-8	2.31E-8	1.51E-8	1.10E-8
SW	2.88E-6	1.16E-6	5.79E-7	3.68E-7	2.64E-7	1.34E-7	5.41E-8	2.80E-8	1.83E-8	1.33E-8
WSW	4.19E-6	1.69E-6	8.48E-7	5.40E-7	3.88E-7	1.97E-7	7.99E-8	4.15E-8	2.70E-8	1.97E-8
W	6.52E-6	2.61E-6	1.34E-6	8.66E-7	6.27E-7	3.24E-7	1.34E-7	7.01E-8	4.60E-8	3.37E-8
WNW	4.62E-6	1.87E-6	9.62E-7	6.23E-7	4.51E-7	2.34E-7	9.67E-8	5.08E-8	3.34E-8	2.44E-8
NW	8.66E-6	3.50E-6	1.82E-6	1.18E-6	8.60E-7	4.48E-7	1.87E-7	9.83E-8	6.48E-8	4.75E-8
NNW	6.69E-6	2.69E-6	1.38E-6	8.93E-7	6.46E-7	3.34E-7	1.38E-7	7.22E-8	4.74E-8	3.47E-8

AVERAGE ANNUAL D-OVER-Q VALUES ($1/m^2$)

SECTOR*	1305.	2414.	4023.	5633.	7242.	12070.	24140.	40234.	56327.	72420.
N	2.78E-9	1.00E-9	4.16E-10	2.30E-10	1.46E-10	6.02E-11	1.84E-11	7.51E-12	4.07E-12	2.47E-12
NNE	2.29E-9	8.26E-10	3.42E-10	1.89E-10	1.20E-10	4.95E-11	1.52E-11	6.18E-12	3.35E-12	2.03E-12
NE	6.58E-9	2.37E-9	9.84E-10	5.43E-10	3.46E-10	1.42E-10	4.35E-11	1.78E-11	9.62E-12	5.84E-12
ENE	8.44E-9	3.04E-9	1.26E-9	6.97E-10	4.43E-10	1.83E-10	5.59E-11	2.28E-11	1.23E-11	7.50E-12
E	6.83E-9	2.46E-9	1.02E-9	5.64E-10	3.59E-10	1.48E-10	4.52E-11	1.84E-11	9.99E-12	6.07E-12
ESE	8.90E-9	3.21E-9	1.33E-9	7.35E-10	4.68E-10	1.93E-10	5.89E-11	2.40E-11	1.30E-11	7.91E-12
SE	5.41E-9	1.95E-9	8.10E-10	4.47E-10	2.84E-10	1.17E-10	3.58E-11	1.46E-11	7.92E-12	4.81E-12
SSE	3.44E-9	1.24E-9	5.15E-10	2.85E-10	1.81E-10	7.45E-11	2.28E-11	9.30E-12	5.04FE12	3.06E-12
S	2.91E-9	1.05E-9	4.35E-10	2.40E-10	1.53E-10	6.29E-11	1.92E-11	7.84E-12	4.25E-12	2.58E-12
SSW	3.15E-9	1.14E-9	4.72E-10	2.60E-10	1.66E-10	6.82E-11	2.09E-11	8.51E-12	4.61E-12	2.80E-12
SW	4.51E-9	1.63E-9	6.74E-10	3.72E-10	2.37E-10	9.75E-11	2.98E-11	1.22E-11	6.59E-12	4.00E-12
WSW	6.19E-9	2.23E-9	9.26E-10	5.11E-10	3.25E-10	1.34E-10	4.10E-11	1.67E-11	9.06E-12	5.50E-12
W	6.36E-9	2.30E-9	9.52E-10	5.26E-10	3.34E-10	1.38E-10	4.21E-11	1.72E-11	9.31E-12	5.65E-12
WNW	3.85E-9	1.39E-9	5.76E-10	3.18E-10	2.02E-10	8.32E-11	2.55E-11	1.04E-11	5.63E-12	3.42E-12
NW	6.12E-9	2.21E-9	9.15E-10	5.05E-10	3.21E-10	1.32E-10	4.05E-11	1.65E-11	8.95E-12	5.43E-12
NNW	7.14E-9	2.58E-9	1.07E-9	5.90E-10	3.75E-10	1.54E-10	4.73E-11	1.93E-11	1.04E-11	6.34E-12

* Distance in meters from the center of the plant site to the center of the sector annulus

\+ Normalized air concentrations and deposition rates were generated using a constant wind direction model and the joint frequency distributions of meteorological data given in Section 2.6.2.2 (Tables 2.6-5 through 2.6-11)

TABLE 5.2-7

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

NUCLIDE	RADIOLOGIC HALF-LIFE (DAYS)	RADIONUCLIDE CONCENTRATION FACTORS		
		FISH	BIOTA	PLANT
H-3	4.48E3	1.00	1.00	1.00
C-14	2.09E6	4.55E3	9.09E3	4.55E3
Na-22	9.50E2	1.00E2	2.00E2	5.00E2
Na-24	6.33E-1	1.00E2	2.00E2	5.00E2
P-32	1.43E1	1.00E5	2.00E4	5.00E5
K-40	4.60E11	2.50E3	8.33E2	6.70E2
Cr-51	2.78E1	2.00E2	2.00E3	4.00E3
Mn-54	3.03E2	4.00E2	1.40E5	3.50E4
Mn-56	1.07E-1	4.00E2	1.40E5	3.50E4
Fe-55	9.50E2	1.00E2	3.20E3	1.00E3
Fe-59	4.56E1	1.00E2	3.20E3	1.00E3
Co-57	2.71E2	3.65E1	1.93E2	6.20E3
Co-58	7.13E1	2.08E1	1.75E2	6.20E3
Co-60	1.92E3	4.75E1	1.99E2	6.20E3
Ni-65	1.07E-1	1.00E2	1.00E2	5.00E1
Cu-64	5.31E-1	5.00E1	4.00E2	2.00E3
Zn-65	2.45E2	1.42E3	9.61E3	2.00E4
Zn-69m	5.75E-1	1.14E1	5.44E2	2.00E4
Zn-69	3.96E-2	7.92E-1	3.94E1	2.00E4
Br-82	1.48	4.20E2	3.33E2	5.00E1
Br-83	1.00E-1	4.20E2	3.33E2	5.00E1
Br-84	2.21E-2	4.20E2	3.33E2	5.00E1
Br-85	2.08E-3	4.20E2	3.33E2	5.00E1
Kr-83m	7.75E-2	1.00	1.00	1.00
Kr-85m	1.83E-1	1.00	1.00	1.00
Kr-85	3.93E3	1.00	1.00	1.00
Rb-86	1.87E1	2.00E3	1.00E3	1.00E3
Rb-88	1.24E-2	2.00E3	1.00E3	1.00E3
Rb-89	1.07E-2	2.00E3	1.00E3	1.00E3
Sr-89	5.27E1	1.04E1	3.99E3	3.00E3
Sr-90	1.01E4	2.97E1	4.00E3	3.00E3
Sr-91	4.03E-1	1.20E-1	3.20E3	3.00E3
Sr-92	1.13E-1	3.39E-2	2.12E3	3.00E3
Sr-93	5.56E-3	1.67E-3	2.11E2	3.00E3
Y-90	2.67	2.50E1	1.00E3	5.00E3
Y-91m	3.47E-2	2.50E1	1.00E3	5.00E3
Y-91	5.88E1	2.50E1	1.00E3	5.00E3
Y-92	1.47E-1	2.50E1	1.00E3	5.00E3
Y-93	4.29E-1	2.50E1	1.00E3	5.00E3

TABLE 5.2-7 (Continued)

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

NUCLIDE	RADIOLOGIC HALF-LIFE (DAYS)	RADIONUCLIDE CONCENTRATION FACTORS		
		FISH	BIOTA	PLANT
Zr-95	6.55E1	3.33	6.70	1.00E3
Zr-97	7.08E-1	3.33	6.70	1.00E3
Nb-95m	3.75	3.00E4	1.00E2	8.00E2
Nb-95	3.50E1	3.00E4	1.00E2	8.00E2
Nb-97m	6.25E-4	3.00E4	1.00E2	8.00E2
Nb-97	5.00E-2	3.00E4	1.00E2	8.00E2
Mo-99	2.78	1.00E1	1.00E1	1.00E3
Tc-99m	2.52E-1	1.50E1	5.00	4.00E1
Tc-99	7.74E7	1.50E1	5.00	4.00E1
Tc-101	9.93E-3	1.50E1	5.00	4.00E1
Ru-103	3.96E1	1.00E1	3.00E2	2.00E3
Ru-106	3.68E2	1.00E1	3.00E2	2.00E3
Rh-103m	3.96E-2	1.00E1	3.00E2	2.00E2
Rh-105	1.48	1.00E1	3.00E2	2.00E2
Rh-106	3.46E-4	1.00E1	3.00E2	2.00E2
Ag-111	7.48	2.00	7.69E2	2.00E2
Ag-110m	2.53E2	2.00	7.69E2	2.00E2
Sb-124	6.02E1	1.00	1.00E1	1.50E3
Sb-125	9.96E2	1.00	1.00E1	1.50E3
Sb-127	3.80	1.00	1.00E1	1.50E3
Te-125m	5.80E1	4.00E2	1.00E3	1.00E3
Te-127m	1.09E2	4.00E2	1.00E3	1.00E3
Te-127	3.92E-1	4.00E2	1.00E3	1.00E3
Te-129m	3.41E1	4.00E2	1.00E3	1.00E3
Te-129	4.77E-2	4.00E2	1.00E3	1.00E3
Te-131m	1.25	4.00E2	1.00E3	1.00E3
Te-131	1.72E-2	4.00E2	1.00E3	1.00E3
Te-132	3.24	4.00E2	1.00E3	1.00E3
Te-134	2.92E-2	4.00E2	1.00E3	1.00E3
I-129	6.21E9	5.00E1	1.00E3	2.00E2
I-130	5.17E-1	1.70E1	1.00E3	2.00E2
I-131	8.05	4.45E1	1.00E3	2.00E2
I-132	9.42E-2	4.30	1.00E3	2.00E2
I-133	8.46E-1	2.29E1	1.00E3	2.00E2
I-134	3.61E-2	1.74	1.00E3	2.00E2
I-135	2.78E-1	1.09E1	1.00E3	2.00E2
Xe-133m	2.26	1.00	1.00	1.00
Xe-133	5.27	1.00	1.00	1.00
Xe-135m	1.08E-2	1.00	1.00	1.00
Xe-135	3.83E-1	1.00	1.00	1.00

TABLE 5.2-7 (Continued)

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

NUCLIDE	RADIOLOGIC HALF-LIFE (DAYS)	RADIONUCLIDE CONCENTRATION FACTORS		
		FISH	BIOTA	PLANT
Cs-134	7.47E2	2.00E3	9.87E3	2.50E4
Cs-135	1.10E9	2.00E3	1.00E4	2.50E4
Cs-136	1.37E1	1.86E3	5.78E3	2.50E4
Cs-137	1.10E4	2.00E3	9.99E3	2.50E4
Cs-138	2.24E-2	4.38E1	2.23E1	2.50E4
Ba-137m	1.77E-3	4.00	2.00E2	5.00E2
Ba-139	5.76E-2	4.00	2.00E2	5.00E2
Ba-140	1.28E1	4.00	2.00E2	5.00E2
La-140	1.68	2.50E1	1.00E3	5.00E3
La-141	1.63E-1	2.50E1	1.00E3	5.00E3
Ce-141	3.25E1	2.50E1	1.00E3	4.00E3
Ce-143	1.38	2.50E1	1.00E3	4.00E3
Ce-144	2.84E2	2.50E1	1.00E3	4.00E3
Pr-143	1.36E1	2.50E1	1.00E3	5.00E3
Pr-144	1.20E-2	2.50E1	1.00E3	5.00E3
Nd-147	1.11E1	2.50E1	1.00E3	5.00E3
Pm-147	9.57E2	2.50E1	1.00E3	5.00E3
Pm-149	2.21	2.50E1	1.00E3	5.00E3
Pm-151	1.16	2.50E1	1.00E3	5.00E3
Sm-147	3.90E13	2.50E1	1.00E3	5.00E3
Sm-151	3.18E4	2.50E1	1.00E3	5.00E3
Sm-153	1.95	2.50E1	1.00E3	5.00E3
Sm-156	3.92E-1	2.50E1	1.00E3	5.00E3
Eu-155	6.61E2	2.50E1	1.00E3	5.00E3
Eu-156	1.54E1	2.50E1	1.00E3	5.00E3
Ta-182	1.15E2	3.00E4	6.67E2	8.00E2
W-187	9.96E-1	1.20E3	1.00E1	1.20E3
Pb-210	8.15E3	3.00E2	1.00E2	2.00E2
Pb-212	4.43E-1	3.00E2	1.00E2	2.00E2
Pb-214	1.86E-2	3.00E2	1.00E2	2.00E2
Bi-212	4.21E-2	1.50E1	1.00E5	1.00E5
Bi-214	1.38E-2	1.50E1	1.00E5	1.00E5
Po-212	3.50E-12	5.00E1	2.00E4	2.00E3
Po-214	1.90E-9	5.00E1	2.00E4	2.00E3
Po-216	1.74E-6	5.00E1	2.00E4	2.00E3
Po-218	2.12E-3	5.00E1	2.00E4	2.00E3
Ra-224	3.64	5.00E1	2.50E2	2.50E3
Ra-226	5.85E5	5.00E1	2.50E2	2.50E3
Ra-228	2.10E3	5.00E1	2.50E2	2.50E3
Ac-228	2.56E-1	3.00E1	5.00E2	1.50E3

TABLE 5.2-7 (Continued)

CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

NUCLIDE	RADIOLOGIC HALF-LIFE (DAYS)	RADIONUCLIDE CONCENTRATION FACTORS FISH	BIOTA	PLANT
Th-228	6.99E2	3.00E1	5.00E2	1.50E3
Th-230	2.81E7	3.00E1	5.00E2	1.50E3
Th-232	5.20E12	3.00E1	5.00E2	1.50E3
Th-234	2.41E1	3.00E1	5.00E2	1.50E3
U-234	8.91E7	2.00	6.00E1	5.00E-1
U-238	1.60E-12	2.00	6.00E1	5.00E-1
Np-238	2.12	1.00E1	4.00E2	3.00E2
Np-239	2.35	1.00E1	4.00E2	3.00E2
Pu-238	3.21E4	3.50	1.00E2	3.50E2
Pu-239	8.91E6	3.50	1.00E2	3.50E2
Pu-240	2.40E6	3.50	1.00E2	3.50E2
Pu-241	5.48E3	3.50	1.00E2	3.50E2
Pu-242	1.41E8	3.50	1.00E2	3.50E2
Am-241	1.58E5	2.50E1	1.00E3	5.00E3
Am-242	6.68E-1	2.50E1	1.00E3	5.00E3
Am-243	2.70E6	2.50E1	1.00E3	5.00E3
Cm-242	1.63E2	2.50E1	1.00E3	5.00E3
Cm-243	1.02E4	2.50E1	1.00E3	5.00E3
Cm-244	6.54E3	2.50E1	1.00E3	5.00E3

TABLE 5.2-8

ANNUAL DOSES TO AQUATIC ORGANISMS LIVING IN THE CLINCH RIVER NEAR THE CRBRP

	Dose Estimates			
	Internal (mrad/yr)		External (mrad/yr)	
Organism	3-cm	30-cm		
Plants	2.6E-2*	1.1E-1	3.4E-5	
Invertebrates	1.7E-2	9.6E-2	3.4E-5	suspended
			3.0E-1	benthic
Fish	1.3E-2	3.3E-2	3.4E-5	

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*2.6E-2 = 2.6×10^{-2}

TABLE 5.2-9

ANNUAL DOSES TO TERRESTRIAL ORGANISMS NEAR THE CRBRP SITE

Organism	Dose Estimates Internal (mrad/yr)	External (mrad/yr)	Total (mrad/yr)
Terrestrial Mammal			
Gaseous Pathway	0.006	0.069	0.075
Liquid Pathway	0.027	<0.001	0.027
Total	0.033	0.070	0.10
Plants		1.4	1.4

TABLE 5.2-10

ANNUAL DOSE TO MAN FROM LIQUID EFFLUENT RELEASES

	Bone	GI Tract	Thyroid	Total Body	Skin
I. Ingestion					
a. Water					
Individual at Nearest public supply	1.3E-6	2.6E-6	4.1E-6	1.3E-6	1.3E-6 mrem
Population	5.5E-5	1.0E-4	9.9E-5	5.4E-5	5.4E-5 man-rem
b. Fish					
Maximum Individual	1.4E-5	1.6E-4	1.8E-5	1.3E-5	1.3E-5 mrem
Population	2.6E-4	2.6E-3	2.6E-4	2.4E-4	2.4E-4 man-rem
c. Duck					
Maximum Individual	1.7E-4	3.6E-5	1.1E-4	1.1E-4	1.1E-4 mrem/duck
II. External					
a. Immersion					
Maximum Individual				6.2E-8	4.8E-7 mrem
Population				5.7E-8	3.4E-7 man-rem
b. Above water					
Maximum Individual				4.5E-8	4.5E-7 mrem
Population				5.4E-8	4.2E-7 man-rem
c. Shoreline					
Maximum Individual				3.5E-5	4.1E-5 mrem
Population				6.2E-5	7.3E-5 man-rem
III. Total*					
a. Maximum Individual	2.2E-4	2.3E-4	1.7E-4	1.6E-4	1.7E-4 mrem
b. Population	3.8E-4	2.8E-3	4.3E-4	3.6E-4	3.7E-4 man-rem

* total organ doses include total body component due to external radiation

TABLE 5.2-11

2020 CLINCH AND TENNESSEE RIVER FISH HARVEST DATA (14,15)

Reach(TRM)[1]	Commercial Harvest (lbs/acre)	Sport Harvest (lbs/acre)	Area (acres)
17.4-0.0(CRM)	23.8	64.9	2,100
568-528	23.8	64.9	26,100
528-471	23.8	64.9	34,900
471-425	23.8	64.9	10,900
425-349	23.8	64.9	67,800
349-275	23.8	64.9	67,000
275-259	23.8	64.9	16,000
259-207	23.8	64.9	43,600
207-165	23.8	64.9	16,000
165-121	23.8	64.9	16,000
121-76	23.8	64.9	48,100
76-22	23.8	64.9	80,200

1. TRM = Tennessee River Mile. CRM = Clinch River Mile

TABLE 5.2-12

USE OF CLINCH AND TENNESSEE RIVER SYSTEM IN 2020 FOR RECREATIONAL PURPOSES (REF. 16)

Reach (TRM)	Above Water* Visits	In-Water* Visits	Shoreline* Visits
17.4-0.0(CRM)	2.0E5**	2.0E5	2.0E5
568-528	2.0E6	2.0E6	2.0E6
528-471	3.4E6	6.5E5	3.1E6
471-425	1.2E5	2.6E4	1.1E5
425-349	6.4E6	1.2E6	5.6E6
349-275	3.6E6	6.9E5	3.2E6
275-259	1.5E6	2.9E5	1.4E6
259-207	1.5E6	3.0E5	1.8E6
207-165	2.2E5	1.7E4	1.9E6
165-121	4.7E5	3.8E4	4.3E6
121-76	8.8E5	5.6E5	1.0E7
76-22	8.7E6	6.3E6	1.2E8

* These are the number of visits assuming five hours per visit. The actual estimates have different times per visit for each activity and reach of river.

** 2.0E5 = 2.0×10^5

TABLE 5.2-13

CRBRP - INDIVIDUAL DOSES FROM GASEOUS EFFLUENTS

External Exposures

Pathway	Point	Dose
air dose	Max. Exp.[1]	0.076 mrad/yr
air dose	Max. Exp.[1]	1.4 mrad/yr
Total Body	Max. Exp.[1]	0.069 mrem/yr
Skin	Max. Exp.[1]	0.55 mrem/yr
Internal Exposures - Total Body		
Tritium	Max. Exp.[1]	5.3E-4 mrem/yr

Breakdown of Internal Exposures - Total Body (mrem/yr)

	Child	Adult
Vegetable Ingestion	2.6E-4	1.9E-4
Beef Ingestion	2.7E-5	4.8E-5
Inhalation	8.3E-5	1.6E-4
Ground Contamination	1.6E-5	1.6E-5
Milk Ingestion	1.4E-4	8.4E-5
Total	5.3E-4	5.0E-4

1. Maximum exposure point is at 820 meters in the NW sector.

TABLE 5.2-14

CRBRP - POPULATION DOSES FROM GASEOUS EFFLUENTS

	Thyroid					Total Body				
	Infant	Child	Teen	Adult	Totals	Infant	Child	Teen	Adult	Totals
Submersion	9.94E-4	6.19E-3	3.94E-3	1.83E-2	2.94E-2	9.94E-4	6.19E-3	3.94E-3	1.83E-2	2.94E-2
Ground	3.76E-7	2.34E-6	1.49E-6	6.91E-6	1.11E-5	3.76E-7	2.34E-6	1.49E-6	6.91E-6	1.11E-5
Inhalation	3.00E-6	4.86E-5	2.35E-5	1.39E-4	2.15E-4	3.00E-6	4.86E-5	2.35E-5	1.68E-4	2.43E-4
Cow Milk	9.88E-6	4.07E-5	1.59E-5	5.13E-5	1.18E-4	9.88E-6	4.07E-5	1.59E-5	5.13E-5	1.18E-4
Beef Ingestion	0.0	1.43E-5	7.57E-6	7.14E-5	9.32E-5	0.0	1.43E-5	7.57E-6	7.14E-5	9.32E-5
Veg Ingestion	0.0	9.57E-6	5.14E-6	4.58E-5	6.05E-5	0.0	9.57E-6	5.14E-6	4.58E-5	6.05E-5
Total Man-Rem	1.01E-3	6.31E-3	4.00E-3	1.86E-2	2.99E-2	1.01E-3	6.31E-3	4.00E-3	1.86E-2	2.99E-2

TABLE 5.2-15

SUMMARY OF ANNUAL RADIATION DOSES TO POPULATION FROM CRBRP

		Thyroid (man-rem/yr)	Total Body (man-rem/yr)
I.	Internal		
	Ingestion (water)	9.9E-5	5.4E-5
	(fish)	2.6E-4	2.4E-4
	(milk)	1.2E-4	1.2E-4
	(meat)	9.3E-5	9.3E-5
	(vegetables)	6.1E-5	6.1E-5
	Inhalation	2.1E-4	2.4E-4
II.	External		
	In-water sports	5.7E-8	5.7E-8
	Above-water sports	5.4E-8	5.4E-8
	Shoreline activities	6.2E-5	6.2E-5
	Submersion in air	2.9E-2	2.9E-2
	Ground concentration	1.1E-5	1.1E-5
III.	Transportation of radioactive material		
	Unirradiated fuel	0.45	0.45
	Irradiated fuel	0.92	0.92
	Wastes	0.43	0.43
	Total	1.83	1.83

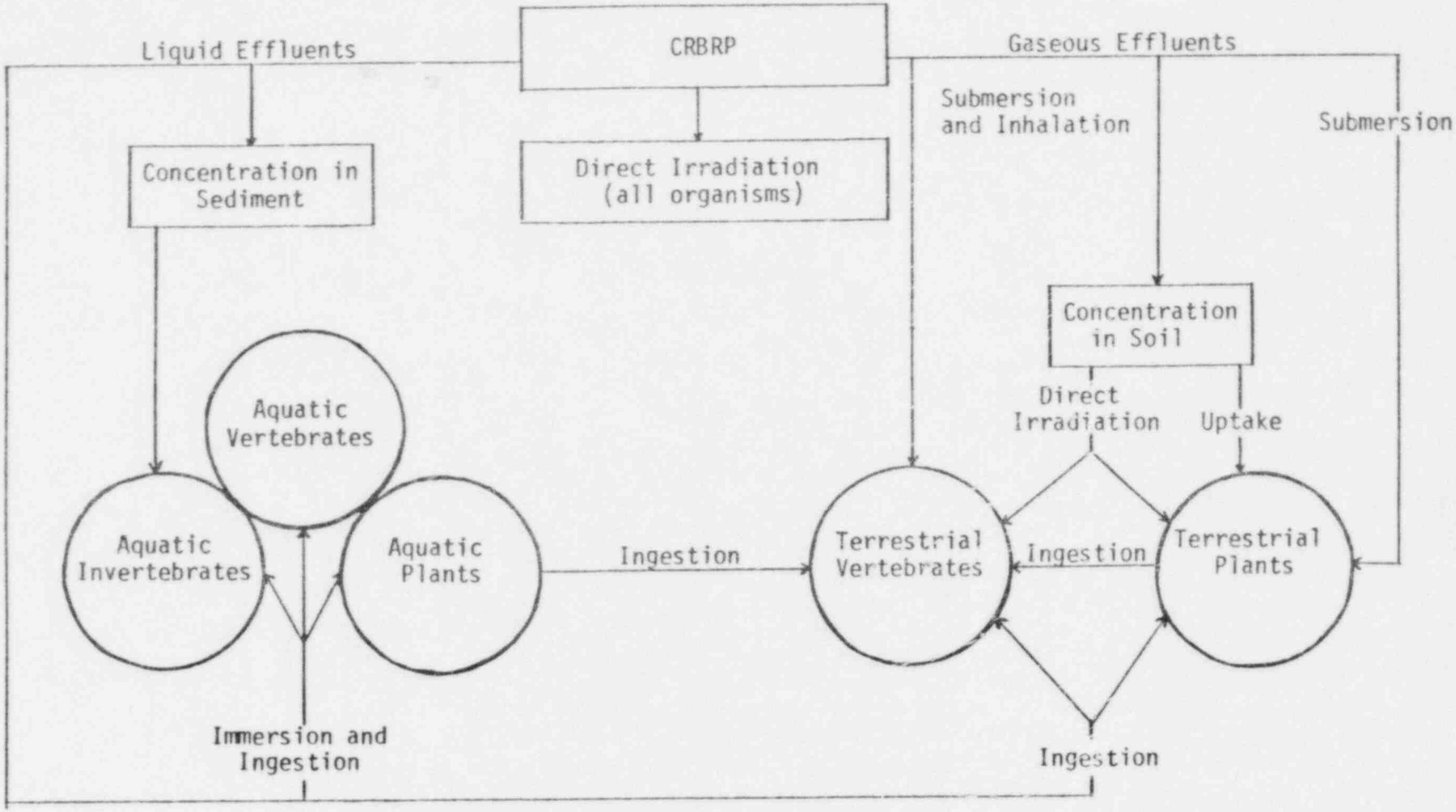

Figure 5.2-1

EXPOSURE PATHWAYS TO ORGANISMS OTHER THAN MAN

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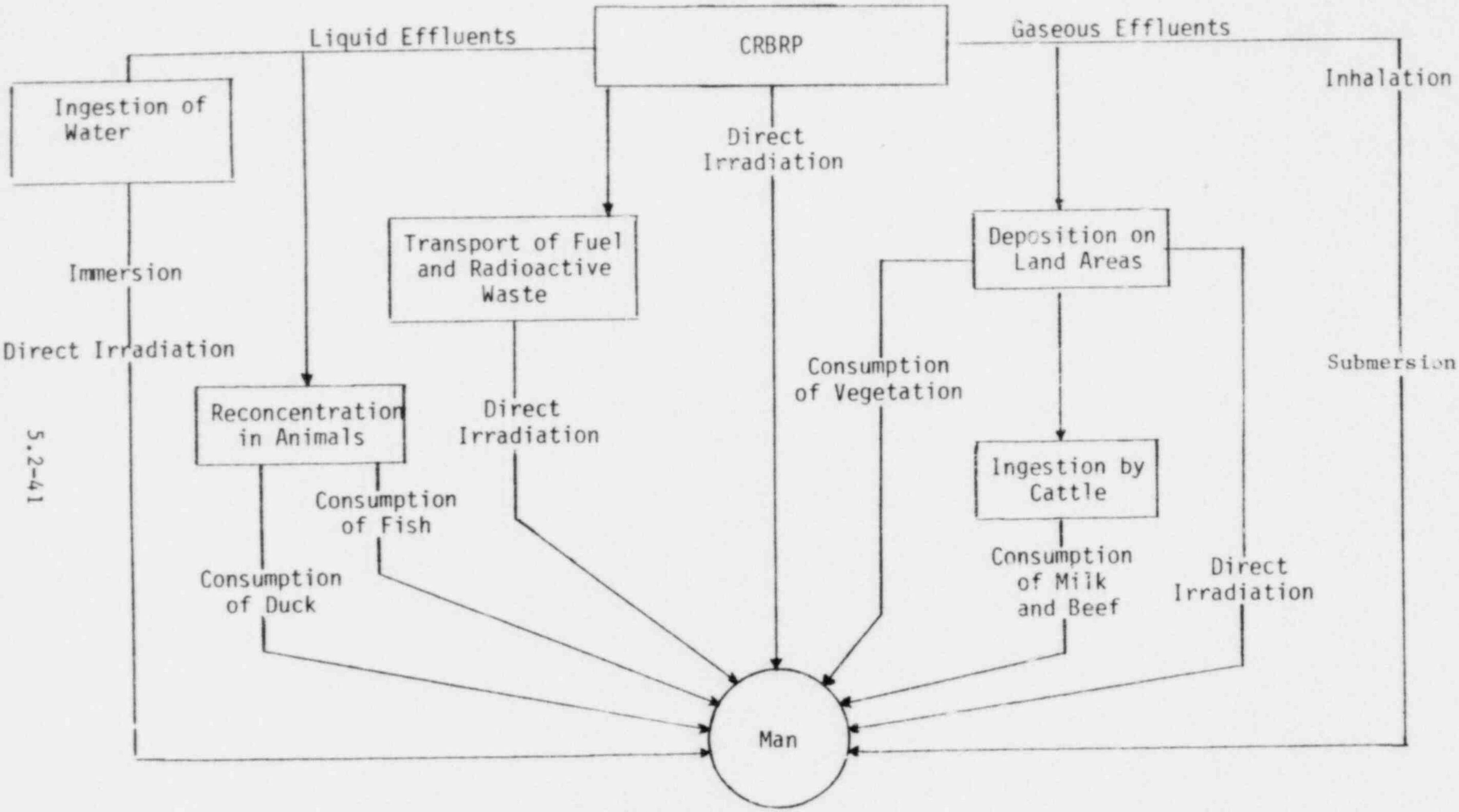

Figure 5.2-2

EXPOSURE PATHWAYS TO MAN

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5.3 RADIOLOGICAL IMPACT ON MAN

This section has been combined with Section 5.2 in Amendment XIII.

Pages 5.3-2 through 5.3-22 deleted by Amendment XIII. 13

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5.5 EFFECTS OF SANITARY AND OTHER WASTE DISCHARGES

In this section effects from sanitary wastes on the Clinch River as well as effects from gaseous effluents from the emergency diesel generator and the diesel fire pump are discussed and evaluated.

5.5.1 EFFECTS FROM SANITARY WASTES

Sanitary wastes are described in Section 3.7. These wastes, comparable to normal domestic sanitary waste, will enter a Sewage Disposal System consisting of an extended aeration package treatment plant. The operating 9
period (permanent) plant will include a slow sand filter that will be installed following the CRBRP construction period.

The sanitary system for the construction period is designed for a peak manning of 2,450 persons. Maximum daily sanitary wastewater design flow will be 61,250 gallons, or 25 gal/person/day. During construction, a unit of 13,000 gal/day and a large unit of 52,000 gal/day capacity will be 8
installed to give a total treatment capacity of 65,000 gal/day.

9

The average daily sanitary wastewater flow during normal operation will be 7,000 gallons. This is based upon 200 plant personnel, or 35 gal/person/day for normal plant operation. Present projected number of plant personnel is 179 persons with a peak manning of 300 men anticipated for annual shutdown. The permanent plant design flow of 13,000 gallons per 8
day will be adequate for this loading.

9

waste systems will be designed in accordance with the Tennessee Department of Public Health Design Criteria.[1,2] Treated effluent discharges will meet NPDES Permit limits. 9

Cooling tower blowdown is approximately 2,650 gpm or 5.9 cfs in the summer and approximately 1,955 gpm or 4.3 cfs in winter. Sanitary effluents during normal operation at full load will become diluted by the cooling tower blowdown 530 fold in the summer and 390 fold in the winter. The small concentration of pollutants (listed in Table 3.7-1) in the sanitary effluent will become further diluted in the Clinch River waters (6,772 cfs, average winter flow and 4,339 cfs average spring flow). The concentration of pollutants in the sanitary effuent before dilution will meet the NPDES Permit discharge criteria and are not anticipated to have any effect on the water quality of the Clinch River or on its aquatic biota at the mixing zone or beyond it, even for the worst case of no-flow conditions discussed in Section 5.4. 9 13

Sludge from the sewage treatment facility (the aeration package) will be trucked off-site by a contractor for ultimate disposal, as discussed in Section 3.7.

5.5.2 EFFECTS FROM GASEOUS EMISSIONS FROM EMERGENCY DIESEL GENERATOR AND DIESEL FIRE PUMP

Emission rates of gaseous pollutants from the emergency diesel generator units (quantity-3) and the diesel fire pumps (quantity-2) are given in Table 3.7-2. Emission regulations for the State of Tennessee for NO_x apply only if the total heat input to all the units exceeds 250 million Btu per hour.[5] Heat input is 159.11 million Btu/hr; thus, these diesel units are not regulated for NO_x emissions. Emission regulations for Roane 13

County limit SO_2 emissions to 5.0 pounds of SO_2 per million Btu per hour heat input.[6] Emissions of SO_2 are 0.547 pounds per million Btu per hour heat input and comply with the standards. Particulate standards limit emissions to 0.13 pounds per million Btu per hour heat input for total plant size of 159 million Btu heat input.[7] Emissions of particulate matter as found in Table 5.5-1 are 0.0076 pounds per million Btu per hour and comply with the standards. Carbon monoxide emissions for stationary sources are not regulated. The limit placed on organic compound emissions will be determined at the time of the permit application review by the Technical Secretary of the Tennessee Department of Public Health; Division of Air Pollution Control.[8] Because the emission rates of the gaseous pollutants are within the limits cited in the governing regulations and the source of these gaseous emissions is the emergency equipment which operates infrequently, the gaseous emissions do not constitute any hazard to the local environment. 13

TABLE 5.5-1

PRINCIPAL PARAMETERS AND EXHAUST EFFLUENTS FROM PLANT DIESEL ENGINES OPERATION (DURING NORMAL OPERATIONS)

	DIVISION 1 & 2 DIESEL GENERATOR (DG) UNITS	DIVISION 3 DIESEL GENERATOR (DG) UNITS	DIESEL FIRE PUMPS
1. Quantity	2	1	2
2. Test			
a. Frequency, per Unit	1 start test per month & at least 1 full loading test every 18 months	Same as Division 1 & 2 DG units	1 start test per week
b. Duration, per Unit	2 hours & 24 hours, respectively	Same as Division 1 & 2 DG units	30 min.
3. Fuel consumption rate, gal/hr	1,012	187.22	26.2
4. Heat input, 10^6 Btu/hr (Fuel Heating Value of 130,000 Btu/gal)	131.4	24.31	3.4
5. Maximum emission rates of pollutants released to atmosphere:			
a. Particulates, lbs/hr	1	0.185	0.026
($lbs/10^6$ Btu/hr)	(0.0076)	(0.0076)	(0.0076)
b. Sulfur dioxide (SO_2), lbs/hr	71.8	13.28	1.87
($lbs/10^6$ Btu/hr)	(0.547)	(0.547)	(0.547)

13

TABLE 5.5-1
(Continued)

PRINCIPAL PARAMETERS AND EXHAUST EFFLUENTS FROM PLANT DIESEL ENGINES OPERATION
(DURING NORMAL OPERATIONS)

13

	DIVISION 1 & 2 DIESEL GENERATOR (DG) UNITS	DIVISION 3 DIESEL GENERATOR (DG) UNITS	DIESEL FIRE PUMPS
5. (Continued)			
c. Nitrogen oxides (NO_X), lbs/hr	402	74.37	10.45
($lbs/10^6$ Btu/hr)	(3.06)	(3.06)	(3.07)
d. Organic compounds, lbs/hr	7	1.295	0.182
($lbs/10^6$ Btu/hr)	(0.053)	(0.053)	(0.053)
e. Carbon monoxide (CO), lbs/hr	14.4	2.664	0.374
($lbs/10^6$ Btu/hr)	(0.109)	(0.109)	(0.110)

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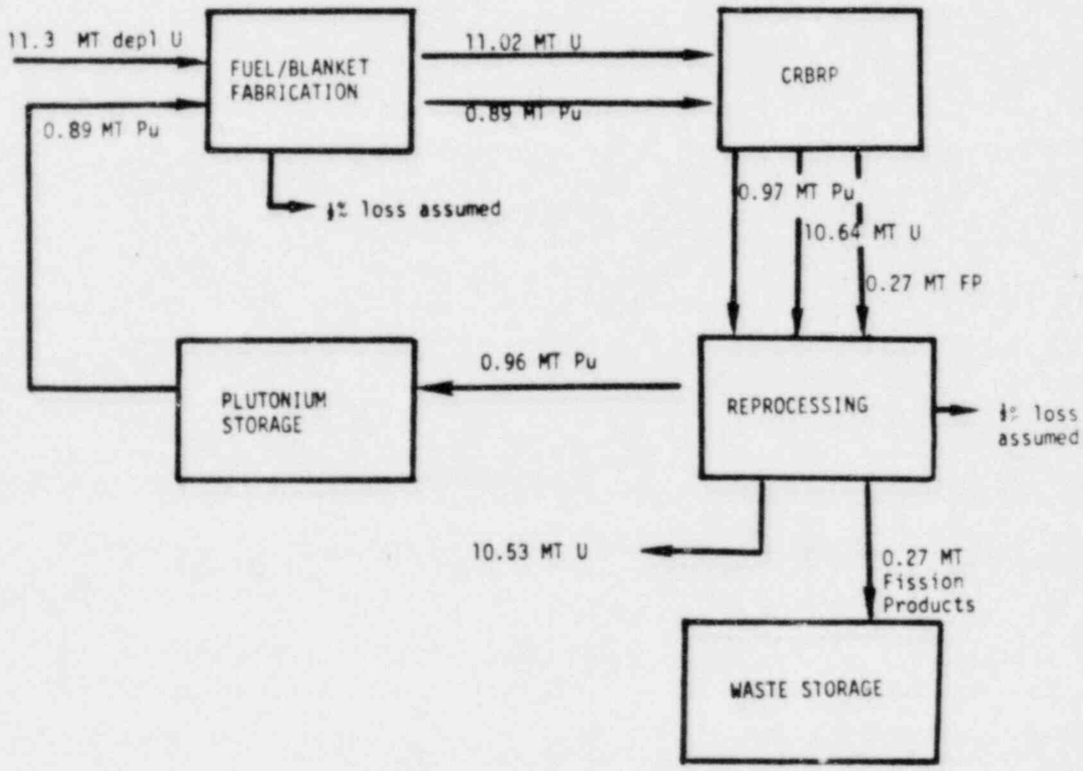
FIGURE 5.7-2

CRBRP EQUILIBRIUM FUEL CYCLE

PLUTONIUM AND URANIUM MASS FLOW

(MT/year, average)



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5.8 RESOURCES COMMITTED

The commitment of resources ascribed to the construction of the CRBRP was discussed in Section 4.3. This section is concerned with the commitment of resources during the expected life of the plant. Commitments of the various types of resources are not all of equal consequence. During operation of the plant, resources are utilized in amounts that, relative to their general availability, will not constitute an irreversible or irretrievable commitment.

5.8.1 COMMITMENT OF LAND RESOURCES

Approximately 135 acres of primarily forested land area (on-site plus off-site) have been committed for permanent plant facilities and the transmission corridor for the CRBRP and its related facilities. 13 This commitment, however, does not represent a measurable fraction of the productive forest resources of the region. The commitment of 135 acres is only 0.27 percent of the total acreage within a five-mile radius of the plant.

The Site has little agricultural potential due to the poor suitability of the soil and has been designated as an area for industrial development as discussed in Section 2.7. Should it be desirable at the end of the facility's expected life, the land can be returned to a condition suitable for future industrial development. Decommissioning and dismantling of the facility are discussed in Section 5.9.

No further alteration or destruction of wildlife habitats should occur during plant operation.

5.8.2 COMMITMENT OF WATER RESOURCES

One of the major resources committed during plant operation will be water from the Clinch River. Flow rate of the river varies

from an average low flow of 4339 cfs in the spring to an average 10 13
high flow of 6,772 cfs in the winter. For maximum power
operation, the anticipated average water makeup requirement is
13.4 cfs. An average of 5.1 cfs will be returned to the river as 9
blowdown and approximately 8.3 cfs will be consumed during plant
operation. The consumptive use of 8.3 cfs is only 0.15% of the
annual average Clinch River flow rate of about 5,380 cfs. The 10
amount of water lost to the atmosphere through evaporation is not
actually an irretrievable loss, however, as the water eventually
will be returned to the earth as precipitation.

Considering aquatic life as a resource, the loss of fish,
zooplankton, benthos, macrophytes and the like will be a
commitment of resources directly attributable to operation of the
CRBRP. Discharges to the Clinch River will be continuously
monitored to prevent introduction of deleterious effects to the
aquatic life by excessive temperature, chemicals or turbulence. 9
A preconstruction survey conducted on the Clinch River will
establish a reference framework for assessing the degree to which
this resource is committed.

5.8.3 COMMITMENT OF FUEL RESOURCES

Initial fuel assembly loading of the Clinch River Breeder Reactor
will consist of approximately 5.2 Metric Tons (MT) of uranium and 9
plutonium metal in a 36-inch high core. The fuel consists of 9
sintered mixed-oxide pellets of PuO_2 and UO_2 encapsulated in the
sealed stainless steel tubing (rods). Plutonium enrichment is
33.2 weight percent. In later cycles the plutonium enrichment
will be approximately 33 weight percent. Each of the 156 fuel 9
subassemblies in the reactor core contains 217 fuel rods. The
reactor core contains 1.7 MT of plutonium metal, 2.5 MT of
uranium metal and 20.7 MT of stainless steel in the fuel.

The isotopic composition of the feed plutonium metal in the core is 0.1 percent Pu-238, 86.0 percent Pu-239, 11.7 percent Pu-240, 2.0 percent PU-241 and 0.2 percent Pu-242. The isotopic split is similar to FFTF-grade plutonium. 9

An additional 25.8 MT of depleted uranium metal is committed in the inner radial and axial blankets. Inner and radial blankets, consisting of 214 assemblies, each containing 61 rods, contain 21.6 MT of depleted uranium metal and 27.6 of stainless steel. Each of the two axial blankets, which are an integral part of the fuel assemblies, contains 2.1 MT of depleted uranium metal. 9

An estimated 2427 fuel assemblies and 2142 blanket assemblies will be committed during the 30-year life of the plant. Operated on the once-through fuel cycle, the total requirement of the plant could be as high as 27 MT of plutonium metal, 336 MT of uranium and 600 MT of stainless steel over 30 years. However, it is expected that the burned fuel will be recycled to the plant after reprocessing and refabrication so that the actual heavy metal commitment to the plant from virgin ore (natural uranium) will be only a fraction of the aforementioned values. 9

If one assumes recycle with CRBRP operating by itself, requiring one full core load in the reactor and an additional reload core in reprocessing and fabrication, then the commitment from resources is only on the order of 3.5 MT of plutonium plus 59.2 MT of uranium. 9

6.2 APPLICANT'S PROPOSED OPERATIONAL MONITORING PROGRAM

The operational monitoring program outlined here will monitor the postulated impacts resulting from operation of the facility. The program covers radiological, chemical, thermal, meteorological and ecological considerations. In some cases the operational program is merely an extension of the preoperational program. However, the operational program may be modified as a result of information gained during either the preoperational or operational phase of the program. In some cases more specific operational monitoring will be performed in order to assess the impact of a particular aspect of plant operation such as operation of cooling towers.

6.2.1 RADIOLOGICAL MONITORING

6.2.1.1 PLANT EFFLUENT MONITORING SYSTEMS

6.2.1.1.1 GASEOUS EFFLUENTS

The radioactive effluent monitoring system will be designed to sample and/or continuously monitor and record radiation levels and concentrations of radioactivity from thirty-four (34) exhaust points (thirty-two building ventilation and two equipment 13
exhaust) from which radioactive gaseous releases may emanate; one located in the Intermediate Bay (SGB-IB), nine located near the top of the Reactor Confinement Building (RCB) dome, two located 9 13
in the Reactor Service Building (RSB), one located in the Radwaste Area (Bay) (RWA), one located in the Plant Service Building (PSB), fourteen in the Turbine Generator Building (TGB), and six located in the Steam Generator Building (SGB). 13

Continuous monitoring will be performed at those exhaust points which conceivably undergo a significant increase in detectable levels of radioactivity. The remaining exhausts will be samlped periodically, on an as-necessary basis.

The exhaust plenum located in the Intermediate Bay (IB) receives ventilation exhaust air from the Steam Generator Building Intermediate Bay (SBG-IB) area. A continuous air monitor (CAM) will be provided to detect gaseous activity in the effluent stream. The air sample will be obtained isokinetically from the exhaust, on a continuous basis. Sampled air will first flow through a particulate filter which will be viewed for beta activity, then through an iodine retention element for radioiodine detection, and finally through a 4π geometry 13
shielded chamber for gas detection.

9

The exhaust plenum located on the Radwaste Building receives ventilation exhaust air from the Radwaste Area. A continuous air monitor (CAM) will be provided to detect particulate and gaseous activity in the effluent stream. The air sample will be obtained isokinetically from the exhaust, on a continuous basis.

The two Reactor Service Building (RSB) exhausts will be 13
continuously monitored for radioactivity releases. Exhaust plenums located on the RSB roof which receive ventilation exhaust from the RCB and exhaust from the RSB via RSB clean-up filtration units will be continuously monitored for particulate, gaseous, and radioiodine activity in the effluent stream.

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The exhaust plenum located near the top of the RCB dome, which receives exhaust from the containment clean-up and annulus pressure maintenance and filtration system (located in the RSB), will be continuously monitored for particulate, radioiodine, gaseous, and plutonium activity in the effluent stream.

The eight exhausts located at the top of the RCB dome for the RCB annulus cooling air become potential radioactivity release points only in the event of very low probability accidents beyond the design basis (Thermal Margin Beyond the Design Base Scenario). The annulus air cooling system may be required to be initiated 24 to 36 hours after the accident. No on line radioactivity monitor will be provided for these exhausts and off site/emergency monitoring techniques will be adopted.

The six Steam Generator Building (SGB) exhausts receive 9 13
ventilation exhausts from the individual steam generator cells. Each exhaust will be sampled for tritium activity using silica-gel dessicants; and analysis of samples will be performed by liquid scintillation techniques. The exhaust sample flow through the silica-gel column will be maintained constant by a regulated pump assembly.

The twelve (12) exhaust fans in the Turbine Generator Building (TGB) receive ventilation exclusively from the various TGB operating areas and could potentially contain some tritium
activity. This potential contribution would not alter the values 13
reported for BOP gaseous tritium release. The condenser vacuum pump discharge is connected to the exhaust duct serving the lube oil areas of the TGB.

A continuous gas sample will be withdrawn from each of the deaerator exhaust, and turbine steam packing exhaustor, into the tritium samplers. The samplers will be comprised of a silica gel dessicant column for determination of tritium activity, in order to indicate unacceptable tritium diffusion into the steam generators. The sample will be analyzed using liquid scintillation techniques in the counting room. 13

In addition, the other TGB areas will be periodically grab sampled and samples will be analyzed for tritium activity.

The exhaust in the Plant Service Building (PSB) receives ventilation from the combined laboratory. Samples will be collected isokinetically by a particulate (and iodine, if required) filter and analyzed for isotopic content in the counting room. 9

The recorded activity levels, based on Counting Room analysis and recorded effluent flow rates out of the vents, provide a record of airborne activity release. Continuous monitoring provides an indication of off-normal conditions or changes in release levels, warranting a manual sample and counting room analysis. The reporting of effluent radioactivity released will be consistent with the guidelines established in Regulatory Guide 1.21. Detailed descriptions of the continuous monitoring/sampling equipment are given in Table 6.2-5, "Continuous Effluent Monitoring/Sampling".

Products Tank, through vent piping to the atmosphere. An igniter is provided to ignite the hydrogen gas generated in the sodium-water reaction as it leaves the vent piping. The affected steam generator loop will be isolated, the sodium pump shut down and the loop depressurized by opening the Power Relief Valves.

Following a postulated single tube failure in the steam generator module, approximately 669 pounds of reaction products and entrained sodium will be carried into the reaction products separator tank. Within the reaction products separator tank, the sodium and reaction products enter tangentially. The tangential motion results in separation of the liquid, solid and gaseous products and in addition, some of the entrained particles are separated. It is conservatively assumed for this evaluation that no separation of the entrained particles occurs within the reaction products separator tank.

During the short time period (28 seconds) while the SWRPRS is venting to the atmosphere during the design basis leak (DBL) and 11 the SGS is blowing down, small amounts of primary sodium might leak into the intermediate sodium. However, this sodium would not be transported to the superheater inlet during the period of time that this steam generator system is being blown down, due to the length of the piping between the IHX and the superheater inlet and the reduced sodium flows during this event. Therefore, no allowance has to be made for venting of primary sodium to the atmosphere. After the venting and blowdown is completed, there could be a trace of this primary sodium mixture vaporized and transported out the SWRPRS vent, however, this would be a negligible amount.

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The dose resulting from the Tritium within the IHTS sodium that 13
is released with the reaction products has been evaluated. The
Tritium concentration in the Steam Generator System at the end of
plant life (30 years) is 0.62 uCi/g and the Tritium concentration
in the IHTS sodium is 0.13 uCi/g for a hydrogen background level 11
in the IHTS of 200 ppb of hydrogen. During a DBL, 204 pounds of
water combines with 465 pounds of sodium and the conservative
assumption is made that all the sodium-water reaction products
are discharged to the atmosphere.

Depressurization of the isolated loop by opening the Power Relief
Valves will result in the release of all water/steam in the loop
to the atmosphere. The total mass released is 5,040 pounds.
Using the end of life (30 years) tritium concentration, 0.62
uCi/g for the steam system, the total tritium release through the 11
Power Relief Valves for this postulated accident is 1.417 Curies.

Thus, the total radioactivity released to the atmosphere as a
result of the postulated steam generator tube failure is 1.50 11
Curies of tritium, 0.083 released through SWRPRS and 1.417 8
released through the Power Relief Valves.

The maximum off-site whole body dose for this postulated release
is 8.3 x 10^{-2} mrem. Doses at specific downwind distances and 4 11
estimates of the potential population dose are provided in Tables 8
7.1-5 through 7.1-13.

7.1.2.6 ACCIDENT 6.0 - REFUELING ACCIDENTS

In accordance with Regulatory Guide 4.2, the refueling accident evaluations used in connection with light-water reactor environmental reports are generally analyses of radioactivity releases caused by dropping a spent fuel bundle into the open reactor vessel or the open spent fuel storage pool, dropping a

While the school enrollments resulting from the CRBRP Project contribute to the crowding in some systems and grades, these new students alone do not create unfavorable conditions. A more reflective analysis is reported in Appendix C.

8.3.2.1.3 TRANSPORTATION IMPACTS

Table 8.3-6 shows the projected increases in traffic volume generated by the day shift on the principal highway segments in the area (see Figure 8.3-1). These volumes are based on the peak construction employment. Since an estimated 80 percent of the construction work force will work day shift, the day shift commuters are anticipated to contribute the major CRBRP related traffic loads to the surrounding highway network.

The following assumptions were used as a basis to evaluate the traffic situation:

1. No sponsored van and bus program.
2. Commuter vehicle occupancy = 2.0.
3. No truck deliveries to construction site during day shift commuting hours.
4. The CRBRP construction work shift hours will be staggered such that the CRBRP commuter traffic will not coincide with the existing (non-CRBRP related) peak hour traffic on the significantly impacted highway segments.
5. Prior to significant construction employment buildup, the following intersections will be upgraded to sufficiently accommodate the projected traffic:
    a. State Route 95 and State Route 58.
    b. State Route 58 and Bear Creek Road (CRBRP Access Road).
    c. State Route 95 and Bear Creek Road (CRBRP Access Road).
6. Annual increase in non-CRBRP related traffic volumes = 2 percent.
7. Peak year of construction = 1985. | 13

Table 8.3-7 provides a perspective as to the day shift commuter traffic impacts on the five key State highway segments (see Figure 8.3-1) anticipated to be significantly impacted by the CRBRP commuter traffic. The table is based on the "level of service" concept of traffic analysis.[8] Existing traffic volumes are based on traffic count data provided by TDOT.[9] From an evaluation of the table, the following general conclusions can be made as to the effect of the CRBRP commuter traffic on these highway segments:

1. The projected traffic volumes do not exceed the calculated capacities (level E) during the hours which the CRBRP traffic contributes to the existing traffic volumes for any of the five highway segments.
2. The service levels during the hour which the commuter traffic contributes will decrease (worsen) by one service level with the exception that the level of service on State Route 58 between the Oak Ridge Gaseous Diffusion Plant and the intersection with State Route 95 will decrease by two levels.
3. With the exception of highway segment 3, State Route 58 between the Oak Ridge Gaseous Diffusion Plant and the Intersection of State Route 95, all segments will operate at low levels of service (D or worse) for about two consecutive hours during the peak commuting hours. The reason for the two hour duration of congested traffic flow is that the CRBRP related commuter traffic will immediately precede or follow the existing peak hour traffic, and therefore, extend the duration of time of low levels of service on highway segments in the project area.

Level of service D represents a condition in which tolerable operating speeds can be maintained, though this may be considerably affected by fluctuations in traffic volume which may in turn cause substantial drops in operating speeds. Level of service E represents a condition of lower operating speeds than in level D with traffic volumes at or near the capacity of the highway. Refer to pages 80-81 of the Highway Capacity Manual (reference 8) for complete definitions of levels of service. 13

8.3.2.1.4 FISCAL IMPACTS

This influx of construction workers and dependents will result in increased revenues to the general fund and school fund of local governments in the four-county impact area. Such a temporary population influx also creates the potential for strains on certain local government services and subsequent increases in expenditures for those services. Because of the relatively small population influx the only service which might require expansion is education. Although no capital expansion should be needed, additional teachers may be required in most of the school systems to meet the demands of the peak population influx. The project revenue increases are sufficient to accommodate the increased costs of providing the additional teachers expected to be needed. Appendix C contains details of the fiscal analysis. Since no other local government services, such as law enforcement or fire protection, should need expansion, no increase in local general fund expenditures will be necessary. However, local governments may expand services, if desired, to the extent made possible by increased revenues. In conclusions, a positive fiscal impact is expected in all local governments in the impact area, despite some projected increased expenditures for education. 10

8.3.2.1.5 OTHER PROJECT IMPACTS

Other potential project impacts include effects upon area health care, public safety, water supply and waste disposal systems, recreation, and aesthetic considerations. The following conclusions regarding impacts upon these several systems are based upon the analysis results reported in Appendix C to this document.

In the area of health care, all of the medical facilities within the four-county study area have access bed capacities of 24 percent or greater and could accommodate increased patient loads.

In terms of the public safety, it appears that additions to the current
law enforcement staffs should not be necessary to accommodate the
temporary population influx in the counties and municipalities. The
anticipated population influx is not large enough to require expansion 10
of services. The moderate size and incremental nature of the popula-
tion influx for the four-county area should not cause any adverse
impacts on fire protection. Thus, no expansion of services should be
necessary.

All of the municipalities have large enough excess capacities in their
water supply, wastewater disposal, and solid waste disposal systems
to accommodate additional residents. The location for disposal of onsite-
generated solid waste has not been selected, therefore, a definitive 13
conclusion on the impact of its disposal cannot be reached.

All communities designated to receive inmovers will experience additional stresses on existing recreation facilities. No community or county recreation program will be significantly adversely affected. However, noticeable stresses on recreation facilities in Roane County may be experienced due primarily to the existing shortage of adequate facilities.

Since the Site is located in a wooded area two miles from SR 58 and the
area surrounding the Site is sparsely populated, any temporary aesthetic
degradation during construction will be experienced by very few people. 10

There are 1,364 acres within the Site boundaries. This acreage is government-owned land and the area has been restricted from public use. As a result, there is a little change expected in terms of impairment of such things as recreation, land or water use. For example, although the river bank will be marked and posted to prevent private or commercial use of this area, activities on the Clinch River related to river traffic and fishing will not be affected by the CRBRP operations.

8.3.2.2 COSTS OF LONG-TERM DURATION

Long-term external costs stem from the changes that may occur throughout the lifetime of the project. These costs may range from minor inconveniences to direct loss of revenues. By and large, however, the operation of a nuclear electric generating facility creates few direct or indirect social-economic long-term external costs.

One of the most noticeable long-term effects will be on the local meteorological conditions since a vapor plume formed by the evaporation of water will be visible above the cooling towers. This may form fog at ground level or rare occasions and create icy conditions on road systems in subfreezing temperatures. These environmental effects are discussed in more detail in Section 5.0.

It is not anticipated that the operation of the plant will increase local government costs. The permanent employees (approximately 250 as compared to the construction workforce peak of about 5,400) will be 10
dispersed throughout the area; therefore, no one county or municipality is expected to support the total workforce. As a result, there will be little or no impact on facilities and services required to accommodate this minimal population increase. An assessment of these effects is reported in Appendix C to this document.

Because of its remote and isolated location, there will be no significant deterioration of aesthetic or scenic values in the vicinity of the CRBRP. Investigation of the Site has revealed no significant scenic or natural landmarks and the only site of local historical interest is the Hensley Cemetery which will be accessible to members of the family. Archaeological sites were excavated; any further investigations will be completed by the time construction begins. Therefore, construction and operation of the CRBRP will have no significant adverse effect on historical, scenic, cultural or natural landmarks.

8.3.2.3 SUMMARY OF EXTERNAL COSTS

The forecasted effects of the CRBRP Project discussed in this section include demographic and socioeconomic conditions associated with the construction and operation of the CRBRP.

Direct and indirect employment associated with the project is expected to peak at about 5,500 workers. Those workers who move into Anderson, Roane, Knox, and Loudon Counties are not expected to cause a rapid rise and fall in the total population of that area. This project-related population influx is expected to peak at about 3,210 men, women, and children and level to about 320 people by start of plant operations.

Associated with this population pattern will be a rise and fall in demand for private and public facilities and services. Need for housing units is expected to peak at about 1,300 units during the fourth year after the start of site preparation. Of this total need, about 50 percent will be for conventional houses, about 30 percent will be for mobile home sites 10
and about 20 percent will be for apartments and rooms. Most of the need for conventional houses is expected to occur in West Knox and Oak Ridge; most of that for mobile home sites is expected to occur in the rural parts of Roane, Knox, and Loudon Counites; and most of the need for apartments and rooms is expected to occur in West Knox and Oak Ridge.

Another need associated with the project-related population is water and wastewater distribution, collection, and treatment. Water supply and treatment capacity are generally expected to be adequate to meet the needs of this population. Distribution and collection systems, however, may require expansion or improvement in districts serving rural areas. Use of subsurface wastewater systems is unacceptable in many parts of these rural areas.

Project-related school enrollments for the area are expected to peak at about 620 students during the fourth year after the start of site preparation. To meet the needs of these students at the system level, about 15 classrooms and teachers will be required. Most of this need is expected to occur in the Knox County School System. With the exception of Knox County, room capacities anticipated in each of the school systems are expected to be sufficient to accommodate the project-related students.

Need for health and recreation facilities and services associated with the project-related population is not expected to reach a level which would adversely affect the existing quality of health and recreation service in 10
the area. This general conclusion also applies to the quality of public safety in the area. Some fire protection problems could arise, however, if mobile home sites are located in areas not having adequate water distribution systems.

A problem commonly experienced during the construction phase of such projects is traffic congestion. In the case of the CRBRP, a substantial increase in load can be anticipated on SR 58 and 95 in the project area. State highway segments in the project area will be congested for about two consecutive hours during peak commuting hours during the peak of construction.

TABLE 8.3-1

CRBRP TOTAL PLANT COST ESTIMATE - BASE COST*
(Millions of 1974 Dollars, Escalated at 8% Compounded)

	74	75	76	76T	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Total
PLANT INVESTMENT																							
NSSS																							
RM EQUIPMENT	.1	3.3	11.6	4.5	41.8	30.7	22.1	22.0	39.5	51.1	52.7	32.9	14.4	.5									327.2
AE EQUIPMEMT	(All AE Equipment is included in the BOP Equipment Category)																						
CONSTRUCTION			.3	.6	1.6	1.2	1.5	2.2	3.2	18.2	44.0	47.0	65.2	56.9	22.9	4.0	(2.8)						266.0
RM ENGINEERING	4.9	6.4	8.0	2.2	9.6	8.6	13.7	9.3	9.6	8.3	3.8	2.4	2.3	2.0	1.4	1.4	1.4						95.3
AE ENGINEERING	(All AE Engineering is included in the BOP Engineering Category)																						
ESCALATION		.8	3.3	1.3	15.0	15.5	18.6	20.5	38.9	68.9	103.9	98.6	112.6	93.0	43.2	10.8	(3.4)						641.5
SUBTOTAL	5.0	10.5	23.2	8.6	68.0	56.0	55.9	54.0	91.2	146.5	204.4	180.9	194.5	152.4	67.5	16.2	(4.8)						1,330.0
BOP																							
EQUIPMENT			.6		2.0	2.2	.2	4.0	13.7	30.0	9.6	4.3	1.4	.3	.8								69.1
CONSTRUCTION			.1	.2	.8	.5	1.1	.9	1.7	9.0	21.8	23.3	32.3	28.2	11.4	2.0	(1.4)						131.9
AE ENGINEERING	7.1	10.1	11.9	4.0	16.0	14.5	16.0	13.1	7.8	3.5	2.1	2.6	2.9	2.6	2.3	1.1	.7						118.3
ESCALATION		.8	2.1	.7	5.3	6.7	8.6	11.1	17.4	37.6	34.7	36.1	50.5	48.6	25.6	6.1	(1.6)						290.3
SUBTOTAL	7.1	10.9	14.7	4.9	24.1	23.9	25.9	29.1	40.6	80.1	68.2	66.3	87.1	79.7	40.1	9.2	(2.3)						609.6
PLANT COST TOTAL	12.1	21.4	37.9	13.5	92.1	79.9	81.8	83.1	131.8	226.6	272.6	247.2	281.6	232.1	107.6	25.4	(7.1)						1,939.6
FUEL FAB (INITIAL)			.1	.1	.2	.1		1.2	1.6	2.1	12.6	12.2	5.9										38.0
ESCALATION					.1			.8	.5	1.1	1.6	2.5	17.4	19.2	10.4								53.6
SPECIAL NUCLEAR MATERIAL													1.0	5.7	3.3								10.0
PLANT INVESTMENT TOTAL	12.1	21.4	38.0	13.6	92.4	80.0	81.8	85.1	133.0	228.9	275.8	252.8	317.3	266.8	123.9	25.4	(7.1)						2,041.2
DEVELOPMENT																							
RM ENGINEERING	13.0	26.5	32.1	8.8	37.3	29.9	28.4	30.4	27.4	14.9	9.0	5.5	3.7	2.6	1.9	1.8	1.8						275.0
RESEARCH & DEVELOPMENT		.4	15.1	20.5	7.7	29.5	28.6	30.7	31.0	11.8	3.0	1.3	.5										180.1
PROJECT OFFICE	4.4	3.5	5.1	1.5	4.9	3.6	3.2	3.9	4.0	4.9	5.2	5.0	4.6	4.6	4.0	3.8							66.2
ESCALATION		3.6	9.6	3.3	20.3	24.1	31.0	40.2	32.3	20.2	16.0	13.3	11.3	11.2	10.5	11.3	4.0						262.2
DEVELOPMENT TOTAL	17.8	48.7	67.3	21.3	92.0	86.2	93.3	105.5	75.5	43.0	31.5	24.3	19.6	18.4	16.4	16.9	5.8						783.5
OPERATING																							
PROJECT OFFICE																	2.9	2.0	1.4	.8	.5	.3	7.9
OPER. & MAINTENANCE											.3	2.1	4.1	4.4	5.3	6.8	11.8	11.8	11.2	11.4	11.2	6.0	86.4
FUEL FAB (RELOAD)												.6	.6	5.8	6.6	11.9	12.4	7.8	6.6				52.3
ESCALATION											.3	3.2	6.5	16.0	21.2	37.2	60.5	53.6	53.2	37.6	39.7	23.5	352.5
SUBTOTAL											.6	5.9	11.2	26.2	33.1	55.9	87.6	75.2	72.4	49.8	51.4	29.8	499.1
REVENUE																	(13.0)	(19.2)	(26.0)	(35.5)	(36.3)	(21.2)	(151.2)
ESCALATION																	(29.1)	(47.8)	(71.9)	(108.0)	(123.2)	(79.3)	(460.C)
OPERATING TOTAL											.6	5.9	11.2	26.2	33.1	55.9	45.5	8.2	(25.5)	(94.5)	(108.0)	(70.7)	(112.1)
ESCALATION TOTAL		5.2	15.0	5.3	40.7	46.3	58.2	72.6	89.1	127.8	156.5	153.7	198.3	188.0	110.9	65.4	30.4	5.8	(18.7)	(71.2)	(83.4)	(55.8)	1,140.1
PROJECT TOTAL	29.9	70.1	105.3	34.9	184.4	166.2	175.1	190.6	208.5	271.9	307.9	283.0	348.1	311.4	173.4	98.2	44.2	8.2	(25.5)	(94.5)	(108.0)	(70.7)	2,712.6
ESCALATION FACTORS	1.000	1.080	1.166	1.188	1.283	1.386	1.497	1.616	1.746	1.885	2.036	2.199	2.375	2.565	2.770	2.992	3.231	3.489	3.769	4.070	4.396	4.742	

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*As of March, 1980.

9.0 ALTERNATIVE APPROACHES AND SITES

9.1 ALTERNATIVE APPROACHES

The LMFBR Program is a key part of DOE's overall long-range energy research and development activities.[1,2] Alternative energy sources have been discussed and analyzed in the ERDA LMFBR Program Environmental Statement[3] and the DOE Supplemental Environmental Impact Statement for the LMFBR Program.[4] These statements and their analyses of alternative energy sources amply demonstrate the need for vigorous pursuit of the LMFBR Program. Since the CRBRP is a necessary step in the LMFBR Program, alternative energy sources for the CRBRP are not again considered in this report. The need for a demonstration plant as part of the LMFBR program is summarized in Section 1 of this report. 13
Since the primary purpose of the CRBRP is broader than the production of electrical power, the treatment of the alternative of not creating new generating capacity, although usually provided in accordance with Regulatory guide 4.2, is not appropriate here.

The operation of the CRBRP supports the overall LMFBR Program and provides the necessary technological base leading to development of larger commercial-sized liquid metal fast breeder reactors. Moreover, the CRBRP represents the development of technology with predicted performance, industrial support, a broad base of technological experience, and proven basic feasibility. The CRBRP is needed as soon as possible in order to demonstrate the technical performance, reliability, maintainability, safety, environmental acceptability, and economic feasibility of an LMFBR power plant on a utility system. The role of CRBRP in the LMFBR Program is discussed in detail in Section 1 and elsewhere.[4]

9.2 ALTERNATIVE SITES AND PLANT ARRANGEMENTS

In late 1971, the AEC appointed a Senior Utility Steering Committee and Senior Utility Technical Advisory Panel to assist them in selecting a utility partner to design, build and operate the demonstration plant. Proposals were submitted to the Liquid Metal Fast Breeder Reactor (LMFBR) Committee and AEC, by groups of utilities interested in participating in the demonstration plant program. Each of the principal sites advanced in the four proposals that were received appeared to meet the general requirement: The proposed site should require "no unusual design features or special consideration in licensing."(1) The Steering Committee noted "that increased siting flexibility could be associated with the Commonwealth/TVA arrangement . . . ."(2)

The Tennessee Valley Authority (TVA) and Commonwealth Edison Company (CE) proposal was subsequently accepted by the Committee and the AEC. This joint proposal by TVA and CE for building and operating the Nation's first large-scale (300 to 500 MWe) LMFBR demonstration plant included guidelines for selecting the site of the LMFBR demonstration plant. Guidelines included building the plant on the TVA system preferably at an existing electric generating plant which would utilize the steam from the LMFBR Nuclear Steam Supply System (NSSS). The proposal specifically named the John Sevier plant as a potentially suitable plant for this hook-on arrangement and indicated that other existing plants on the TVA system might also be suitable. As an alternate to the hook-on arrangement, the provision was made in the proposal to build an entirely new plant on the TVA system, where TVA would provide links from its transmission system to the switchyard at no cost to the project. A site on the Clinch River, which is in the custody of TVA, was named as one possible location which could be made available at no cost to the project.(2)

10.0 PLANT DESIGN ALTERNATIVES

This section of the ER discusses the alternative systems designs as they were presented over the period October, 1974 through February, 1977, which resulted in the acceptable findings published in the NRC's FES (NUREG-0139). Since the publication of the FES in February 1977, there have been no significant technological breakthroughs which would alter the relative effectiveness ranking of the various candidate systems. Similarly, the cost rankings would remain the same, since the effects of inflation would increase costs approximately equally. Therefore, a detailed update to the ER which discusses the various alternatives and their costs is not necessary nor is it justified. The various sections have been revised to update the descriptions of the chosen alternative systems so that these descriptions are consistent with information appearing in other Sections of the ER and in the PSAR. 13

The following discussions of alternatives provides the information upon which the 1977 FES (NUREG-0319) was based.

It must be recognized that any act of man or nature has some impact upon the environment. It is also important to note that although adverse impact can be reduced by the allocation of additional resources for environmental protection, the law of diminishing returns applies to the resources expended. This point was recognized by the U.S. Congress in enacting the National Environmental Policy Act of 1969 and was further reinforced by the U.S. Court of Appeals for the District of Columbia in 1971 in the Calvert Cliffs Decision. A benefit-cost analysis of the proposed project (the cost-effectiveness portion in particular) brings into account the environmental aspects of the proposed project and, therefore, assists in the implementation of both the letter and spirit of the National Environmental Policy Act of 1969.

The benefit-cost analysis of the Clinch River Breeder Plant requires a discussion of the proposed nuclear power station and a comparison of the proposed station and its feasible alternatives.

The environmental effects of a nuclear power station can be associated with the operation of certain identifiable systems, each of which has been selected, through evaluation of environmental, economic and other costs, as the optimal choice for its category. 3

In some instances, the interaction of these systems may be such as to require their selection on the basis of an optimal combination rather than on the basis of individual optimal systems. The weak point in this form of analysis is not the logic but (1) the availability of realistic data on many of the parameters associated with each of the systems and (2) meaningful quantitative estimates on the importance of environmental changes and the extent of change assignable to a particular alternative. Although energy requirements, hardware costs and economic considerations are relatively easy to predict, social benefits and costs, such as the impact upon human health and safety and preservation of the biological ecosystem, are not well defined and are therefore, by necessity, more subjective.

Whenever there is no objective method of determining benefits or costs, or when effects are highly uncertain because of the lack of basic understanding and knowledge they shall, nonetheless, be identified and discussed. All relevant knowledge must be included in attempting to come to a reasonable judgement. Hence, "benefits" and "costs" as used herein are defined on a broad scope. This approach is in agreement with the philosophy of the Calvert Cliffs Decision and U.S.A.E.C. guidelines.

To provide continuity and uniformity to the logic process through which the alternatives study for each plant system is conducted, a single general format for Section 10 is employed. A guide to its structure appears in Table 10.0-1.

The quantity of air flow through the wet and dry sections can be controlled by a feedback system which senses cold water temperature. In this manner, cold water temperature can be maintained at an upper limit, while evaporation, and thus fogging, is kept to a minimum.

In addition to its environmental advantage of plume control, the wet/dry tower offers reductions in water consumption and drift rate compared to all-wet cooling. However, winter cold water temperatures are higher due to the utilization of the dry sections resulting in a warmer blowdown and reduced generating capability.

10.1.2 ELIMINATION OF IMPRACTICAL ALTERNATIVES

10.1.2.1 ONCE THROUGH COOLING

The Committee on Power Plant Siting of the National Academy of Engineering has established the following criterion: "Plants sited on large streams and using once-through cooling should not use more than 20% of the low water flow of the stream".[2] Due to the unique hydrology of the Clinch River described in Section 2.5, the low water flow condition is actually one of no flow, as shown in Figure 10.1-2. Under such a condition, the condenser heat load could not be adequately dissipated and the discharge water temperatures would cause significant impact to aquatic life. Once through cooling is not, therefore, a viable alternative for the CRBRP.

10.1.2.2 COOLING LAKE

Use of a cooling lake requires sufficient land suitable for impoundment. Noting that an efficient lake system in regions of moderate humidity must be sized to $\geq$ 1 acre per MWe, a 350 to 400 acre lake would be needed for the CRBRP. Due to the uneven topography of the Site, a lake of this size would be subject to extensive fingering with attendant reduction in heat dissipation capability and probable off-site land loss. Thus, a lake cooling system is not an applicable alternative.

10.1.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

10.1.3.1 SPRAY POND

The spray pond cooling system considered for the CRBRP consists of two rectangular channels 80 feet wide and 2,175 feet long and occupies approximately eight acres of land. A floating platform spray system consisting of 54 modular cells is used. Each module is self-contained and includes pump, water intake and four spray nozzles. Design conditions for the spray pond are given in Table 10.1-1.

10.1.3.2 NATURAL DRAFT WET COOLING TOWER

A single natural draft wet cooling tower is required for the CRBRP. Dimensions for this tower are a 310-foot base diameter and a 385-foot height. Range and approach are both 20 degrees F. Design parameters for the natural draft tower are presented in Table 10.1-1. Exhaust conditions are depicted in Figure 10.1-3.

10.1.3.3 MECHANICAL DRAFT WET COOLING TOWER

Two alternative mechanical draft wet cooling towers are identified for the CRBRP. They are the same in all respects except in tower configuration. One design utilizes the standard linear arrangement of tower cells and the other design incorporates the recent innovation of circular cell configuration. Circular design permits a greater plume rise with attendant reductions in ground fog potential and recirculation of the exhausted air stream.

Both mechanical draft towers have a 25 degree F range and 15 degree F approach and utilize 5 cells in a single tower. Exhaust 13
conditions and evaporation rate for these towers are depicted in Figure 10.1-4 and 10.1-5, respectively. The linear tower is 400 13

feet long, 55 feet wide and 60 feet high. The circular tower has a 250-foot diameter base and a 60-foot height, as shown in Table 10.1-1.

10.1.3.4 MECHANICAL DRAFT DRY COOLING TOWER

The mechanical draft dry cooling system considered for the CRBRP is a four tower unit utilizing a total of 82 cells. Each circular tower has a base diameter of 245 feet and a height of 78 feet. Required circulating water flow for the dry cooling alternative is nearly twice that of the mechanical draft wet tower, as seen in Table 10.1-1. A Heller cycle dry tower,[3] shown in Figure 10.1-6, is employed. Cold water temperatures and exhaust conditions for the dry tower are depicted in Figures 10.1-7 and 10.1-8, respectively. 13

10.1.3.5 MECHANICAL DRAFT WET/DRY COOLING TOWER

Two mechanical draft wet/dry towers are considered for the CRBRP; a 30 percent plume severity tower and a zero percent severity tower. Plume severity is defined in Figure 10.1-9 and is used to indicate the design conditions for which no visible plumes are produced. The zero percent severity tower provides the greater level of plume control. Both of the wet/dry towers utilize a circular configuration. Design conditions for the towers are given in Table 10.1-1.

10.1.4 ENVIRONMENTAL COSTS

10.1.4.1 PLUME FORMATION

Environmental concerns relating to the formation of vapor plumes from evaporation cooling towers include ground fog and ice, plume interference with air traffic and aesthetic impact. To predict the magnitude of these potentially adverse effects, a vapor plume study has been performed and is included as an appendix to this section.

10.1.4.1.1 GROUND FOG AND ICE

Occurrences of ground fog and ice are predicted for the five alternative cooling towers in Appendix 10.1. A summarization of the potential total hours per year of ground fog attributable to each of the alternatives is given in Table 10.1-2. Plumes for the natural draft wet tower are sufficiently elevated that interception with the terrain will not occur; hence, no ground fogging is expected. Potential fogging hours are the highest for the mechanical draft wet tower, linear array, and are the lowest for the zero percent plume severity wet/dry tower.

System selection cannot be determined solely by fogging potential, as a major consideration relates to the fogging of highways, bridges and water ways. These are areas of concern where the local population may be most severely affected. For the CRBRP vicinity, three points of interest are identified for which the effects of fogging pose potentially significant environmental costs. These are Interstate Highway 40 at Caney Creek, Gallaher Bridge and the Oak Ridge National Laboratory (ORNL). Each is within the predicted areas of plume interception with the ground as shown in Tables 10.1A-7 through 10.1A-10. Ground fog hours per year for these three points of interest are presented in Table 10.1-3. For all four mechanical draft wet-type towers, ground fog occurrences are limited to one hour or less per year. Compared to the occurrences of natural fog indicated in Tables 2.6-26 and 2.6-27, the small | 13
quantities of cooling tower induced fogging at Interstate Highway 40, Gallaher Bridge and ORNL are insignificant. Consequently, no substantial environmental advantage would be gained by any of the alternatives from the viewpoint of fog control.

The valleys located along a SW-NE line passing through the Site will experience the largest portion of the potential fog hours identified in Table 10.1-2 due to the predominance of wind action in these two directions as shown in Table 2.6-20. As these valleys are lightly populated (particularly to the northeast which is DOE restricted area), fogging is not expected to present a significant environmental concern. Ground fog caused by any of the alternative cooling systems will not extend to regional airports and will not significantly affect navigation on the Clinch River, as indicated in Section 5.1.8.2. 13

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10.1.4.1.2 AESTHETIC IMPACT OF PLUMES

Mean lengths of visible plumes for the five cooling tower alternatives are given in Table 10.1A-5. These values represent maximum plume extents as the effects of changing weather conditions that would tend to dissipate the plumes are not considered. The longest plumes are produced by the natural draft tower while the zero percent plume severity wet/dry tower produces the shortest plumes. In general, extensive plumes occur during days of high relative humidity when natural cloud cover is to be expected. Merger of cooling tower plumes with the cloud cover would be likely, particularly for the natural draft tower plumes which rise higher than those of the mechanical draft towers.

As the Site is located in a sparsely populated area, significant aesthetic impact is not anticipated. The uneven topography of the Site area will tend to obscure the full extent of cooling tower plumes from the local populace.

10.1.4.2 DRIFT

Drift deposition for the five cooling tower alternatives are presented in Table 10.1-4. Highest drift deposition occurs for the mechanical draft wet tower, linear array, while the lowest deposition occurs for the zero percent plume severity tower. (No drift is produced by the dry tower.) Drift deposition for the spray pond would be similar to that of the mechanical draft tower, linear array. The drift calculations in Table 10.1-4 are based on highly conservative assumptions; notable is the disregard for the diluting effects of rainfall. Given these assumptions, the drift depositions calculated are extremely small. Drift deposition is the highest for the mechanical draft wet tower, linear array; however, it is equivalent to less than 0.00007 pounds per square foot per day. Drift deposition of this magnitude does not pose a significant environmental concern, as indicated in Section 5.1.8.3.

10.1.4.3 WATER USE

Potential environmental concerns relating to cooling system water use include entrainment and impingement of aquatic life due to withdrawal from the Clinch River, consumption via evaporation and drift losses and changes to river water quality and impact on aquatic life arising from the blowdown of waste heat and chemicals. None of these concerns are applicable to the mechanical draft dry tower as it is designed for a 100 percent closed water cycle.

10.1.4.3.1 WITHDRAWAL

The cooling system utilizes the largest portion of the CRBRP makeup water flow and is primarily responsible for the entrainment of aquatic life. As discussed in Section 5.1, entrainment losses for the mechanical draft wet tower are not significant due to the small size of the makeup flow in relation to the Clinch River. Although the natural draft wet tower requires a greater makeup flow (0.3% above that of the mechanical draft wet towers) and the wet/dry towers use less water (~8% below the mechanical draft wet towers makeup flow), only marginal differences in the magnitude of entrainment effects would exist among the alternative cooling systems (except for the dry tower). 6

Impingement of fish and other aquatic life is not directly a function of the cooling system water requirements but depends primarily on the design but deviate in winter as the utilization of the dry section reduces cooling efficiency. The same is true for the 30 percent plume severity wet/dry tower although its blowdown is uniformly warmer than the zero percent tower.

As previously noted, the primary environmental concern associated with the discharges of waste heat is the formation of thermal plumes. A discharge plume study has been performed to estimate the size and character of the anticipated CRBRP thermal mixing zones. This study is based on the performance of the selected cooling system and appears as an Appendix to Section 10.3. Figures 10.3A-8 through 10.3A-11 of this appendix illustrate the extent of the thermal plume formation under various mixing conditions. As discussed in Sections 5.1 and 10.3, these plumes are sufficiently small both in size and temperature differential that no significant impact on aquatic life is anticipated. Thermal plumes that would result from the alternative cooling systems would be expected to be of similar size as those produced by the mechanical draft wet tower blowdown but of slightly higher temperature in accordance with the information presented in Figure 10.1-10. 6

Chemical Composition

Chemical discharges from all of the cooling system alternatives (with the exception of the dry tower) will be nearly identical as all have the same chemical concentration factor and produce similar blowdown flow rates. As indicated in Section 5.4, chemical discharges by the selected cooling system will not significantly affect either water quality or aquatic life in the Clinch River.

10.1.4.4 LAND USE

The CRBRP Site comprises over 1,300 acres of woodland. It is not at present, nor has it been recently, inhabited or utilized (for farming, forestry, etc). Use of a portion of the 1,300 acres for plant structures does not represent a significant land use concern as the area has for many years been in government custody and unavailable to the general public.

Land requirements for various alternative cooling systems range from one-half acre for the mechanical draft wet tower (both linear and circular configurations) to eight acres for the spray pond. Land requirements for each alternative both in terms of acres needed and percent of Site area utilized are presented in Table 10.1-5. When viewed in the latter perspective, the land requirement of even the spray pond (0.6% of Site acreage) appears small.

Although the development of the CRBRP Site does not represent loss of publicly-utilized land, the acreage required by the cooling system becomes a valid land use concern insofar as additional undisturbed woodland area within the Site boundaries must be committed. The results, shown in Table 10.1-5, indicate that this potential increase in land consumption is quite small for any of the alternative systems.

10.1.4.5 AESTHETIC IMPACT OF STRUCTURES

The Oak Ridge, Tennessee area in which the CRBRP Site is located is characterized by undulating topography. The region's many ridges will form a natural barrier to visual encounters with plant structures. Except for several residences on the south shore of the Clinch River across from the Site, observation of the plant will be limited.

Compared to the tallest plant structure, the Reactor Containment Building measuring 179' above plant grade, only the natural draft |13 are within a range of $2.0 to 2.5 million higher in cost. By far the most expensive system is dry cooling with a $15.5 million price increase over that of the mechanical draft wet tower.

10.1.6 COMPARISON OF ALTERNATIVES

10.1.6.1 DIRECT COMPARISON OF REASONABLE ALTERNATIVES

A summary of the environmental and economic costs for the cooling system alternatives is presented in Table 10.1-10. The lowest economic costs are realized by the mechanical draft wet tower. As capsulized in the Table 10.1-10 and detailed in Section 5.1, differences in environmental costs are not significant. 6

Improved control over atmospheric releases is the primary environmental advantage offered by the natural draft wet tower and both wet/dry towers. 6 Although the natural draft tower eliminates ground fogging and produces the least drift of the wet-type systems, greater plume lengths, higher blowdown temperatures and increased plant visual impact counterbalance these positive features. Consequently, the $2.19 million additional system's cost is not offset by a clear environmental advantage over the mechanical draft wet tower. Reductions in both ground fogging and plume extent are offered by the wet/dry tower alternatives; however, winter blowdown temperatures are substantially increased. As the predicted ground fog hours for the mechanical draft wet tower are not significant in relation to regional occurrences of natural fogging, there is no overriding incentive to absorb the offsetting environmental disadvantage and higher economic costs associated with the wet/dry towers.

Spray pond performance is similar to the mechanical draft wet tower. 6 Its environmental costs are roughly equivalent with a potential advantage in plume formation counterbalanced by higher blowdown temperatures and a larger land area requirement. Economic cost for the two systems is the deciding factor as a $2.52 million price increase and 3 MWe capability penalty are assessed against the spray pond alternative.

The lowest environmental costs are realized by the mechanical draft dry tower. As this system is designed for closed cycle operation, no makeup water is normally required and no vapor plumes, drift or blowdown are produced. Land requirements are increased, however, as many more cells are required to dissipate the plant heat load by dry mechanisms than are needed for the wet towers. Economic costs for the dry tower are substantial as a 13.6 MWe capability penalty and $15.5 million price increase over the mechanical draft wet tower are 6
incurred. The burden of these economic costs would have to be offset by significant reductions in environmental impact. However, as the mechanical draft wet tower does not represent a significant 6
environmental concern, the dry tower economic costs are not justified.

13

10.1.6.2 REASONS FOR SELECTION OF CHOSEN SYSTEM

The selected cooling system for the CRBRP is the mechanical draft wet tower like that shown in Figure 10.1-12. In contrast to once 6
through cooling, it provides significant protection from the adverse environmental effects of thermal discharges. It is economically preferable to, and environmentally competitive with, other recirculating mode cooling systems and will not have any significant environmental costs associated with its operation.

6

TABLE 10.1-5

LAND REQUIREMENTS FOR ALTERNATIVE COOLING SYSTEMS

			Mechanical Draft Wet Tower			Mechanical Draft Wet/Dry Tower	
	Spray Pond	Natural Draft Wet Tower	Linear Array	Circular Array	Mechanical Draft Dry Tower	30% Plume Severity	0% Plume Severity
Land required (in acres)	8.0	1.7	0.5	1.0	4.3	2.1	3.3
Fraction of Site Area (as %)	0.57	0.12	0.03	0.07	0.31	0.15	0.24

TABLE 10.1-6

VISUAL IMPACT OF NATURAL DRAFT WET COOLING TOWER COMPARED TO REACTOR DOME

Regional Points of High Population Use	Distance from CRBRP (miles)	Visual Impact (%)* Reactor Dome (179 feet)	Visual Impact (%)* Natural Draft Tower (385 feet)
Gallaher Bridge	1.8	20	53
I-40 W**	2.6	0	11
ORNL	4.0	9	23
Melton Hill Dam	4.5	0	9
		29	96

*Visual Impact: degree of impact varies directly with height of structure above horizon (h) and inversely with viewing distance from plant site (d)

$$I(\%) = \frac{h/385}{(d/2)/0.7} \times 100$$

**An approximate one mile long section of I-40 located SE of plant site in which the driver of a vehicle traveling in the westbound lane will have a portion of the natural draft wet tower in the center of his vision.

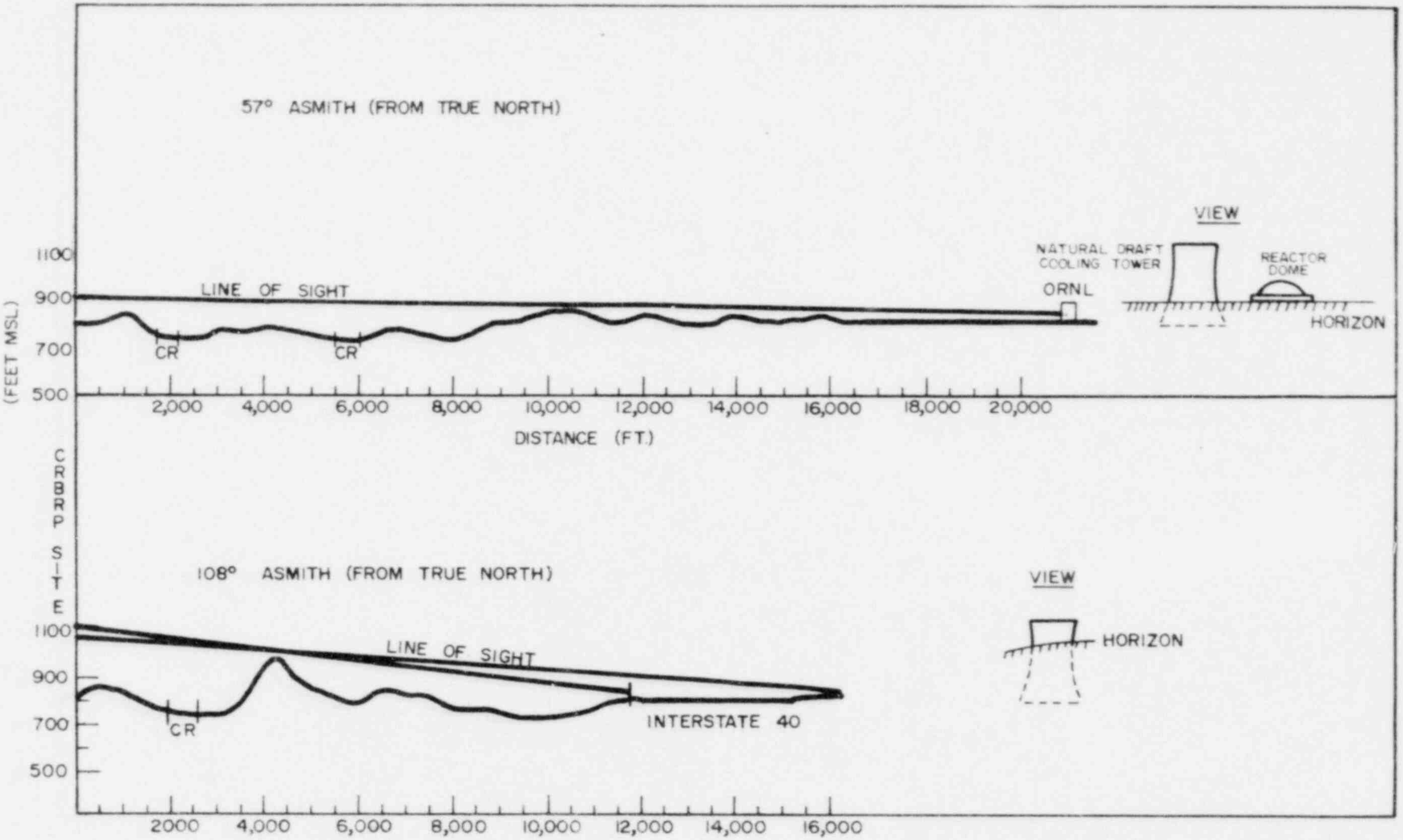

Figure 10.1-11 GROUND PROFILES AND DEPICTION OF CRBRP VISIBILITY FOR THE NATURAL DRAFT TOWER

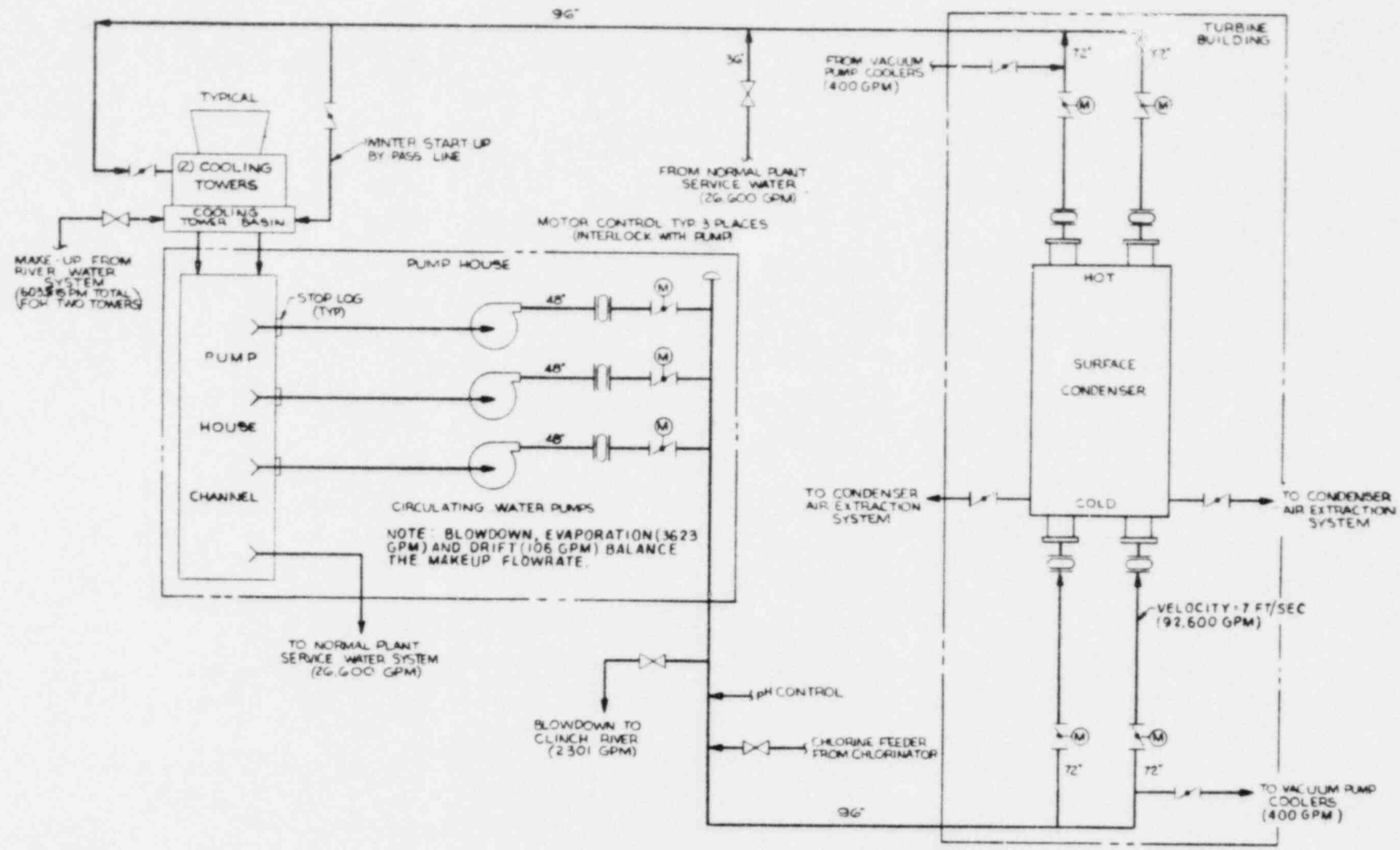

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Figure 10.1-12 SELECTED COOLING SYSTEM--MECHANICAL DRAFT WET TOWER

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10.2.2.2 LOUVER SYSTEM

The louver system is technically feasible at this time. However, certain features of the system render it non-adaptable to the CRBRP Site.

Louver barrier efficiency in reducing impingement losses is highly dependent upon the water velocity through the louvers. This is a function of water level and flow rate. Only small variations in these two parameters can be tolerated. At the Site, the Clinch River regularly experiences six-foot water level differentials on a seasonal basis.

In addition to seasonal fluctuations, daily fluctuations can vary by about three feet at summer operational level to about eight feet during winter operational level. Hourly rate of flow can vary from zero to Melton Hill turbine capacity (approximately 22,000 cfs) at any time during the year. As presently conceived, the louver system could not function successfully under these conditions and does not constitute a viable alternative for the CRBRP intake system.

10.2.2.3 ELECTRIC SCREENS

While it has been shown effective for diverting upstream migrating fish in several cases, the electric screen does not appear practical for use in the CRBRP intake system. No unique or regular migration of a key species is evident in the Clinch River. Selection of the proper voltage and pulse for the screen would be difficult as the river contains a variety of species, no one of which is of dominating importance. Because fish entering the intake structure are moving with the flow of water, any that become stunned by the electrical barrier will be drawn directly through it and impinged on the intake screens. Additionally, the electric screen presents a hazard to other wildlife and to humans due to the high voltages used. For these reasons, the electric fish fence cannot be considered a reasonable alternative for the CRBRP intake system. |13

10.2.2.4 BUBBLE, LIGHT AND SOUND BARRIERS

The success of bubble, light and sound behavioral barriers has been far from dramatic. They have not adequately demonstrated degrees of reliability or effectiveness that would permit their consideration as viable alternatives for the CRBRP intake system.

Of the three types, the air bubble screen has shown the most promise;[2] however, it suffers from an inability to repel fish during the cold winter months. Light barriers have had poor success owing to the rapid acclimation response of fish to them. Sound barriers must be directed at one particular species to be effective. This is not practical for the Clinch River Site.

10.2.2.5 INFILTRATION BEDS

The composition of the Clinch River bottom in the Site vicinity is rock; no permeable material is present that would permit the use of a radial well intake. The employment of an artificial filtering medium would impose a potentially severe construction impact on aquatic life in the river. Additionally, currently operating artificial media have been prone to clogging and cannot guarantee an uninterrupted water supply. Infiltration beds, either natural or artificial, do not, therefore, represent reasonable alternatives for the CRBRP intake system.

10.2.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

10.2.3.1 MODIFIED CONVENTIONAL TRAVELING SCREENS

The modified conventional traveling screens intake structure for the CRBRP would be located along the shore of the Clinch River at the position indicated in Figure 10.2-5. The entire facility is approximately 18 feet wide, extends 42 feet back from the shoreline and rises 38 feet above the river bed.

Fish have a clear escape passage in all directions except directly into the perforations.

Two 100-percent capacity perforated pipes are provided, to permit backwashing one while the other is in operation. Normal maximum inlet water velocity with both inlets in operation will thus be less than 0.2 fps.

Uniform inlet velocity through the perforations is produced by an internal perforated sleeve. Details of the inlet pipe for this specific design concept have been developed through extensive model tests.[3] Water velocity profiles at the point of intake are described in Section 10.2.4.2.2.

Removal of debris from the inlet pipe is accomplished by flow reversal in the intake piping. It is anticipated that because of the low inlet velocities associated with the perforated pipe, backwashing should be an infrequent operation. When backwashing is required, makeup water supply to the plant is interrupted and the water discharged through the plugged perforated pipe.

The pumphouse structure is located near the river bank, similar to the conventional intake design. It is, however, substantially smaller due to elimination of the racks and screens.

10.2.4 ENVIRONMENTAL COSTS

10.2.4.1 ENTRAINMENT

As the intake system draws water from the Clinch River for plant use, certain aquatic organisms in the vicinity of the intake's velocity field and small enough in size to pass through the screens will become entrained in the water supply. These organisms will be primarily composed of floating plankton but will also include (during the spawning season) fish eggs that are not laid in nests or attached to vegetation and larvae.

Numbers of aquatic organisms that become entrained are not principally a function of the intake system. Heat Dissipation System water requirements determine to the largest extent the degree of entrainment. Additionally, the fate of the organisms carried into the plant water supply system is a function of the Heat Dissipation System design. Although survival of some life forms discharged from a once through cooling system does occur, a closed cycle system such as that employed by the CRBRP causes nearly 100 percent entrainment mortality.

The influence of the intake system with reference to entrainment is limited to the effects of its location. An intake that draws water from a region of the waterway that serves as a fish spawning area or is characterized by dense plankton populations will cause an additional amount of entrainment. It is, therefore, important to avoid such unique areas for the intake location.

The location of the CRBRP intake structure is shown in Figure 10.2-5. The aquatic baseline and preconstruction monitoring 13 programs as described in section 2.7 and 6.1 have been completed. This area of the river does not possess any unique abundance of aquatic life that would disfavor its selection. Entrainment effects may be considered substantially the same for the traveling screens intake options. Due to its off-shore location near the river bottom, the perforated pipe may have a lower level of entrainment (particularly in regard to fish eggs and larvae) associated with its operation.

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10.2.4.2 ENTRAPMENT AND IMPINGEMENT

The principal environmental concern that is the direct responsibility of the intake system is entrapment and impingement. Entrapment occurs when dead water areas in which fish can congregate exist within the intake structure (such as behind curtain walls). (4) Impingement refers to the physical attachment of aquatic organisms (primarily fish) on the intake

The perforated pipe alternative utilizes a unique internal sleeve design that produces essentially uniform velocity through all perforations. Extensive model testing has been employed to verify this effect and to optimize the pipe design.[3] Figure 10.2-13 shows the velocity profile of a perforated pipe without internal sleeving. Velocity varies considerably along the screen length rising to as much as 60 percent above the design condition. In Figure 10.2-14, the velocity profile for the perforated pipe with internal sleeve modification is presented. In this case, the design velocity is not exceeded except for a small segment at the screen ends and the velocity field is nearly 100 percent uniform.

Figure 10.2-15 is a graph of approach velocity versus distance from the surface for the perforated pipe intake. It shows that the field of accelerating flow for this intake design does not extend beyond 1/4 inch from the pipe surface. Thus, a fish must pass extremely close to the surface itself to be affected by suction force. As both perforated pipes represent only 0.4 percent of the cross-sectional area of the river at the proposed intake location, the potential for impingement is confined to a very small region of the river.

Two 100-percent capacity pipes are employed by the perforated pipe intake. During normal operation, both will be functioning resulting in a screen approach velocity of less than 0.2 fps.

10.2.4.2.3 FISH RESOURCES IN CLINCH RIVER

The degree to which consideration is given to intake systems that provide extensive fish protection features is to a certain extent a function of the significance of the fish resources of the waterway. An important game or commercial fish production area or residence of a unique or rare and endangered fish species should quite naturally receive greater attention in reference to intake design than a water body for which no such conditions exist.

Only three game fish species are well represented, the sauger, striped bass, and white bass. Forage and rough fish dominate in both numbers and biomass.[5] Although Watts Bar Reservoir produced a commercial fish harvest of nearly 95,000 pounds in 1973, catches within a 10-mile radius of the Site amounted to only one percent of this total.[6] No unique or rare and endangered fish species live in this portion of the Clinch River, as discussed in Section 2.7. 13

10.2.4.3 CONSTRUCTION EFFECTS

Construction of the CRBRP intake systems will cause temporary dislocation of some aquatic life and produce potential silt and turbidity additions to the river. Specific practices and techniques used to minimize the construction impact are examined in Section 4.1.

The three traveling screen intake alternatives are similar in design and will have essentially identical construction effects. Although substantially different in design, the perforated pipe intake should not cause a construction impact dissimilar to the other three as the additional adverse effect of installing the submerged pipes will be balanced by the smaller amount of work required at the shoreline for the perforated pipe pumphouse. Consequently, none of the intake system alternatives offers any significant decrease in construction impact.

10.2.4.4 AESTHETIC IMPACT OF INTAKE STRUCTURE

At present the portion of the Clinch River in the vicinity of the intake location may be characterized as a natural setting. The shoreline is relatively undisturbed. As such, the CRBRP intake structure represents an aesthetic intrusion, although its individual impact will be lessened by the presence of the plant itself.

The three traveling screen intake alternatives will present large, open concrete structures rising from the river bed at the shoreline.

Their aesthetic impact will be considerable with the angle-mounted screens intake the most imposing due to its angled posture.

The perforated pipe intake will present the least visual impact of the intake alternatives. The pipes themselves will be submerged and hidden from view. The only visible structure will be the enclosed pumphouse along the shoreline which is much smaller than the other three intake structures.

10.2.5 ECONOMIC COSTS

Monetary costs (capital and operating) for the CRBRP intake system alternatives are presented in Table 10.2-1. Due to its simple design which eliminates the need for trash rakes and traveling screens and subsequent large shoreline structure, the perforated pipe intake is the lowest cost alternative as shown in Table 10.2-1. The modified conventional traveling screens intake is nearly two and one-half times as costly and the angle-mounted and single entry-double exit traveling screens intakes are approximately three and four times, respectively, the cost of the perforated pipe alternative.

There are fewer moving parts associated with the perforated pipe and no debris disposal is required. System maintainability for the four alternatives will be influenced by the presence of Asiatic clams in the Clinch River; however, no significant differences among the system designs would be anticipated.

10.2.6 COMPARISON OF ALTERNATIVES

10.2.6.1 DIRECT COMPARISON OF ALL REASONABLE ALTERNATIVES

A comparative summary of the economic and environmental costs for the four CRBRP intake alternatives is presented in Table 10.2-2. The results indicate that the perforated pipe intake is the economically preferable system and for two environmental costs, entrainment and construction effects, the four alternatives are equivalent. The aesthetic impact of the perforated pipe system is moderate when compared to travelins screen alternatives. Therefore, 13 the benefit-cost analysis revolves about a balancing of fish impingement against the economic costs. 13

The intake system chosen for the CRBRP should be designed to reduce fish mortality to that degree consistent with the value of the fish resource of the river and the constraints of economics. These constraints dictate that the additional monetary cost incurred by the employment of an intake system equipped with extensive fish protection features be matched by an equivalent reduction in its environmental cost. In view of this, the modified conventional traveling screens intake alternative is eliminated from further consideration because of its failure to produce environmental improvement in proportion to its higher monetary costs (in comparison to the base case perforated pipe intake). In fact, in terms of

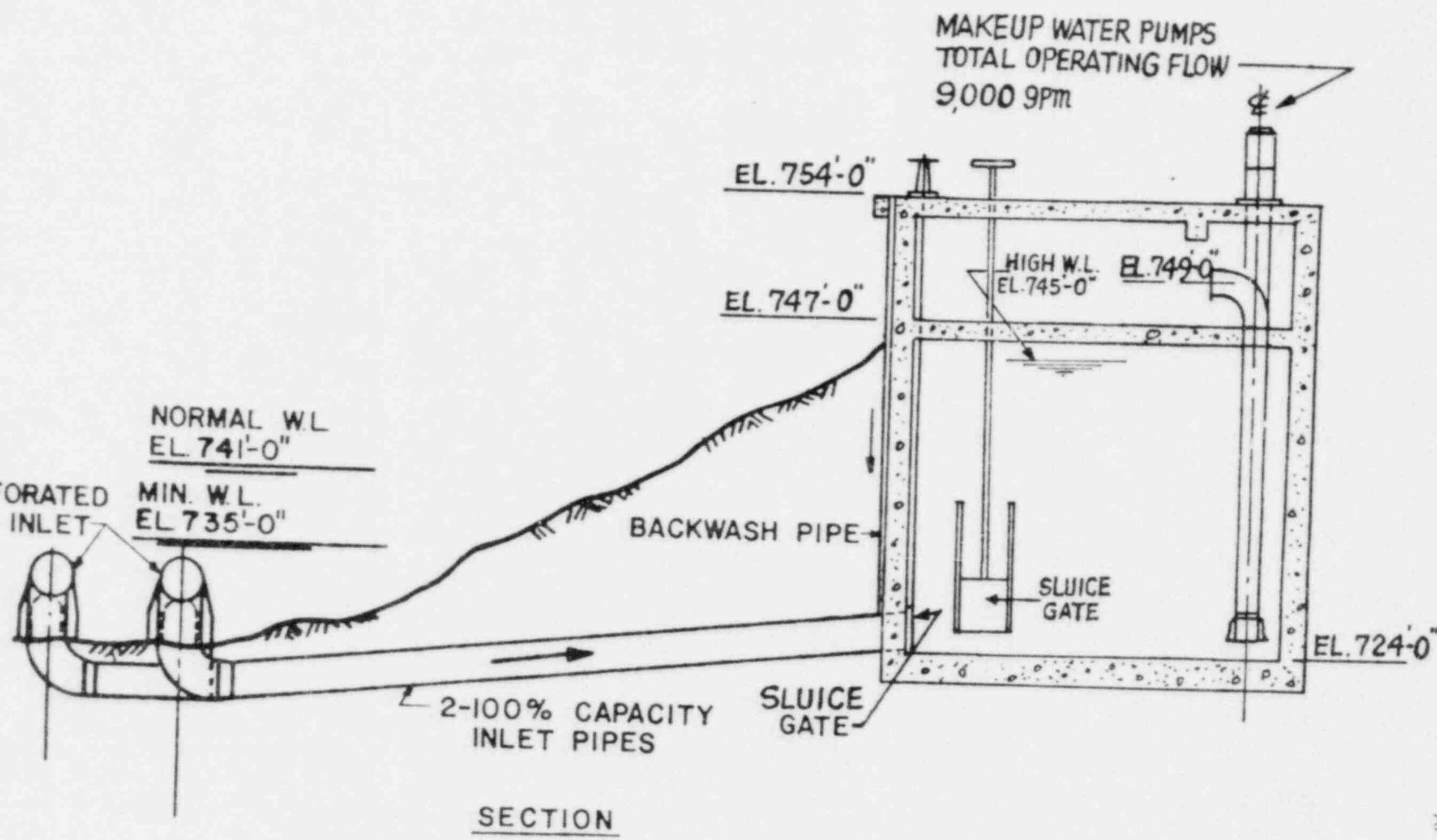

Figure 10.2-9 PERFORATED PIPE INTAKE SYSTEM

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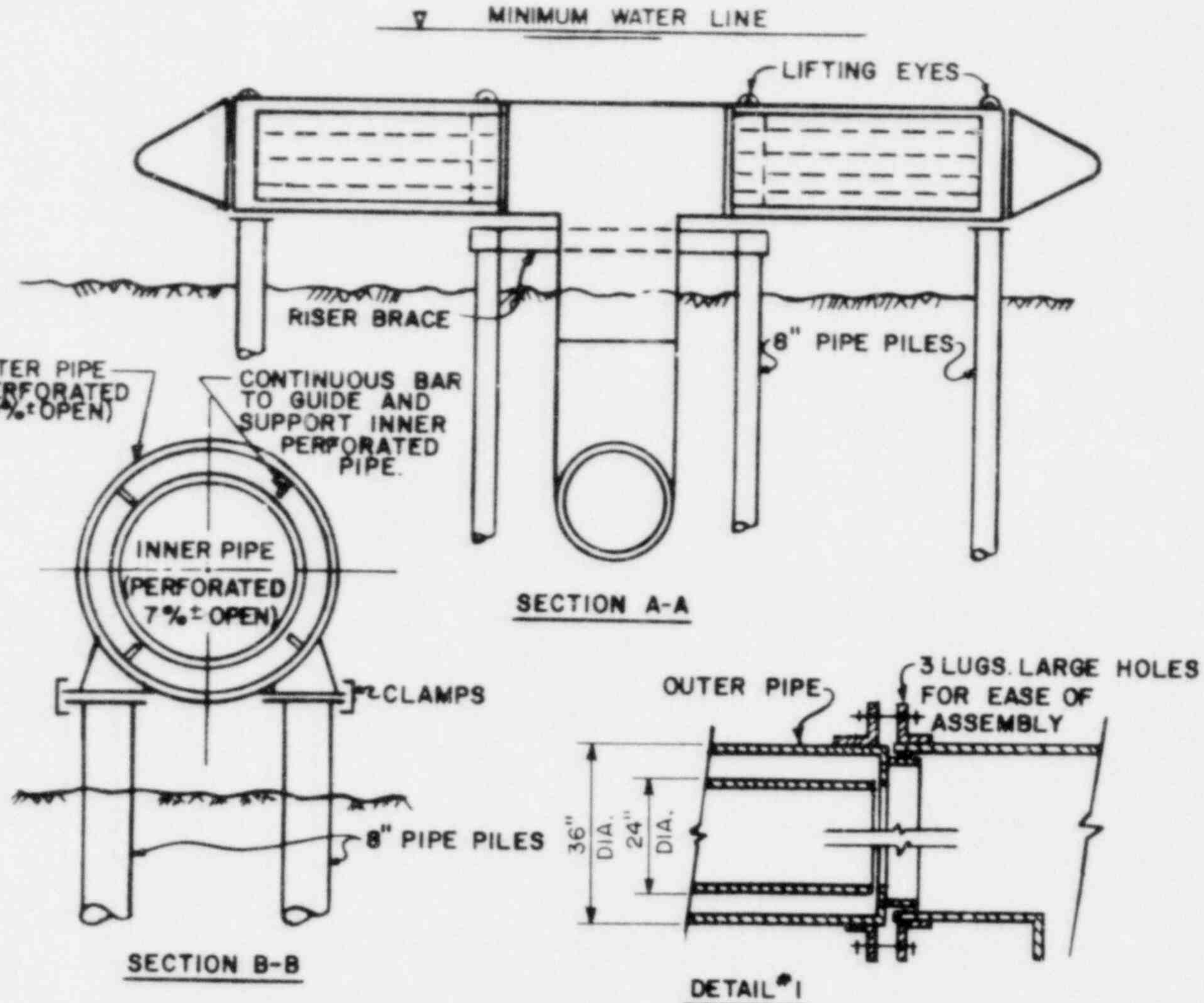

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Figure 10.2-10 PERFORATED PIPE SUPPORTING FRAMEWORK

10.3 DISCHARGE SYSTEM

The discharge system is the mechanism for release of all CRBRP effluent streams that are scheduled for final disposal in the Clinch River. (Storm water discharge is the single exception - see Section 10.4). Flows to the discharge system include cooling tower blowdown, process wastewater, radioactive waste system effluent and 13
the sanitary system effluent. It is the function of the discharge system to provide for the integration of the plant discharge into the main body of the Clinch River. Location of the discharge structure is shown in Figure 10.3-1.

Flow quantities and thermal and chemical composition of the CRBRP discharge are presented in Section 3.4, 3.6 and 3.7. Summarizing, the discharge may be characterized as similar to Clinch River water with major points of difference being elevated temperature (maximum temperature of 90°F in July and minimum temperature 60.5°F in December through February) and concentrated chemical composition (by 13
a factor of 2.5). The discharge flow is an annual average of approximately 2,300 gpm with a maximum of approximately 3,100 gpm. During periods following intermittent loadings, the discharge will contain residual chlorine, the concentration of which will not exceed the limitations cited in the NPDES Permit. 13

In an environmental sense, the primary concern associated with the discharge system is the degree to which it promotes rapid and thorough mixing of the plant effluent with the river. The mixing zone, its extent and effect on river water quality and aquatic life, is predominantly influenced by the discharge system. The ultimate effects of the thermal and chemical properties of the effluent are beyond the control of the discharge system and constitute the provinces of the specific plant systems responsible for those properties (thermal characteristics -- cooling system, chlorine residual -- biocide system, etc.). These effects are addressed, as appropriate in Sections 10.1, 10.4, 10.5 and 10.6. Discharges from the CRBRP must comply with the applicable State guidelines relating to the size of the mixing zone and the standards found in the NPDES Permit. Further, the selected discharge system should reflect the desired goal of reducing adverse environmental impact to that level consistent with the economic constraints of diminishing returns. 13

The discharge system selected for the CRBRP is a submerged single port discharge.

Alternatives considered for the discharge system are:

1. Surface discharge;
2. Submerged discharge; and
3. Variations of submerged discharge angle of nozzle inclination and orientation to river flow.

10.3.1 DESCRIPTION OF ALTERNATIVES

10.3.1.1 SURFACE DISCHARGE

Surface discharge is the simplest and most economically attractive discharge system. The plant effluent is transported via a canal or pipe to the shoreline where merger with the water body is accomplish by an open trough. An environmental disadvantage of surface discharge for power plant applications is the potential for the heated effluent to float out over the surface of the waterway its buoyant properties causing retardation of mixing action.

10.3.1.2 SUBMERGED DISCHARGE

An environmentally desirable alternative to the surface discharge that promotes more rapid and thorough mixing is the submerged discharge. The submerged discharge is designed to provide higher exit velocities than the surface discharge. The opportunity for the formation of an extensive floating layer of heated water is substantially reduced because significant mixing, fostered by a higher discharge velocity, is initiated below the river surface.

A submerged discharge may utilize either a single exit nozzle or any arrangement and number of individual nozzles in a multiport design.

10.3.1.3 VARIATIONS IN SUBMERGED NOZZLE INCLINATION AND ORIENTATION

Submerged discharge nozzles may be positioned in various configurations to respond to the particular characteristics of the receiving water body. Angle of inclination refers to the elevation of the discharge nozzle with respect to the horizontal plane of the water surface. While an angle of zero (horizontally directed jet) is most commonly used, a desire to prevent the expanding discharge plume from interfacing with the bottom of the water body may be satisfied by inclining the nozzle upwards.

Where the plant effluents are to be discharged to a flowing water body, nozzle orientation becomes an important determinant of mixing. Single port discharge nozzles may be oriented to achieve either cross-flow or coflow mixing. Multiports have an additional option in that individual nozzles may be staggered to produce both cross-flow and coflow mixing.

10.3.2 ELIMINATION OF IMPRACTICAL ALTERNATIVES

10.3.2.1 SURFACE DISCHARGE

The surface discharge alternative is eliminated from further consideration because it does not provide for enhanced environmental performance in comparison to the selected system (the submerged single port). As noted in 10.3.1.1, a potential disadvantage of the surface discharge is the flotation of the 13
thermal plume across the water's surface. While this may be advantageous for certain applications on large, quiescent water

bodies (lakes, reservoirs, etc.) where it is desirable to have the plume extend over a sizeable surface area to promote radiant and evaporative heat transfer to the atmosphere, it would not be so for the CRBRP because of the potential for surface water temperatures of several F degrees above ambient developing across the full width of the river during periods of zero flow. Additionally, an area of the river in the vicinity of the discharge would be subjected to water temperature increases in excess of five F degrees due to the poor initial mixing of the heated effluent.

10.3.2.2 COFLOW NOZZLE ORIENTATION

Discharges located on unidirectional flowing waterways are often oriented in the downstream direction to reduce the potential for entrainment of the heated plume in the plant intake and/or to prevent the plume from extending across to the opposite shoreline. For the CRBRP, the intake is sufficiently far upstream from the discharge point to preclude recirculation. Additionally, since the Clinch River does not maintain unidirectional flow, there is a potential for the effluent plume 13 to reach along the discharge point shoreline during periods of zero or reverse flow. Accordingly, orientation of the CRBRP discharge to produce coflow mixing is not considered a practical alternative.

10.3.2.3 INCLINED SINGLE PORT DISCHARGE

In the vicinity of the CRBRP discharge, the Clinch River varies from 6 to 12 feet in depth. A potential problem associated with submerged discharge systems in such shallow water is scouring of bottom material. As noted in 10.3.1.3, inclination of the discharge nozzle is an alternative design feature that may be utilized to prevent the developing plume from interfacing with the river bottom. However, an adverse consequence of nozzle inclination is that the plume reaches the water surface faster and is less diluted by entrained ambient water. This would be particularly pronounced for a single port discharge where the jet momentum at the surface of the Clinch River would be great enough to cause noticeable turbulence. During periods of low pool elevation, a "boil" would be visible at the water surface which could potentially affect small river craft. It is not felt, therefore, that nozzle inclination is a viable design modification for the submerged single port discharge.

10.3.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

10.3.3.1 SUBMERGED SINGLE PORT DISCHARGE

Design of the submerged single port discharge system is illustrated in Figure 10.3-2. The plant effluent flows through a 20- inch diameter buried pipe which terminates in an 8-inch diameter exit nozzle. (Note: Previous design was a 12-inch pipe 13
based on pressure flow). Based on studies performed at the Site, a submerged discharge depth of four feet below the minimum water level of 735 feet MSL was selected. Deeper locations are not considered feasible due to the extensive piping into the river traffic channel that would be required. The exit nozzle is oriented for cross-flow mixing.

10.3.3.2 SUBMERGED MULTIPORT DISCHARGE

The submerged multiport discharge alternative employs four exit nozzles as shown in Figure 10.3-3. Piping from the plant and discharge depth are identical to that for the single port system. However, the supply pipe is oriented parallel to the river so that the perpendicularly mounted exit nozzles produce cross-flow mixing in the horizontal plane of the water surface. The nozzles are four-inch diameter extensions to the supply pipe and are equally spaced at three-foot intervals.

10.3.3.3 INCLINED MULTIPORT DISCHARGE

The inclined multiport is identical to the system described above (10.3.3.2) except that the nozzles are inclined at an angle of approximately 25 degrees from the horizontal.

10.3.4 ENVIRONMENTAL COSTS

The principal environmental concern relating to the CRBRP discharge system is the manner and effectiveness with which it promotes mixing of waste heat and chemical effluents in the river. Additional considerations include bottom scouring and effects on navigation.

As a discharge plume study has been conducted to evaluate the performance of the selected single port discharge, the results of this study will be described initially to provide a benchmark against which the operation of alternative discharge designs may be measured.

10.3.4.1 ENVIRONMENTAL PERFORMANCE OF THE SELECTED DISCHARGE SYSTEM

To predict thermal and chemical plume development in the Clinch River resulting from plant discharges, a thermal-hydraulic modeling study of the selected single port discharge system was performed by the University of Iowa, Institute of Hydraulic Research. The results of this investigation are presented in Appendices A and B to Section 10.3, and are utilized as the basis for the following discussions. Additionally, the environmental impacts due to thermal and chemical discharges are examined in Sections 5.1 and 5.4, respectively.

10.3.4.1.1 CLINCH RIVER HYDROLOGY

The Clinch River is a regulated stream controlled by TVA dams. As a result, pool elevation and river flow experience fluctuations uncommon to a free flowing stream. The most important consequence of this regulation is the occurrence of periods of no flow at the CRBRP Site due to shutdown of the Melton Hill Dam turbines. Accordingly, the standard parameter for analyzing worst case flow conditions, the 10 years 7 days consecutive low flow, is not applicable to the Clinch River.

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While thermal and chemical plume development may be predicted on the basis of average values for the various influencing parameters (river flowrate, temperature, pool elevation; discharge velocity and temperature), the above noted variances of the Clinch River make it desirable to examine worst case mixing situations in order to determine upper bound limits on the extent of anticipated adverse environmental impact. Accordingly, extreme as well as typical conditions were modeled and are reported in the Appendices to Section 10.3. The mixing conditions examined include the following:

1. Winter and summer seasonal-average cases;
2. Winter and summer hypothetical worst case for thermal mixing; and
3. Short duration and extended no-flow events - worst case chemical mixing.

Values for the key parameters associated with each of these mixing conditions are presented in Table 10.3-1.

10.3.4.1.2 THERMAL PLUMES

Thermal plumes that may result in the Clinch River due to CRBRP waste heat discharges are illustrated in Figures 10.3-4 through 10.3-7. For all but the winter worst case, the river areas affected by excess temperatures above one F degree are small and confined to the section of the waterway in the immediate vicinity of the discharge point. The 0.9 F degree isotherm for the winter worst case will potentially extend across the river; however, this temperature rise is not considered biologically significant (see Section 5.1).

10.3.4.1.3 CHEMICAL PLUMES

Chemical isopheths (expressed as the percent difference between initial discharge and river ambient concentration) are indicated in Figures 10.3-4 through 10.3-7 for the corresponding isotherms. For all cases examined, the extent of chemical concentration increases which encompass measurable areas of the river is 13
limited to six percent. As a basis for further assessment of worst case chemical mixing, an extended period of zero river flow is discussed in Appendix A to Section 10.3. During such events, chemical plumes may extend for several miles up and downstream of 6
the discharge point. Even this extreme case of a lengthy period of quiescent water will not lead to a substantial concern (see Sec. 5.4), since the plant effluent is essentially river water concentrated by a factor of 2.5 with minor additions of the chemicals. 13

10.3.4.1.4 BOTTOM SCOURING

As the single port discharge nozzle is centered approximately one and one half feet above the river bottom, the expanding discharge jet will intercept the bottom within several feet from the nozzle. The jet will have retained sufficient momentum at this point to induce movement of bottom material. Based on measurements of the area of bottom scour in the flume used for the thermal-hydraulic modeling, the anticipated areas of the river bottom that would be subjected to sediment disturbance are depicted in Figure 10.3-8. For each of the various cases of river and discharge parameter values examined, the areas of predicted bottom scour are less than 0.01 acre (see Table 10.3A-9, Appendix A to Section 10.3). 6

10.3.4.1.5 EFFECTS ON NAVIGATION

As the proposed discharge structure is submerged to a minimum depth of four feet and does not extend into the navigation channel, no adverse effects on navigation are anticipated.

and extreme mixing conditions and ensures a rapid reduction in cooling tower blowdown excess temperature and adequate dilution of chemical effluents.

TABLE 10.3-1

INPUT PARAMETERS FOR MODELING OF THE CRBRP DISCHARGE PLUMES

Mixing Conditions	Plant Discharge: Atmospheric Wet Bulb (°F)	Blowdown Temp. (°F)	Blowdown (gpm)	Flow[e] (cfs)	Ambient River Conditions: Water Temp. (°F)	Flow Rate (cfs)	Velocity (fps)	Pool Elevation[h] (ft MSL)	Initial Jet Parameters: ΔT_o (°F)	V_o (fps)	F_o	Z/D	
Typical Cases													
Average Winter (Jan/Feb/Mar)	43.3[a]	74.9[c]	2,500	5.57	43.9[c]	6,772[g]	1.39	736	31.0	15.96	67.8	7.5	13
Average Summer (July/Aug/Sep)	73.2[a]	89.3[c]	3,240	7.22	65.7[c]	5,066[g]	0.63	741	23.6	20.68	77.1	15.0	13
Thermal Worst Cases													
Hypothetical Winter (Jan)	56.2[b]	79.8[d]	2,810	6.26	33[f]	0	0	735	46.8	17.93	68.2	6.0	
Hypothetical Summer (June)	74.4[b]	89.6[d]	3,280	7.31	78[f]	0	0	739	11.6	20.94	84.3	12.0	
Chemical Worst Cases													
Short Duration No Flow													
Winter (Jan)	56.2[b]	79.8[d]	2,810	6.26	33[f]	0	0	735	46.8	17.93	68.2	6.0	
Summer (June)	74.4[b]	89.6[d]	3,280	7.31	78[f]	0	0	739	11.6	20.94	84.3	12.0	

[a]Table 3.4-3

[b]Bull Run Steam Plant Data, 1/70-12/73

[c]Table 10.3A-1

[d]Figure 10.3A-2; account taken of cooling effect of makeup flow

[e]Figure 10.3A-2

[f]Clinch River (m 21.6) Data, 6/62-9/72

[g]Table 2.5-3

[h]Table 2.5-5

TABLE 10.3-2

CAPITAL COSTS FOR DISCHARGE SYSTEM ALTERNATIVES

	Submerged Single Port	Submerged Multiport	Inclined Multiport
Material Cost	Base	$1,000	$1,000
Installation Cost	Base	$3,000	$3,000
Total Differential Capital Cost	Base	$4,000	$4,000
Operating Cost (Pumping Requirement)	Same	Same	Same

(Note: Economic comparison based on 12-inch pipe. Present design is 20-inch. Relative economics are not affected by this revision in design) 13

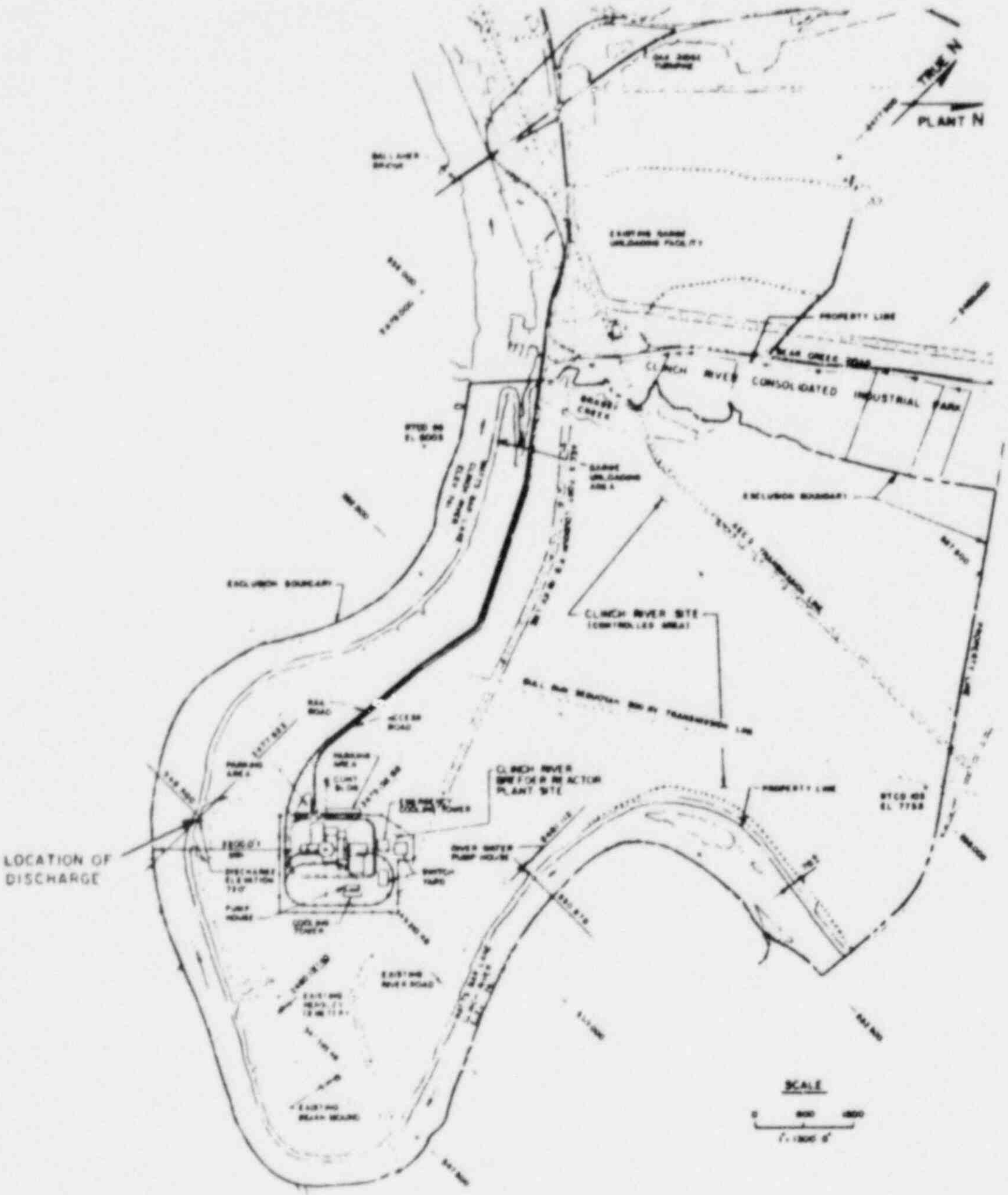
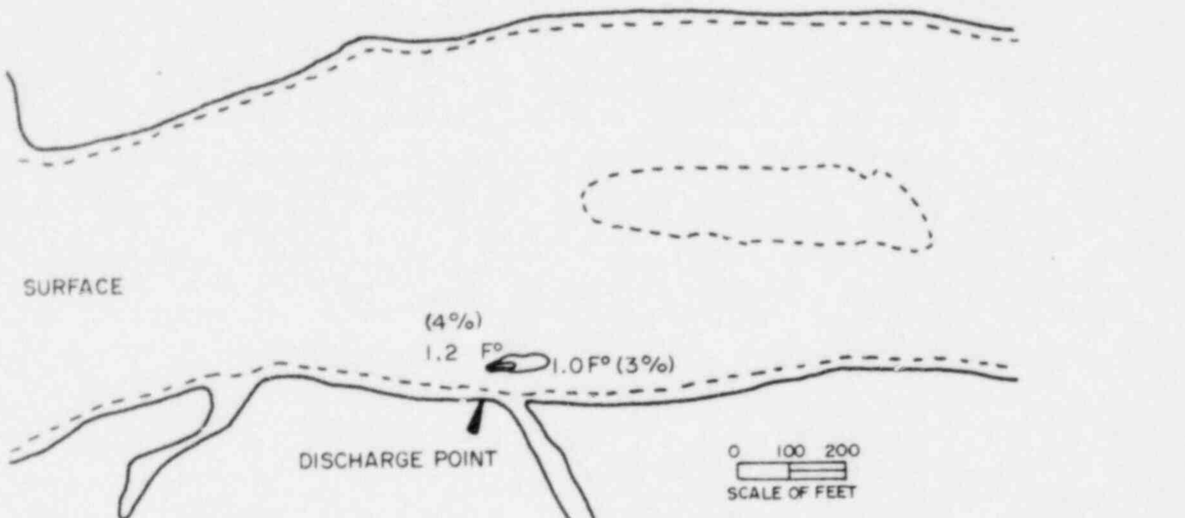


Figure 10.3-1 LOCATION OF CRBRP DISCHARGE



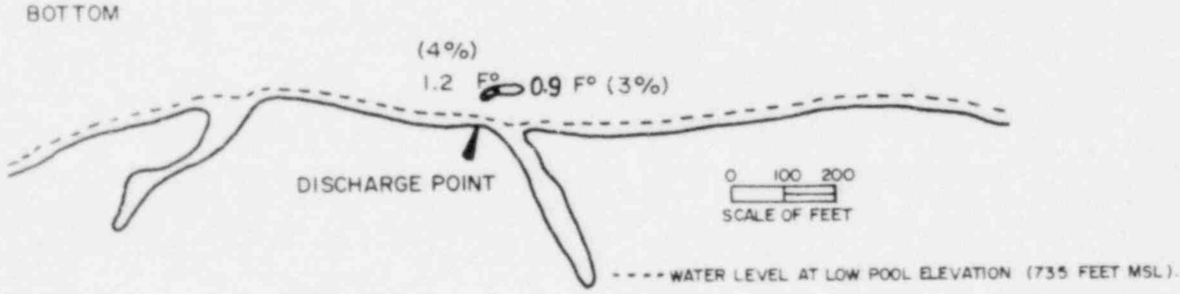
RIVER

flow = 5338 cfs
velocity = 1.39 fps (0.87 fps)*
pool elevation = 736 ft MSL

DISCHARGE JET

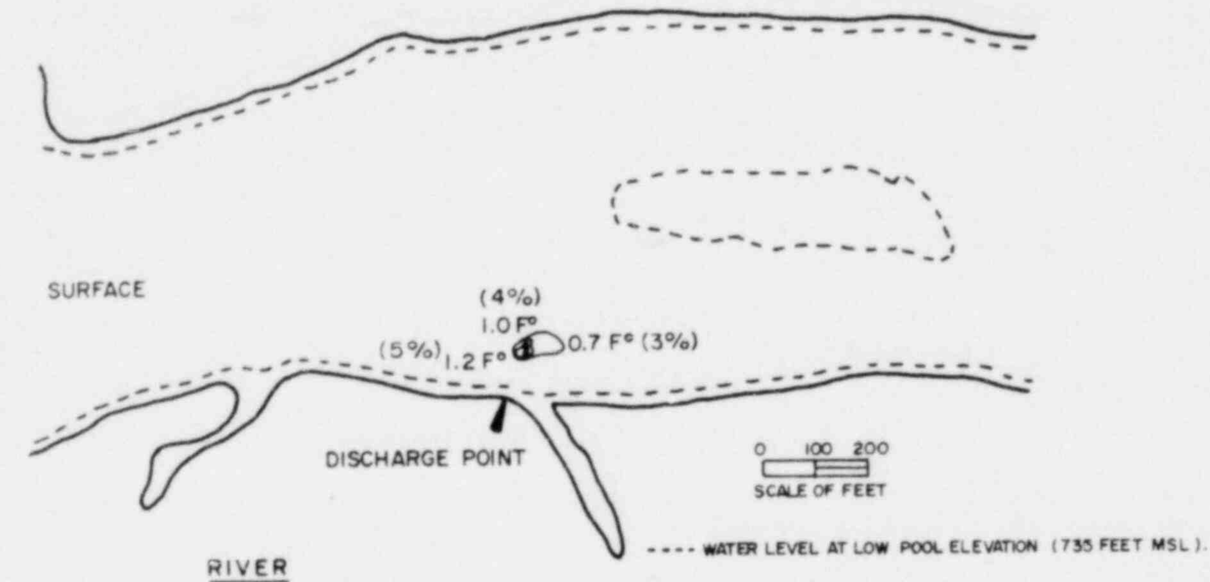
flow = 5.57 cfs
velocity = 15.96 fps
temp. diff. = 31.0F°

*Prototype velocity based on hydraulic model velocity. Reflects physical limitations of the flume.



13

Figure 10.3-4 TYPICAL CASE-WINTER



RIVER

flow = 4777 cfs
velocity = 0.63 fps (0.50 fps)*
pool elevation = 741 ft MSL

DISCHARGE JET

flow = 7.22 cfs
velocity = 20.68 fps
temp. diff. = 23.6F°

*Prototype velocity based on hydraulic model velocity. Reflects physical limitations of the flume.

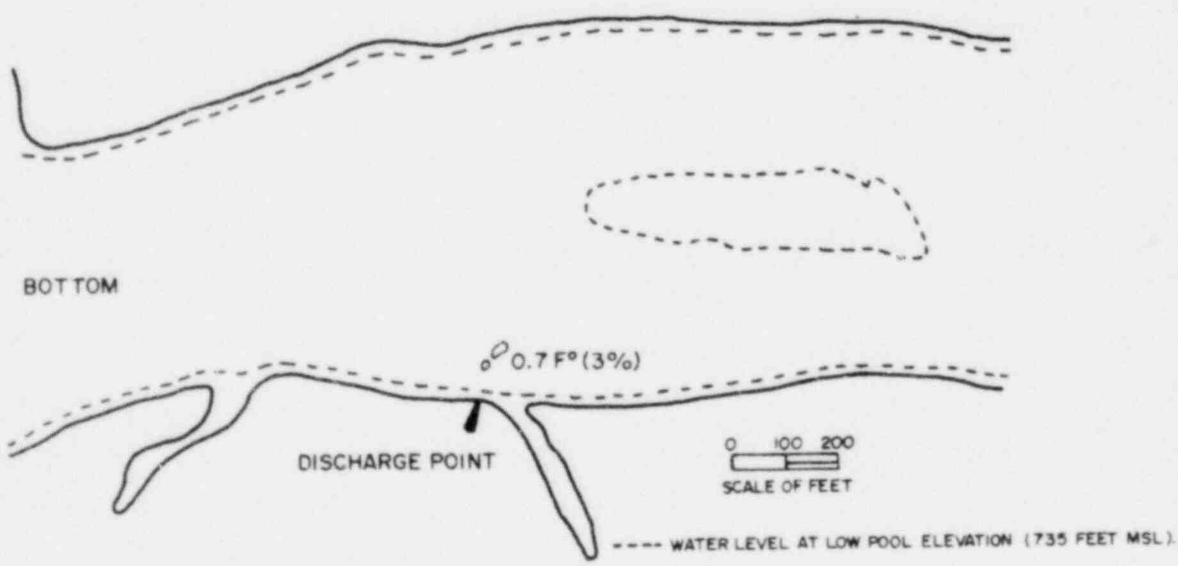


Figure 10.3-5 TYPICAL CASE-SUMMER

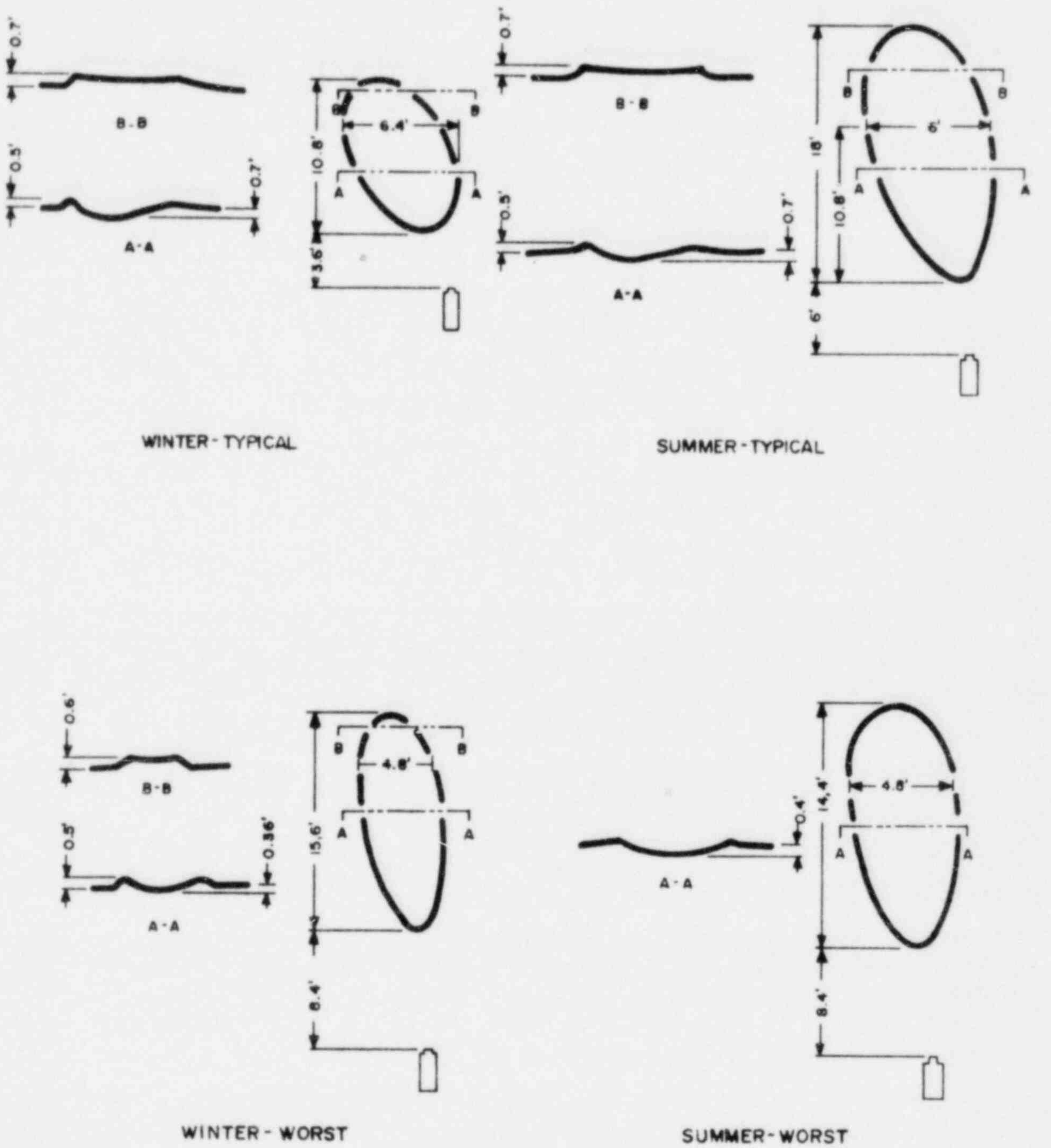


Figure 10.3-8 AREAS OF BOTTOM SCOURING

10.4 WASTE WATER TREATMENT SYSTEM

The Waste Water Treatment System (WWTS) provides facilities for collection, treatment and disposal of all non-radioactive floor drainage, cooling tower blowdown, and process water treatment 13 system wastes. Most of the wastes are discharged to the system on an intermittent basis, both scheduled and unscheduled. The wastes vary in chemical/physical characteristics and in temperatures.

A primary environmental concern associated with the WWTS is the 13 effect of its liquid effluent discharge on the water quality and aquatic life of the Clinch River. Secondary concerns include disposal of sludges and environmental costs related to the operation of treatment processes.

The WWTS is designed to comply with applicable Federal and State 13 requirements as indicated in Table 10.4-1 and is furthermore designed to minimize environmental impacts consistent with the benefit-cost balance.

The WWTS selected for the CRBRP is depicted in Figure 10.4-1. 13

13

The alternatives study does not involve the examination of completely different systems but rather the consideration of further treatment procedures that may yield additional 13 environmental benefits. The alternatives are:

1. Mechanical dewatering of clarifier blowdown;
2. Reverse osmosis in makeup water treatment system; and
3. Zero discharge of effluent.

13

10.4.1 DESCRIPTION OF ALTERNATIVES

To facilitate the description of alternatives and to clarify their relation to the system as a whole, a description of the reference (selected) Waste Water Treatment System will precede the presentation of the alternatives. 13

10.4.1.1 REFERENCE SYSTEM DESIGN

10.4.1.1.1 WASTE STREAMS

As previously noted, the proposed WWTS handles waste streams that vary widely in volume, type and frequency. These may be divided into two major categories: neutral wastes, (non-rad floordrains, HVAC cooling coil condensate drains, non-sodium fire protection sprinkling, auxiliary boiler blowdown and oil storage area drains) and non-neutral wastes, (polisher regeneration waste water, chemical storage area drains, make-up demineralizer regeneration waste water, feedwater and steam sampling wastes). 13 Additional sources of discharge are cooling tower blowdown, stormwater drainage, sewage treatment effluent and low activity level liquid (LALL) radioactive wastes. Sewage treatment effluent and LALL discharges are discussed in Sections 10.6 and 10.7, respectively.

The source of all waste streams, the anticipated frequency and average and maximum quantities of these wastes are identified in Table 10.4-2.

<u>Cooling Tower Blowdown</u>

Cooling tower blowdown is the largest continuous waste stream produced during plant operation. The quantity of cooling tower blowdown depends on reactor power level, ambient temperature and humidity, drift losses and the concentration of solids in the makeup water. Generally, the blowdown is continuous during normal operation and for full power operation varies from a summer time average of approximately 2,650 gpm to a winter average of 1,955 gpm. Blowdown 13 temperature also varies from a maximum of 91 to a minimum of 61 degrees F.

During operation of the cooling tower, the combination of evaporation, drift, makeup and blowdown results in a buildup in the concentration of dissolved solids in the cooling system. Bicarbonate alkalinity in the cooling system also increases. The increase in alkalinity results in an increase in pH and carbonate concentrations. As pH and carbonate concentrations increase, the solubility of calcium carbonate decreases resulting in a calcium carbonate scale. Scaling of the condenser heat transfer surfaces results in a gradual decrease in plant operating efficiency and eventual loss of generating capacity. To preclude this loss, the blowdown rate is controlled to maintain the concentration of dissolved solids in the cooling system at approximately 2.5 times the river water dissolved solids concentration. The normal range of dissolved solids concentration in the blowdown will be approximately 220 to 360 mg/l. Calcium carbonate scaling conditions are not anticipated during normal operation of the CRBRP.

Use of corrosion inhibitors in the cooling water will not be required since the blowdown ranges from chemically balanced to only slightly scale forming. It should be noted that the cooling water system services not only the main condenser but other plant auxiliary cooling systems.

No wood will be used in the cooling tower construction. Therefore, chemical wood preservatives will not be extracted and discharged to the river.

The makeup water coming from the river will contain various types of microbiological organisms. Biological growth on heat transfer surfaces causes fouling which reduces heat transfer and creates a loss in efficiency. The service lifetime of the cooling system components will also be decreased, since algae, slimes and bacteria all increase the corrosion rate of metal surfaces. To prevent deposits from forming, a biocide system will be employed. This system and alternatives are discussed in Section 10.5. 13

Storm Water

Storm water is comprised of rainwater collected by roof drains and yard drains. The quantity of runoff is a function of rainfall intensity, frequency, duration, site topography, vegetation, condition of soil and general layout of buildings, roads and other paved areas. 13

Outdoor oil and chemical storage tanks, unloading facilities and the transformer area are provided with dikes designed to retain leakage or spillage from this equipment. This will preclude their entry into the yard drain system.

Neutral Wastes

1. Filter Backwashes -- The Makeup Water Treatment System produces demineralized water for consensate makeup, laboratory use and other plant uses. The Makeup Water Treatment System includes gravity filters and activated 13 carbon filters as part of the treatment process. All collect some suspended solids in their beds during operation. Filters are backwashed once a day for about 15 minutes. Backwash Water will be discharged to the sludge lagoons of the Waste Water Disposal System

2. Clarifier Blowdown--The Makeup Water Treatment System employs a clarifier which produces a sludge blowdown, consisting of river water, suspended solids and aluminum hydrate. Blowdown will be directed to the sludge lagoons. 13

13

3. Non-Radioactive Floor Drainage--The building floor drains collect a wastewater that requires processing for oil removal. This water will be similar to river water and may contain a higher concentration of suspended solids.

13

Non-Neutral Waste 13

1. Condensate Polishing System Wastes--The rinses, backwashes and regenerants from the condensate polishing system will consist of high dissolved solids wastewater. Concentration of dissolved solids in this stream is expected to be from 8,000 to 14,000 mg/l. About 85 percent of these solids will be sodium and sulfate and the remaining 15 percent will be primarily iron, calcium and magnesium with some traces of nickel and copper. 13

2. Makeup Water Treatment System Demineralizer Regenerant Waste--This waste stream will be similar to the Condensate Polishing System Wastes.

13

3. Auxiliary Steam Generator Blowdown--During startup, a small generator is used and approximately one gpm of blowdown will be produced. The blowdown will be alkaline, pH 9.0 to 9.5 and the temperature will be approximately 250 degrees F. It will contain approximately 200 mg/l dissolved solids and 0.5 mg/l ammonia. Hydrazine will be used as an oxygen scavenger in the generator water. Hydrazine decomposes to nitrogen and ammonia and does not produce suspended solids in the reaction.

4. Plant Laboratory and Feedwater and Steam Sampling Wastes--These wastes will be non-radioactive chemical wastes produced by laboratory analysis of the treated water systems and the various samples from in-plant monitoring.

5. Chemical Cleaning Wastes--Periodic chemical cleaning of large components such as the Auxiliary Steam Generator and Condenser will be required. This cleaning is done in several stages and the chemicals used depend on the metallurgy. A typical procedure involves alkaline and acid washings and rinsing and neutralizing and passivating rinses. The volume of these wastes is expected to be in the order of 500,000 gallons. Chemical cleaning wastes will be disposed of off-site by a state-approved, licensed contractor.

10.4.1.1.2 PROCESS DESCRIPTION

A schematic diagram of the reference Waste Water Treatment System is shown in Figure 10.4-1. The treatment processes for waste water treatment (neutral and non-neutral wastes), blowdown, and stormwater are described below.

<u>Wastewater Treatment</u>

Floor drain wastes that may contain oil undergo oil-water separation prior to discharge to the equalization basins. Oil from the separation process is discharged to a waste oil tank which will be periodically pumped out by a licensed contractor who will dispose of the waste oil off-site. Non-oily floor drains discharge to the equalization basins directly.

Chemical wastes, associated with process water treatment, consist of regeneration cycle wastes from the Condensate Polishing System, the Make-up Water Treatment System, Plant Laboratory and Feedwater and Steam Sampling and TGB (Turbine Generator Building) chemical storage area drains, and discharge to the chemical waste sump in the TGB. The wastes are then pumped to the batch chemical waste neutralization system located in the Waste Water Treatment area of the plant yard. Following neutralization, these wastes are discharged to the equalization basins.

The equalization basins consist of two equal capacity compartments, each compartment sized to provide one full day of storage capacity for normal plant waste volumes. Dual compartment design permits the basins to operate alternately: one in service, one in clean-up or standby. Since plant wastes are discharged at variable frequency and duration, and have 13
variable characteristics, the basins provide equalization of flow and characteristics and hold-up capacity prior to processing in downstream treatment units.

Plant wastewater is pumped from the equalization basins to downstream treatment units by three submersible pumps which are located in a pre-cast concrete wetwell adjacent to the eualization basins. Each pump is designed to provide continuous discharge of wastewater based on average plant flows. Two pumps will handle unusual waste volumes resulting from intermittent discharges such as Fire Protection System discharge, high volume tank and basin cleanings and any unscheduled discharges. The third pump is a standby in case of pump failure. A flow meter on the discharge line monitors and records plant waste flows and provides a signal for pacing chemical feed in downstream treatment units.

The wastewater treatment units consist of the following major components: pH trim tank, solids contact clarifier and automatic gravity filters. These units are located in the Waste Water Treatment area of the plant yard. Appurtenant equipment consisting of bulk chemical storage tanks, mix tanks, chemical feed pumps, controls, instruments and associated panels is located within the Waste Disposal Building in the same area of the yard.

Wastewater pumped from the equalization basins is discharged to the pH trim tank which provides sufficient detention time for adjustment of wastewater pH to optimize the performance of the downstream solids contact clarifier. The pH trim tank is fitted with a mixer at the inlet end and a pH sensor at the outlet end. This sensor works in conjunction with a pH sensor located in the wastewater wetwell at the equalization basins to provide pH control. The pH controls pace a set of acid or caustic feed pumps, as required, to maintain a narrow preset pH range. The optimum pH range will be determined on a regular basis by plant operators. 13

From the pH trim tank, wastewater flows by gravity to the solids contact clarifier. The clarifier removes suspended solids and dissolved iron and copper from the wastewater stream. The clarifier provides flash mixing of chemicals and previously formed precipitates with inlet wastes, flocculation and clarification of wastewater. Solids produced in the clarifier are moved by a sludge scraper mechanism to a hopper in the clarifier bottom and are removed from the clarifier by an automatic system of backflush and blow-off valves. The sludge removal cycle is adjustable and is paced by inlet flow. Cycle adjustments will be established and modified as required to maintain optimum clarifier performance based on waste characteristics. Chemical feed to the clarifier is paced by the flowmeter in the influent pump discharge line. Chemical dosage rates will be determined by plant operators on a periodic basis.

Following the solids contact clarifier, treated wastewater flows by gravity to two full design capacity automatic gravity filters. The filters remove traces of suspended solids, oil and grease and assure that the effluent meets the discharge limits stipulated in the CRBRP discharge permit. The backwashing of the filters is completely automatic and is based on loss of head through the filter media. The filter backwash system includes air scour of filter media to enhance the removal of sticky or gelatinous materials. Filter controls are interlocked so as to prevent simultaneous backwash of both filters. 13

Filter effluent is monitored for turbidity, oil and grease, and pH by automatic analyzers located in the Waste Disposal Building. An excursion in any of these parameters beyond discharge limits automatically diverts plant effluent back to the equalization basins so as not to contravene discharge limits.

Normally, plant effluent is combined with blowdown and discharged to the Clinch River. If chemistry permits, plant effluent can be discharged to the cooling tower basins for recycling.

The Waste Disposal building contains bulk storage tanks for acid and caustic; acid and caustic feed pumps; coagulant mix tanks and feed pumps; coagulant acid mix tanks and feed pumps; and instruments, controls and alarms associated with the waste water treatment and disposal process.

Solid Wastes

Plant wastes containing high suspended solids, including Make-up Water Treatment System clarifier blowdown, gravity filter backwash and activated carbon filter backwash; Waste Water Disposal System clarifier blowdown and gravity filter backwash; and other plant wastes such as cooling tower basin clean-up, are discharged to the sludge lagoons. The sludge lagoons are located adjacent to the equalization basins and are comprised of two equal capacity compartments. Dual compartment design permits the lagoons to operate alternately: one in service, one in clean-up or standby. Each compartment is sized to hold the solids production of approximately six months. Accumulated solids 13
(sludge) will be removed and disposed of off-site by a licensed contractor. As sludge settles and thickens, clear supernatant is recycled to the equalization basins.

Cooling Tower Blowdown

The cooling tower blowdown discharge is designed to satisfy all effluent limitations imposed by the NPDES Permit. Monitoring of temperatures, pH and residual biocide is provided. No oil or grease is expected in the blowdown.

13

Storm Water 13

Storm water collected by the roof and yard drains is sent to stormwater retention ponds for removal of suspended solids prior to discharge to the Clinch River. A portable oil skimmer will be available in case a visible oil slick appear on the surface of 13
the catch basin. Any oil collected will be disposed of off-site.

13

10.4.1.2 ALTERNATIVES

Three areas within the Waste Water Treatment System were 13
considered potentially applicable to further treatment: the
clarifier blowdown; the volume of regenerant wastes produced; and
the plant effluent. Each of the alternatives presented is 13
designed to reduce the volume and/or improve the quality of its
associated waste stream, thus enhancing the overall environmental
performance of the waste treatment system. (Relative performance 13
of several of the alternatives is included within Table 10.4-3).

10.4.1.2.1 MECHANICAL DEWATERING OF CLARIFIER BLOWDOWN

Gravity sludge drying beds and lagoons generally produce a sludge
that is 10 to 40 weight-percent solids. The percentage achieved 13
is a function of retention time and meteorological conditions.
Mechanical dewatering is an alternative that often produces a
more compact and a dryer sludge. The environmental advantages of
this process include reduction in solid waste volume and a slight
increase of recyclable water.

Two mechanical dewatering methods may be utilized: rotary vacuum filtration or centrifugation. Both require a thickener for pretreatment of the sludge.

10.4.1.2.2 REVERSE OSMOSIS IN MAKEUP WATER TREATMENT SYSTEM

The waste stream containing the highest level of impurities is
the process water treatment wastewater. One method of further 13
treating this stream is to reduce its volume at the source.
Demineralizers are employed by the Makeup Water Treatment System
to obtain the high quality water required for condensate makeup.
Daily regeneration of the demineralizer beds is needed. This
produces approximately 27,000 gpd input to the waste stream. 13

Frequency of regeneration and, consequently, the volume of wastewater can be reduced by providing pretreatment of the demineralizer influent through reverse osmosis.

Reverse osmosis reduces the dissolved solids content of water by reversing the process of natural osmosis through pressure-forced flow across a semipermeable membrane. The products of reverse osmosis are a low TDS effluent and a high TDS brine.

10.4.1.2.3 ZERO DISCHARGE OF WASTE WATER TREATMENT EFFLUENT 13

A second alternative method of treating the waste streams is to provide a level of additional treatment to the effluent that will 13
result in zero discharge to the Clinch River. Three processes that accomplish this are identified: off-site treatment at an existing facility, on-site percolation ponds, and evaporation.

Off-Site Treatment

The processing of wastewater at an existing treatment 13
facility is a potential means of achieving zero discharge at the site. A suitable facility capable of handling the increased load without suffering loss of efficiency and located close enough to keep pipeline construction and pumping costs reasonable is required. Pretreatment standards (EPA) would have to be met.

Percolation Ponds

Percolation ponds would utilize the natural capacity of soil to absorb the wastewater treatment effluent prior to its 13
entry into the groundwater supply.

Successful application of ground discharge requires suitable soil composition and depth such that anticipated hydraulic 13 loadings can be applied without clogging or back-up.

13

Evaporation

An evaporation process can be employed to produce a high quality liquid effluent that is suitable for recycle. The evaporation procedure is a form of distillation in which the wastewater influent is vaporized and then condensed. Typical TDS levels for the condensate are in the order of 10 mg/l. By-products of the evaporation cycle are a concentrated brine and some release of chemicals to the atmosphere. The evaporation process would not only provide zero release of high TDS effluent to the river but also reduce makeup water requirements through recycle of the liquid effluent to the cooling tower basin.

10.4.2 ELIMINATION OF IMPRACTICAL ALTERNATIVES

10.4.2.1 MECHANICAL DEWATERING OF CLARIFIER BLOWDOWN

Sludge dewatering by either vacuum filtration or centrifugation are alternatives to the sludge lagoons. Use of these processes will require sludge holding tanks, mixing tanks, pumping 13 equipment and process control equipment. Consequently, it is a process that requires continuous operator attention. Other disadvantages of thickening using sludge dewatering equipment include increased energy consumption, higher local noise levels, potential use of chemicals as sludge conditioning agents for 13 rotary vacuum filtration or centrifugation. Unlike sludge lagoons, the rotary vacuum filters and centrifuges will be placed 13 inside a building.

13

Therefore, in view of its many drawbacks, mechanical sludge dewatering cannot be considered a reasonable alternative. 13

10.4.2.2 REVERSE OSMOSIS IN MAKEUP WATER TREATMENT SYSTEM

Addition of a reverse osmosis system to the Makeup Water Treatment System has the potential to reduce the frequency of the demineralizer regenerations and, therefore, the quantity of this waste stream. However, this application of reverse osmosis has several disadvantages. The reverse osmosis unit reduces the amount of regenerant waste, but its brine flow, while lower in 13 solids, is higher in volume than the regenerant waste from the demineralizers. The unit will have to be operated on a start-stop basis or employ a surge tank since the flow rate is basically fixed by the minimum pressure requirement for proper salt rejection and the maximum pressure to avoid serious compaction of the membranes. The high alkalinity water will require pretreatment to avoid carbonate scaling in the unit. A decarbonator is required for the removal of carbon dioxide and to reduce the anion load in the demineralizer. Reliability of the reverse osmosis system is questionable. Therefore, the size of the demineralizers and the waste treatment facilities cannot be reduced, since there is a risk of loss of capacity in the reverse osmosis sytem.

In view of the above enumerated difficulties and the fact that its use would only reduce (not eliminate) a regeneration waste stream that represents about one-third of the influent flow to the waste water treatment facility, reverse osmosis does not 13 represent a reasonable alternative for the waste treatment system.

10.4.2.3 OFF-SITE DISPOSAL OF WASTEWATER TREATMENT EFFLUENT |13

Off-site disposal of effluent was considered. Upon |13
investigation, it has been learned that, at this time, there are no treatment plants in the vicinity of the Site which can accept this quantity or type of effluent. This alternative is, therefore, not considered to be feasible.

10.4.2.4 PERCOLATION PONDS

Sending the effluent to percolation ponds for disposal was |13
considered. The use of ground discharge is predicated on the availability of suitable soil conditions. Soil in the area of the CRBRP has been determined to be clay to a depth of 20 to 30 feet. This alternative is, therefore, not considered to be feasible based on the poor absorption characteristics exhibited by clay soils.

10.4.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

The only alternative to the reference waste treatment system |13
which warrants futher consideration is the additional treatment
of effluent by an evaporation system. |13

Employment of an evaporator will result in concentration of the
wastewater into a brine and recovery of about 95 percent of the |13
water as a high quality condensate (approximately 10 mg/l total solids).
|13

Evaporator design is based on a vapor-compression thermodynamic cycle. Other evaporation types would provide a similar service but would involve multiple units because of the high flow during startup operation. Also the metallurgical design of other less expensive evaporators was not considered to be operationally reliable for this application.

Vapor-compression evaporation concentrates the waste stream by raising the inlet water to the boiling point. Following pH correction and carbon dioxide removal with a scrubber, the feedwater is pumped to the heat transfer tubes where additional heat is added and the water vaporizes. Vapor is pumped to the opposite side of the tubes where condensation occurs. The condensate is then recycled to the cooling tower as makeup water and the brine sent for further processing. 13

Two processing methods for the brine are a small solar pond and 13 mechanical spray dryers. While a solar pond is an inexpensive and reliable method for ultimate disposal, this alternative is limited to sites having higher net evaporation rates than are available at the Site. A mechanical spray dryer can be used to produce a dry powder that is collected in a dust-free manner in containers for disposal.

10.4.4 ENVIRONMENTAL COSTS

The principal environmental concern associated with the CRBRP 13 waste treatment system is the effect of its liquid discharge on the water quality and aquatic life of the Clinch River. For the purpose of the alternatives study, it is sufficient to utilize a single parameter -- total dissolved solids -- for comparing the magnitude of the effects produced by the reference system and evaporator alternative.

By eliminating the discharge of a high solids content effluent and permitting recycle of the waste stream, the evaporator reduces by about 100 gpm the plant makeup water requirement and cooling tower blowdown flow rate, and produces less than a 1.5% 13 decrease in the TDS concentration resulting from the CRBRP common plant discharge. The significance of these environmental improvements is a function of the magnitude of their ultimate benefit to the Clinch River.

The waste recycle afforded by the evaporation process yields a 13
net decrease of 1.6 and 4.3 percent in makeup water requirement
and blowdown flow rate, respectively. These quantities are quite
small and constiture only a negligible water use savings.

Value of the improvement in discharge water chemistry realized by
employment of the evaporator alternative must be measured against
the severity of the potential adverse effects produced by the
reference system discharge. Changes in river TDS concentration
caused by the effluents of the reference waste treatment system 13
alone and with the addition of the evaporator are presented in
Table 10.4-4. Four cases representing the full range of possible
river flow conditions, including extended no flow cases, are 6
examined as discussed in the Appendices to Section 10.3.

Increases in river TDS concentrations for flowing water (typical)
cases due to discharges from the reference system are
approximately 8 mg/l and are limited to 0.07 acre of the river 13
surface. Even for the extreme cases, these levels are
considerably below the 500 mg/l maximum adopted by the Tennessee 6
Water Quality Control Board as a general criterion for its most
stringent water quality requirements.[2] Addition of the
evaporator yields very small reductions in the concentrations
associated with the reference system effluent.

An evaluation of the data presented in Table 10.4-4 indicates
that the quality and quantity of the effluent from the reference 13
waste treatment system are such that no significant water quality
changes will occur under any probable river conditions.
Consequently, no adverse impact on aquatic life is anticipated.
The inclusion of an evaporator process yields only marginal
environmental improvements in river water quality due, primarily,
to the low volume of the waste stream. A greater reduction in
TDS would be produced by evaporation 13

(or similar treatment) of the large volume cooling tower blowdown
stream. However, two factors strongly argue against such action:
(1) the actual amount of solids in the tower blowdown is the same
as that removed from the river during makeup -- TDS concentration
is raised only because the water volume is decreased (through
cooling tower evaporation, drift, etc.); and (2) the reference 13
Waste Water Treatment System has been shown to be environmentally
acceptable and, thus, the high costs of blowdown TDS treatment
would not be justified.

10.4.5 ECONOMIC COSTS

Monetary costs for the waste treatment system alternatives are 13
presented in Table 10.4-5. The increases in the investment cost
attributable to the evaporator is $592,850. 13

10.4.6 COMPARISON OF ALTERNATIVES

10.4.6.1 DIRECT COMPARISON OF REASONABLE ALTERNATIVES

Employment of an evaporator process within the proposed waste 13
treatment system has been identified as a viable alternative for
the CRBRP. The foregoing environmental and economic analyses
presented the benefits and the costs associated with evaporation
of the waste stream. Summarization of these findings, presented 13
in Table 10.4-6, indicates that the economic costs outweigh the
environmental benefits. Reductions in discharge TDS attributable
to the evaporator amount to about 1 1/2 percent and, in view of 13
the environmental acceptability of the reference system, do not
justify the expenditure of over one-half million dollars.

10.4.6.2 REASON FOR SELECTION OF CHOSEN SYSTEM

The Waste Water Treatment System identified in Figure 10.4-1 has been selected for the CRBRP. Its levels of treatment comply with all applicable governmental standards. Further, its effluent discharge to the Clinch River will not produce adverse environmental effects for either normal or extreme case flow conditions in the river. 13

TABLE 10.4-1

CLINCH RIVER BREEDER REACTOR PLANT
EFFLUENT LIMITATIONS AND WATER QUALITY*

Constituents	NPDES Permit Limitations	Proposed CRBRP Treatment Method
A. HEAT REJECTION SYSTEM BLOWDOWN: Thermal Discharge	The receiving water shall not exceed: (1) a maximum water temperature change of 3°C (5.4°F) relative to an upstream control point; (2) a maximum temperature of 30.5°C (86.9°F), and (3) a maximum rate of change of 2°C (3.6°F) per hour outside of a mixing zone which shall not exceed the dimensions of a circle with a maximum diameter of 30.5 meters (100 ft.)	Mechanical Draft Cooling Tower with cold leg blowdown and submerged discharge.
Hydrogen Ion Concentration (pH)	pH in the range of 6.0 to 9.0 at all times	pH control, as required.

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TABLE 10.4-1 (Continued)

CLINCH RIVER BREEDER REACTOR PLANT
EFFLUENT LIMITATIONS AND WATER QUALITY*

Constituents	NPDES Permit Limitations	Proposed CRBRP Treatment Method	
A. HEAT REJECTION SYSTEM BLOWDOWN			
(Continued)			13
Chlorine (Cl)	Total residual chlorine shall not exceed a maximum instantaneous concentration of 0.14 mg/l	Controlled chlorination with blowdown stopped.	
Other Debris	There shall be no discharge of floating solids or visible foam in other than trace amounts.	No dumping to river	

TABLE 10.4-1 (Continued)

CLINCH RIVER BREEDER REACTOR PLANT
EFFLUENT LIMITATIONS AND WATER QUALITY*

Waste Stream	NPDES Permit Limitations	Proposed CRBRP Treatment Method
B. WASTE WATER DISPOSAL SYSTEM EFFLUENT		
Low volume waste sources**	Total suspended solids; 30 mg/l daily average 100 mg/l daily maximum	Neutralization/clarification/ filtration provided
	Oil and grease; 15 mg/l daily average 20 mg/l daily maximum	Oil separator provided where appropriate.
	pH; Not less than 6.0 nor greater than 9.0	
Polychlorinated Biphenyl Transformer Fluid	No Discharge	PCB containing equipment shall not be placed on the plant site, however, if such equipment is required, administrative procedures will be instituted to preclude release of PCB's to the environment.
Other Debris	There shall be no discharge of floating solids or visible foam in other than trace amounts.	No dumping to river

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*Permits required to meet these criteria are listed in Section 12.

**Includes water treatment system backwashes and rinse water, ion exchange regeneration wastes, cooling tower basin cleaning wastes, etc.

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TABLE 10.4-2 DISCHARGE FLOW RATES

WASTE STREAM SOURCE		DISCHARGE FREQUENCY	AVERAGE AND MAXIMUM QUANTITY
I. Cooling Tower Blowdown		Continuous	2,300 - 3,100 gpm
II. Storm Water Yard and Roof Drains		Unscheduled Intermittent	Design Basis; 10 years - 24 hours storm
III. Waste Water Treatment			ESTIMATED WASTE VOLUME, GPD
1. Condensate Polish[illegible]	Ion exchange regeneration wastes (sulfuric acid, sodium hydroxide), and rinses	once/week	40,000
2. Make-up Water Demineralizers (anionic and cationic)	"	daily	27,000
3. Make-up Water Demineralizers (mixed bed)	"	once/5 days	4,500
4. Make-up Water Treatment	Gravity Filter Backwash	daily	8,750
5. Make-up Water Treatment	Clarifier Blowdown	daily	2,140
6. Make-up Water Treatment	Activated Carbon Filter Backwash	daily	8,400

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TABLE 10.4-2 (continued)

WASTE STREAM SOURCE			DISCHARGE FREQUENCY	ESTIMATED WASTE VOLUME, GPD
7.	Waste Water Treatment	Clarifier Blowdown	daily	1,650
8.	Waste Water Treatment	Gravity Filter Backwash	daily	5,000
9.	Feedwater and Steam Sampling	Laboratory Analysis Wastes	daily	28,800
10.	Non-radioactive Floor Drains	Equipment drainage, floor washing, etc.	daily	20,000
11.	Cooling Coil Drainage	-	seasonal	0-74,000
12.	Hypochlorite Generating Plant	Water softener regeneration wastes (brine) and rinses	daily seasonal	800

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TABLE 10.4-3

WASTE TREATMENT SYSTEM

Stream Description

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Stream Description	Treatment Mode	Effluent Content	Range of Effluent Quantity	Remarks
I. Cooling Tower Blowdown	Provision for monitoring and control of pH, temperature, total residual chlorine	Clinch River Water concecentrated 2-3 times. Total residual chlorine less than 0.14 mg/l	2,300 - 3,100 gpm	Base Case treatment
II. Plant Wastes				
Clarifier Blowdown, Filter Backwashes		Clinch River Water, Aluminum Hydrate & trace Iron & Manganese. Approx. 0.2% solids	Approx. 26,000 gpd	
Clarifier Blowdown Filter Backwashes	Sludge Lagoons	Sludge Approx. 10% solids	Approx. 500 gpd	Base Case Treatment Mode as shown in Figure 10.4-1
		Liquid Clinch River water with slight increase in sodium sulfate	Approx. 25,500 gpd	
Clarifier Blowdown Filter Backwashes	Thickener followed by Vacuum Filtration	Sludge Approx. 40% solids	Approx. 130 gpd	Alternative Treatment Mode for Clarifier Blowdown, Filter Backwashes
		Liquid Same as sludge lagoon	Approx. 25,870 gpd	

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(Continued)

TABLE 10.4-3 (continued)

Stream Description	Treatment Mode	Effluent Content	Range of Effluent Quantity	Remarks
Clarifier Blowdown Filter Backwashes	Thickener followed by centrifugation	Sludge Approx. 25% solids	Approx. 210 gpd	Alternative Treatment Mode for Clarifier Blowdown, Filter Backwashes
		Liquid Same as sludge lagoon	Approx. 25,790 gpd	
Waste Water Treatment System Effluent	Neutralization, Flocculation, Clarification, Filtration	Clinch River Water with slightly high sodium sulfate content, pH 6.5-8.5, 1350 mg/l TDS TDS: 85% Sodium and Sulfate Remaining 15% consists primarily of Fe, Ca, Mg, PO_4, with trace quantities of Cu, Cr and Ni below detectable limits	Approx. 144,000 gpd	Base Case
	Evaporator	Evaporator Distillate is a high quality water (10 ppm TDS) and will be recycled	143,600 gpd	Alternative
		Sludge 50% solids content	400 gpd	

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(Continued)

TABLE 10.4-3 (Continued)

Stream Description	Treatment Mode	Effluent Content	Range of Effluent Quantity	Remarks
Non-Radioactive Floor Drains		Similar to Clinch River Water	Approx. 20,000 gpd	Water in Floor Drain System is assumed to be water used for washdown, pump seal leakage, etc.
Non-Radioactive Floor Drains	Oil Separator Effluent	Treated effluent will contain 15 ppm free oil	20,000 gpd	
III. Storm Water				
Roof and Yard Drain: Retention Ponds		Rain water that may have picked up a trace of oil+	Design basis: 10 yr. - 24 hr. storm	

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(Continued)

TABLE 10.4-3 (Continued)

Stream Description	Treatment Mode	Effluent Content	Range of Effluent Quantity	Remarks
Retention Pond Oil Waste	Oil Skimmer++	Oil & Misc. entrained solids	N.A.	Waste placed in container, sealed and disposed off-site

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+Oil traces are interpreted to mean virtually undetectable.
++To be used only if visible oil slick is detected. 13

TABLE 10.4-4

EFFECT OF WASTE TREATMENT SYSTEM DISCHARGES OF TOTAL DISSOLVED SOLIDS ON CLINCH RIVER WATER QUALITY* 13

Mixing Conditions**	Clinch River Concentration* (mg/l)	Reference System: Discharge Concentration (mg/l)	Reference System: Concentration in River (mg/l)	Reference System: Affected River Surface Area (acres)	Reference System with Evaporator: Discharge Concentration (mg/l)	Reference System with Evaporator: Concentration in River (mg/l)	Reference System with Evaporator: Affected River Surface Area (acres)
Typical Cases							
Winter	142	396	150	0.05	355	148	0.05
Summer	142	396	150	0.07	355	148	0.07
Extreme Cases							
Short Duration No Flow (Winter)	174	473	180	3.92	435	179	3.92

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*Values derived from Tables 10.3A-2 and 10.3A-7.

**See Tables 10.3A-4 and 10.3A-10 for description of cases.

+142 mg/l - average, 174 mg/l - maximum concentration.

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TABLE 10.4-5

INVESTMENT COSTS FOR
WASTE TREATMENT SYSTEM ALTERNATIVES | 13

(All Costs in 1974 Dollars)

Evaluated Costs ($)	Reference Waste Treatment System	Reference System With Evaporator	
A. INVESTMENT COSTS			
1. Civil-Structural	BASE	800	
2. Electrical	BASE	4,100	
3. Mechanical	BASE	570,000	
4. Total Equipment Costs	BASE	574,900	
B. EQUIVALENT INVESTMENT COSTS			
1. Chemical Costs	BASE	200	
2. Storage and Handling of Chemicals	BASE	100	
3. Storage and Handling of Wastes	BASE	100	
4. Disposal of Wastes	BASE	400	
5. Operation and Maintenance	BASE	8,300	
6. Total Operating Costs	BASE	9,100	
C. AUXILIARY POWER COSTS			
1. Total Power (kW)	BASE	150	
2. Equivalent Investment Costs*	BASE	8,700	
TOTAL EQUIVALENT INVESTMENT COST	BASE	592,850	13

*At $57.8/kW based on 3 hours per day operation

TABLE 10.4-6

SUMMARY OF ENVIRONMENTAL AND ECONOMIC FACTORS

FOR EVAPORATOR ALTERNATIVE

Environmental Benefits	Evaporator	
Reduction in River TDS Levels		
Typical Cases*		
Winter	1.3%	
Summer	1.3%	13
Extreme Case*		
Short Duration No Flow	0.5%	6 13
Economic Costs		
Additional Investment Cost	$592,850	13

*See Tables 10.3A-4 and 10.3A-10 for description of cases. Winter cases used for Short Duration and Extended No flow events. 6

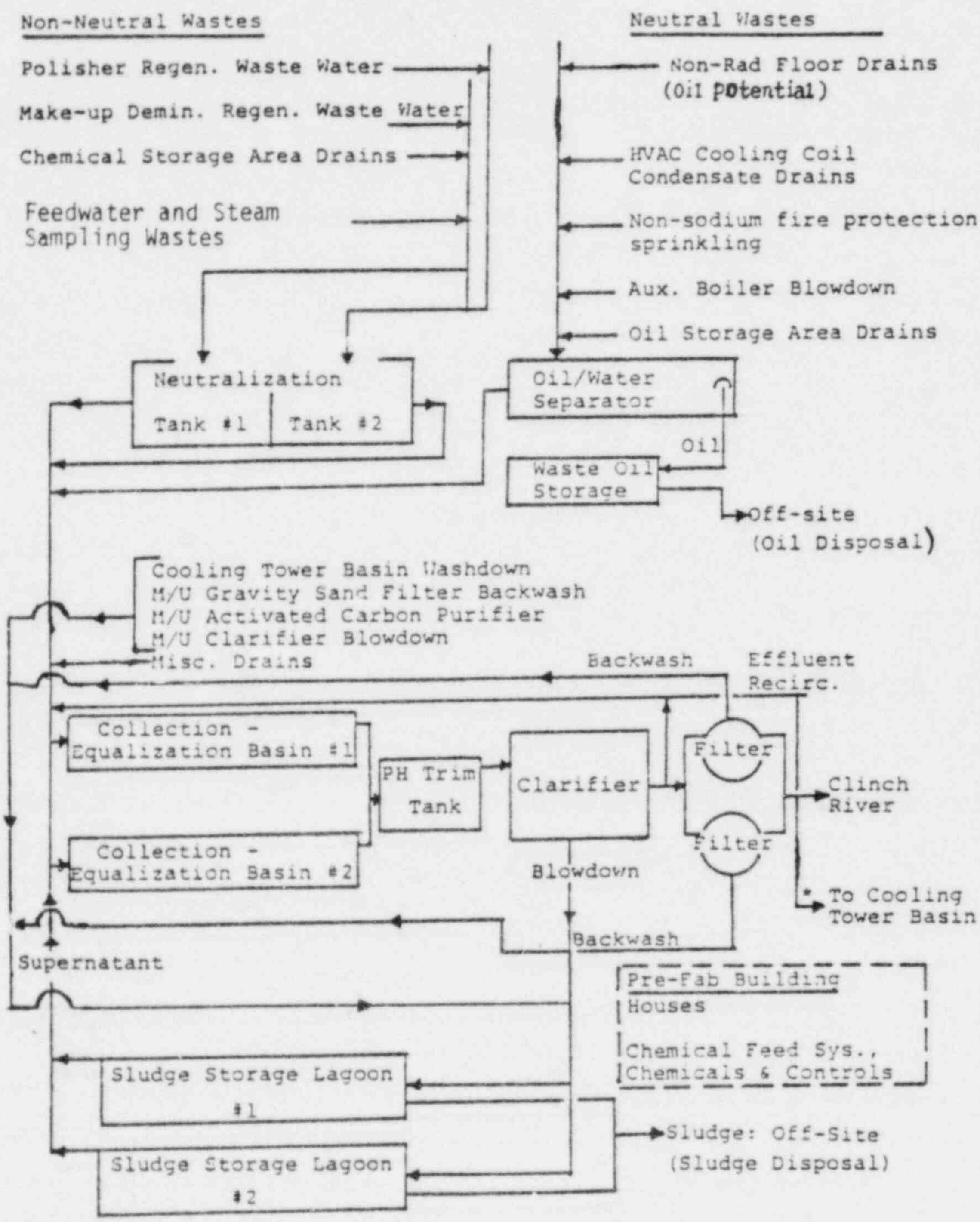

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Figure 10.4-1 WASTE WATER TREATMENT SYSTEM

* Whenever cooling tower chemistry permits, will discharge effluent to the cooling tower basin

10.5.2 ELIMINATION OF IMPRACTICAL ALTERNATIVES

10.5.2.1 ORGANIC CHEMICALS

Organic biocides are beset by the same environmental disadvantage as chlorination -- residual activity. Further, the fate of complex hydrocarbons released in a water body is less well understood. Organic biocides would be preferable only for those cases where high chlorine demand, fouling caused by iron/manganese-chlorine reactions, or deterioration of wooden cooling towers is anticipated. The organic loading of the Clinch River at the Site is low and no unusually high chlorine demand is expected. Concentrations of iron and manganese are also low and the cooling towers will be of concrete. Consequently, no economic, performance, or environmental advantage exists that would favor the use of an organic biocide for the CRBRP.

10.5.2.2 OZONE

Although its use in water and wastewater disinfection has been rising, ozonation has not achieved sufficient operational exposure as a biocide to recommend its employment at this time. Experience in selecting proper dose levels and application frequencies is lacking, a point that is particularly important in reference to the Asiatic clam infestation of the Ohio and Tennessee River Valleys.[6] These clams are prevalent in the Clinch River at the Site and are known to create clogging problems in plant waterlines. Considerable experience has been gained in controlling such organisms through chlorination. The use of ozonation would require the development of new control procedures.

The main environmental advantage of ozonation is its lack of residual activity. However, as ozone is rapidly reduced, oxygen levels increase and supersaturation may occur. This likelihood is particularly enhanced for a power plant where the ozonated water is also heated prior to discharge. Supersaturated conditions in the thermal plume would be detrimental to fish. If the ozonator receives air rather than pure oxygen, the more serious case of nitrogen supersaturation is a distinct possibility.

10.5.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

The chlorination biocide system for the CRBRP will primarily utilize intermittent application several times daily to control biological fouling. Residual chlorine levels in the cooling tower basin will be continuously monitored. System design will provide the capabiity for automatically stopping the blowdown flow in case of excursion beyond total residual chlorine (TRC) effluent limits, and for maintaining zero release of total 13 residual chlorine until the residual concentration has fallen to an acceptable preset level that assures compliance with state and Federal requirements. 13

A feasible addition to the chlorination system is mechanical cleaning. As noted in Section 10.5.1.4, mechanical cleaning has limited applications and cannot supersede chlorination. It does permit reductions in the quantity of chlorine applied and would be advantageous in situations where discharged residual chlorine presents a significant environmental concern.

10.5.4 ENVIRONMENTAL COSTS

The effect of the chlorine residual on aquatic life in the Clinch River is the principal environmental concern associated with the CRBRP Biocide System.

Free available chlorine does not present a significant
environmental concern as oxidation and dissipation will occur
rapidly at the point of discharge to the river. Chlorine demand
in the river (in terms of BOD and COD concentrations, from
preliminary aquatic baseline survey data) is sufficient to
consume the low level chlorine addition well within the near 13
field mixing zone. The 5.1 cfs annual average cooling tower
blowdown represents only 0.1 percent of the 5066 cfs summer river 13
flow and will be significantly diluted within the near field
mixing zone.

The most potentially severe effect on aquatic life would result
from complexation of the free available chlorine with ammonia
that may be present in the plant discharge. Chloramine compounds 13
formed by such a reaction are relatively stable compared to
chlorine and are highly toxic to aquatic life. Sufficient
ammonia is available from the sanitary waste treatment (0.5 mg/l
ammonia-N in 7,000 gpd) and auxiliary steam generator (hydrazine 13
decomposition: 0.5 mg/l NH_3-N in 480 gpd when operating)
influents to the plant discharge to complex a portion of the
available chlorine. An extreme case can be postulated by
assuming the remaining chlorine is complexed by the ammonia
available in the river before any oxidation or dissipation can
occur. Given this conservative assumption, the resulting
chloramine concentrations in the Clinch River for various flow
regimes are presented in Table 10.5-1. As EPA has limited the
permissible duration of discharges of free available and total
residual chlorine to two hours per day, (7) the values given in
Table 10.5-1 represent maximum possible concentrations.
Chloramine in the river will approach these levels during the
period of chlorine discharge and then recede from them after

chlorine release is terminated. Due to its intermittent presence in the CRBRP effluent, chloramine will not be subject to the same concentration increases during an extended no-flow occurrence as are plant chemicals whose discharge is continuous. 6

A review of the toxicity literature indicates that the maximum chloramine concentrations given in Table 10.5-1 are below levels associated with acute toxicity to aquatic life.(1) Although sublethal effects (reductions in number of young produced in the amphipod and egg production in the minnow) have been observed at concentrations greater than 0.0034 mg/l and 0.0165 mg/l for an amphipod and minnow species, respectively,[8] aquatic life will not receive constant exposure to chloramine levels in these ranges, as noted above.

The control of residual chlorine in the cooling tower blowdown will ensure that the CRBRP Biocide System will comply with applicable standards. Further, the foregoing analyses indicate that residual chlorine activity will not adversely affect aquatic life in the Clinch River.

10.5.5 ECONOMIC COSTS

The addition of mechanical cleaning to the CRBRP Biocide System would result in increased capital and operating costs that would not be offset by the reductions in chlorine requirements provided.

10.5.6 COMPARISON OF ALTERNATIVES

As indicated in Section 10.5.4, the environmental costs associated with a "worst" case of discharge of complexed residual chlorine during no-flow river conditions are not significant. Consequently, the intermittent chlorine application method to be utilized by the CRBRP Biocide System will not adversely affect aquatic life in the Clinch River.

Although mechanical cleaning does not offer a measurable environmental advantage over the proposed chlorination system, it would be desirable from a plant performance viewpoint.

Chlorination, with or without supplemental mechanical cleaning, is an environmentally acceptable Biocide System for the CRBRP.

TABLE 10.5-1

MAXIMUM CHLORAMINE CONCENTRATIONS IN CLINCH RIVER RESULTING FROM BIOCIDE SYSTEM RESIDUAL CHLORINE DISCHARGES*

Mixing Conditions**	Chloramine Concentration+ (mg/1)	River Surface Affected (acre)
Typical Cases		
Winter	0.009-0.015	0.05
Summer	0.009-0.015	0.07
Extreme Case++		
Short Duration No Flow	0.006-0.015	3.92
Extended No Flow∇	0.079	71	6

*Values presented based on Table 10.3A-7. 6

**See Tables 10.3A-4 and 10.3A-10 for description of cases.

+Chloramine concentration is computed as follows:

$$NH_2Cl = (\text{isopleth }\%) \times (0.2 \text{ mg/1 } Cl_2) \times (1.47)$$

(1.47 is a stoichiometric factor -- 0.68 moles of Cl_2 are required to produce one mole of NH_2Cl.)

++Winter cases

∇Based on revised Section 5.4.1.2.3. The system selection decision is not affected. 6

10.6 SANITARY WASTE SYSTEM

A sanitary waste system will be required to provide sewage treatment during normal operation of the CRBRP. It will be a permanent facility designed to process a waste stream that is similar to domestic sewage, except that kitchen and laundry wastes are not anticipated. Radioactive wastes are not handled by the sanitary waste system. 13

The average daily sanitary wastewater flow during normal operation will be 7,000 gallons. This is based upon 200 plant personnel and 35 gal/person/day for normal plant operation. Present projected number of plant personnel is 179 persons with a peak manning of 300 men anticipated for annual shutdown. The permanent plant design flow of 13,000 gal/day will be adequate during normal operation and annual shutdown. 13

Plant sanitary wastes will be processed in a manner that is consistent with applicable State regulations[1] and reflects the goal of reducing environmental impact. Alternatives considered represent a variety of approaches offering different levels of environmental and economic cost.

The selected sanitary waste system for the CRBRP is on-site treatment via an extended aeration variation of the activated sludge process with chlorination of the effluent prior to discharge into the Clinch River. This system has a design capacity of 13,000 gpd. 13

Alternative systems considered for processing plant sanitary wastes are:

1. Tap-in to existing treatment facility;
2. Ground discharge;
3. Incineration;
4. Extended aeration/filtration/chlorination;
5. Activated sludge/membrane filtration;

6. Clarification/filtration/carbon adsorption; and
7. Extended aeration/chlorination. 13

10.6.1 DESCRIPTION OF ALTERNATIVES

10.6.1.1 TAP-IN TO EXISTING TREATMENT FACILITY

An environmentally attractive alternative for plant sanitary waste treatment is to tap-in to an already existing sewage treatment facility. In this manner, use is made of available capability and the potentially adverse environmental effects of construction and operation of an on-site facility are avoided. This alternative is dependent upon the existence of a nearby sewage treatment plant that can accept the additional load without suffering reduced treatment efficiency.

The tap-in scheme would require construction of a pipeline to the treatment plant and sufficient pumping power at the CRBRP. 13

10.6.1.2 GROUND DISCHARGE

Ground discharge of sanitary wastes possesses several environmental advantages. It utilizes the natural assimilative capacity of soil, eliminating the need for extensive treatment facilities. Energy requirements are low and no effluent is discharged directly into the river.

Successful application of ground discharge requires suitable soil composition and depth such that anticipated waste loadings can be applied without clogging or back-up. Soils subject to short-circuiting with attendant introduction of inadequately treated wastes into ground water supplies must be avoided.[2] Several application techniques can be utilized in a ground discharge treatment system. Notable among these are percolation ponds and spraying.

10.6.1.3 INCINERATION

Incineration of sewage sludge provides the least quantity of sludge achievable. The small quantities of dry ash produced considerably lessen the environmental costs associated with the disposal of moisture-laden sludge from conventional sludge treatment processes. 13

Incineration of sewage sludge is preceded by comminution and dewatering to reduce the water content of the sludge feed so that combustion can occur. In the incinerator, fuel (commonly No. 2 oil) is utilized to initiate and sustain burning when the heat content of the sludge is insufficient. Combustion gases are cycled through a stack scrubber prior to atmospheric release to reduce particulate emissions.(3) 13

10.6.1.4 EXTENDED AERATION/FILTRATION/CHLORINATION

A fourth alternative to off-site treatment, ground discharge, or sludge incineration of sanitary wastes is on-site treatment that produces a liquid effluent environmentally acceptable for discharge to the Clinch River and a sludge for land disposal. In comparison to off-site processing, an on-site treatment facility offers the environmental advantages of more direct control over effluent quality and greater flexibility to changing loads. It does not release airborne particulates or consume water as occurs with incineration and the odor problems that may accompany ground discharge are eliminated. 13

The extended aeration/filtration/chlorination alternative system provides tertiary level treatment for the CRBRP sanitary wastes. Liquid effluent quality will comply with the EPA guidelines for secondary treatment, Table 10.6-1, and the NPDES Permit standards for CRBRP sanitary waste discharges, shown in Table 10.6-2. 13

Extended aeration provides secondary level treatment. It uses a modification of the diffused air-aerobic digestion process for sewage decomposition and treatment. It functions by maintaining sufficient oxygen, mixing and detention time to allow microorganisms to decompose the treatable wastes. Detention times are much longer than conventional activated sludge (on the order of 24 hours) eliminating the need for primary settling and reducing sludge production.[4] Extended aeration treatment will reduce suspended solids and biochemical oxygen demand by approximately 85 percent.[3] Filtration of the above effluent will provide tertiary level treatment and ensure that effluent suspended solids content is within permissible levels. The filtration unit utilizes two 100 percent capacity slow sand filters and will be capable of removing 85 percent of the suspended solids from the normal effluent of extended aeration and producing an overall BOD reduction of 95 to 98 percent. 13

Chlorination of the tertiary treatment effluent provides disinfection for the elimination of water-borne pathogens as required by the State.

10.6.1.5 ACTIVATED SLUDGE/MEMBRANE FILTRATION

The activated sludge/membrane filtration sewage treatment system produces a higher quality effluent than that possible via extended aeration/filtration/chlorination.

Activated sludge is a basic secondary treatment process utilizing biological decomposition of sanitary wastes in an aerobic environment. 13

The higher effluent quality of the activated sludge/membrane/ filtration system is accomplished at the tertiary treatment level. Membrane filtration produces an effluent with virtually no suspended solids, BOD of 0-20 mg/l and a "very low" coliform count.[3]

10.6.1.6 CLARIFICATION/FILTRATION/CARBON ADSORBTION

The clarification/filtration/carbon adsorption sewage treatment system also produces a final effluent of higher quality than extended aeration/filtration/chlorination.

Clarification is a secondary level treatment process that utilizes coagulation, flocculation and sedimentation to achieve suspended solids reductions greater than that of conventional biological decomposition systems. Chemical coagulants are added to the wastewater to form small flocs which will settle and are removed in a sedimentation tank. Filtration similar to that employed with the extended aeration system is utilized to polish the clarification effluent.

Activated carbon possesses a very high sorptive capacity for soluble organic matter. The carbon adsorption unit is a tertiary level treatment process that utilizes this capacity to produce a final effluent lower in BOD than that of the activated sludge/membrane/filtration system.

10.6.1.7 EXTENDED AERATION/CHLORINATION

The extended aeration/chlorination process is identical to that described in Section 10.6.1.4, except that the filtration of sewage effluent is omitted. The deletion of the tertiary treatment level is justified on the basis that the extended aeration process alone is sufficient to produce effluent meeting the NPDES Permit limits of 30 mg/l BOD and 30 mg/l suspended solids. Flow equalization and post aeration are provided to insure good plant operation. 13

10.6.2 ELIMINATION OF IMPRACTICAL ALTERNATIVES

10.6.2.1 TAP-IN TO EXISTING TREATMENT FACILITY

The employment of this alternative system requires the presence of an existing treatment plant located close enough to the CRBRP that pipeline construction and pumping costs do not become excessive. Additionally, the existing facility must be capable of handling the plant waste load without detriment to its efficiency or effluent quality.

Three sewage treatment facilities in the general vicinity of the
CRBRP Site were considered. The DOE Gaseous Diffusion Plant 13
facility located four miles to the north does not have sufficient reserve capacity at this time. Although it is scheduled for expansion in the near future, dependence on this cannot be advised and the distance is too far to merit further consideration of the diffusion plant facility. The Oak Ridge municipal sewage treatment plant is located 15 miles away and on this basis it is considered too remote to be included as a viable
alternative. There is a small treatment plant planned for 13
servicing the Clinch River Industrial Park (at CRM 14.6);
however, this facility is not yet constructed. Consequently, an 13
off-site treatment alternative cannot be considered adaptable for use with the CRBRP.

10.6.2.2 GROUND DISCHARGE

Utilization of ground discharge is predicated on the availability of suitable soil conditions. As the soil in the area of the CRBRP has been determined to be clay to a depth of 20 to 30 feet, this alternative is not considered to be feasible based on the poor absorption characteristics exhibited by clay soils.

10.6.2.3 INCINERATION

Sewage sludge incineration is not considerd feasible because of a 13
lack of demonstrative applications of this technology and the prohibitively high capital and energy costs involved in a small
volume unit. Additionally, conventional treatment units are 13
required for processing the liquid fraction.

10.6.3 SPECIFICATIONS FOR REASONABLE ALTERNATIVES

10.6.3.1 EXTENDED AERATION/FILTRATION/CHLORINATION

A schematic diagram of the extended aeration/filtration/ chlorination sanitary waste treatment system for the CRBRP
appears in Figure 10.6-1. System capacity is 13,000 gpd, a size 13
that provides a reserve margin for handling peak loads. Packaged extended aeration units are offered by a variety of manufacturers and have been widely employed nationwide for handling small waste volumes.[3,5]

Three units comprise the treatment facility. The extended aeration unit includes the aeration, settling and sludge holding tanks. Sludges will be disposed of off-site by a licensed contractor. Sand filtration utilizes two 100 percent capacity slow sand filters and does not require filter backwashing. Chlorination is by hypochlorite; a 1.0 mg/l residual level will be maintained in the treatment system effluent.

The final effluent from the treatment facility will contain less than 10 mg/l BOD and 5 mg/l suspended solids and will be released
to the river through the common plant discharge system. 13

10.6.3.2 ACTIVATED SLUDGE/MEMBRANE FILTRATION

Activated sludge/membrane/filtration sanitary waste treatment system for the CRBRP is designed for a flow of 13,000 gpd. It is 13 estimated to produce a final effluent with 10 mg/l BOD and 1 mg/l suspended solids.

10.6.3.3 CLARIFICATION/FILTRATION/CARBON ADSORPTION

The clarification/filtration/carbon adsorption sanitary waste treatment system for the CRBRP is designed for a flow of 13,000 13 gpd and is estimated to produce a final effluent with BOD and suspended solids of less than 5 mg/l.

10.6.3.4 EXTENDED AERATION/CHLORINATION

The extended aeration/chlorination process for the CRBRP is designed for a flow of 13,000 gpd and is estimated to produce a 13 final effluent having BOD and suspended solids concentrations of less than 30 mg/l.

10.6.4 ENVIRONMENTAL COSTS

The principal environmental concern associated with the four 13 sanitary waste systems identified in 10.6.3 is the effect of the liquid effluent discharge on the Clinch River. Effluent quality of the sanitary treatment system alternatives as compared to the NPDES Permit standards is shown in Table 10.6-3. 13

Compared to the discharge of chemicals resulting from cooling tower blowdown (~2400 gpm), the sanitary system effluent stream (~5 gpm) is a minor contributor to the total plant discharge. The sanitary system contribution is approximately 0.2 percent, 13
and the differences in treatment level among the four alternatives are inconsequential when compared to the overall plant discharge.

Concentrations of BOD and TSS occurring in the Clinch River as a result of plant chemical discharges are presented in Table 10.6-5 for the selected sanitary system. These levels represent very modest increases above ambient river values and do not constitute a significant environmental concern. The values in Table 10.6-5 13
would be essentially the same regardless of which sanitary system alternative is employed.

Each of the alternative sanitary waste treatment systems produces an effluent too small in volume and high in quality to be capable of any significant adverse environmental impact on the Clinch River. Each alternative's effluent complies with applicable standards for the chemical constituents examined as shown in Table 10.6-3. Relatively small sludge quantities are produced by 13
each alternative sanitary waste system.

10.6.5 ECONOMIC COSTS

Total monetary cost for the extended aeration/chlorination system 13
is estimated at $1.50 per 1,000 gallons treated.(3) This treatment facility is a packaged unit that affords easy installation. Reliability is good and the required level of operator attention is low. Monetary costs for the extended aeration/filtration/chlorination system are about the same as for 13

extended aeration/chlorination, however, the level of operator attention is higher. Specific monetary costs were not available for the activated sludge/membrane/filtration and clarification/ filtration/carbon adsorption systems. However, general cost differences among the three alternatives can be estimated. 13

The activated sludge/membrane filtration system is more expensive than the packaged extended aeration unit due principally to the higher capital and operating costs of membrane filtration as opposed to sand filtration and chlorination.[3] The reliability of the activated sludge system is lower, also, as a result of the membrane filtration process. The membrane is subject to physical deterioration and requires continuous monitoring.

Due to the relatively high cost of clarification as a secondary treatment process and the additional expense of carbon reactivation in the tertiary level treatment, the clarification/ filtration/carbon adsorption system is the most expensive of the four alternatives.[3,6] 13

10.6.6 COMPARISON OF ALTERNATIVES

10.6.6.1 DIRECT COMPARISON OF REASONABLE ALTERNATIVES

The environmental costs for the four sanitary waste system alternatives are substantially identical because of the negligible effect of the sanitary discharge on the Clinch River. There is little environmental preference, therefore, for the alternatives producing marginally higher quality effluents. 13

The packaged extended aeration facility is economically preferable in terms of monetary costs, ease of installation, reliability and operational experience.

10.6.6.2 REASONS FOR SELECTION OF CHOSEN SYSTEM

The extended aeration variation of the activated sludge process with chlorination prior to discharge is the selected system for the treatment of sanitary wastes from the CRBRP. It produces a liquid effluent for discharge to the Clinch River that fully complies with the applicable governmental regulations, Section 3.7, and has no adverse effects on river water quality. Furthermore, the extended aeration facility utilizes a well proven technology, provides reserve capability for peak loads and is economically advantageous. 13

TABLE 10.6-1

EPA GUIDELINES FOR SECONDARY TREATMENT EFFLUENT QUALITY (7)

	Monthly Average	
Biochemical Oxygen Demand (BOD)	30 mg/l	
Suspended Solids (SS)	30 mg/l	13
pH	6.0-9.0	

TABLE 10.6-2

NPDES PERMIT STANDARDS FOR THE CRBRP SANITARY WASTES DISCHARGE 13

	Monthly Average
Biochemical Oxygen Demand (BOD)	30 mg/l
Suspended Solids (SS)	40 mg/l
Residual Chlorine	*
pH	6.0-9.0

13 13

*TRC limitation in NPDES Permit is applied at the edge of the Mixing Zone. 13

TABLE 10.6-3

EFFLUENT QUALITY OF SANITARY SYSTEM ALTERNATIVES*

	NPDES Permit	Extended Aeration/ Filtration/ Chlorination	Activated Sludge/ Membrane Filtration	Clarification/ Filtration/ Carbon Adsorption	Extended Aeration/ Chlorination	
BOD	30 mg/l	10 mg/l	10 mg/l	5 mg/l	<30 mg/l	
Suspended Solids	30 mg/l	5 mg/l	1 mg/l	5 mg/l	<30 mg/l	13
Residual Chlorine	0.14+	1.0 mg/l	0	NA**	1 mg/l	
Ammonia Nitrogen	++	0.5 mg/l	NA**	NA**	<5 mg/l	
pH	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	

*Monthly averages

**Not available

+TRC limitation in NPDES Permit is applied at the the edge of the mixing zone. 13

++Not applicable.

TABLE 10.6-4 DELETED 13

TABLE 10.6-5

CHANGES IN RIVER QUALITY RESULTING FROM PLANT DISCHARGES OF BOD AND TSS*

Mixing Conditions**	Ambient River Concentration+ (mg/l)		Extended Aeration/Chlorination: Concentration in River (mg/l)		Extended Aeration/Chlorination: Affected River Surface Area (acres)
	BOD	TSS	BOD	TSS	
Typical Cases					
Winter	<1.0	7.0	1.0	7.7	0.05
Summer	<1.0	7.0	1.0	7.7	0.07
Extreme Case++					
Short Duration No Flow	<1.0	7.0	1.0	7.5	3.92

6 13

*Values presented derived from Table 10.3A-7.
**See Tables 10.3A-4 and 10.3A-10 for description of cases.
+From Table 2.5-14a; CRM 17.9
++Winter Case

6 13

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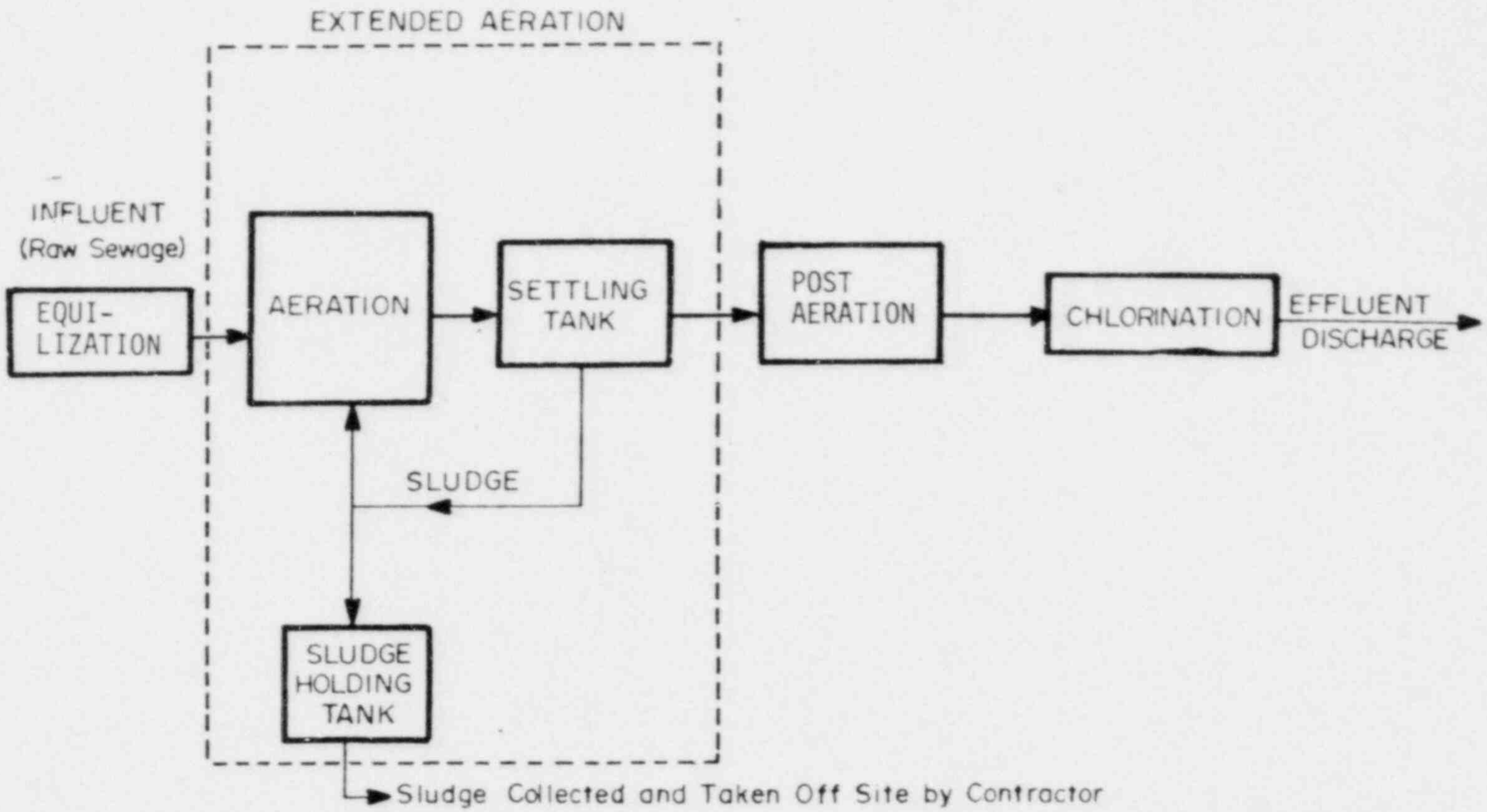

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Figure 10.6-1 EXTENDED AERATION/CHLORINATION SANITARY WASTE TREATMENT SYSTEM (Selected Treatment Process)

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10.7 LIQUID RADWASTE SYSTEM

10.7.1 SYSTEM

The Liquid Radwaste System is designed to process contaminated liquids from the Clinch River Breeder Reactor Plant (CRBRP) prior to reuse or discharge. Design of one subsystem is aimed at no planned release of radioactivity to the environment under normal plant operating conditions. The basic approach is to decontaminate the liquid so that it can be reused, to solidify the resultant concentrated radwaste in cement, to package in disposable drums and to transfer the drums to a licensed contractor for disposal. A second subsystem processes low level 13
wastes. The source of the low activity liquid is the plant drains. This activity will be reduced to a small value, as low as is reasonably achievable (never more than permissible levels) 13
even under abnormal plant operating conditions.

10.7.1.1 PURPOSE OF SYSTEM

Major input of radioactive contaminated fluids consists of effluents from the Large Component Cleaning Vessel (LCCV). 13
Solutions are generated when various components are maintained or replaced. Before maintenance, inspection or disposal of the component can be performed, the residual sodium containing tritium, fission products (FP) and corrosion products (CP) must be removed. In some instances high activity levels of fission and corrosion products may be deposited on the equipment surfaces. In these cases, the deposited activity must be removed by acid etching before the maintenance personnel can repair the component.

The performance requirements described in this Section 10.7.1 are those estimated as of February 1977, and were the basis for the original choice of the selected Liquid Radwaste System. Plant design changes since that date have resulted in a reduction in the estimated process input. However, the choice of the selected system remains valid. 13

The current estimates of the process input to the Liquid Radwaste System during normal operations are provided in Section 3.5 of the ER.

The process for accomplishing the decontamination is as follows. A component is removed and transferred to an inerted cleaning cell. Moist nitrogen is added to the cell and the sodium coating on the component is converted to sodium hydroxide. The component is immersed in water and after a suitable time, the water is pumped to the Liquid Radwaste System (LRS). This process is followed by two water rinses of the component. It is presently estimated that at least 294 components will be processed in this fashion during the 30-year life of the plant. Concentration of sodium and radioactivity and the volume of fluid associated with this cleaning process is described in Table 10.7-1. A small quantity, estimated as at least 14 components, will require acid etching following the steam nitrogen reaction and three rinses. The anticipated acid solution is five percent HNO_3. The acid etch process is also followed by two rinses, making a total of six rinses. Volume and concentration of these fluids are also described in Table 10.7-1. Fission product concentrations presented are based on an assumed design value of one percent failed fuel.

The computed concentrations are based on an assumption that all of the sodium and 40 percent of the plated activity on the surface are removed during the first rinse. In subsequent calculations, it is assumed that all of the radioactive elements form soluble salts and that none of these are removed by the filters through which the liquid is pumped.

The final flush of a component surface is used to insure that a component is free of contamination before the component is reused or moved to a facility for repair or inspection. It is assumed, therefore, that when the solutions are reused, the process system restores the fluid to an acceptable purity. The sodium limit is equivalent to 5 ppm Na (as $NaNO_3$) based on the 20 μmhos/cm specific conductance given in F5-1T "Cleaning and Cleanliness Requirements for Nuclear Components".[1]

Based on performing hands-on-maintenance, the residual removable activity should be minimized for direct dose personnel protection. A tentative selection for this requirement is 0.1 disintegrations per second per cubic meter squared (dps/cm^2). The removable (smearable) remains on the component are proportional to the activity concentration of the rinse solution. In general, one can assume that a one mil film of water remains on the component. If the solution contains 10^{-3} μCi/cc, the surface contamination after evaporation of the film will be about 0.1 dps/cm^2 of beta and gamma radiation.

The average concentration of the sodium and radioactivity being processed and various special processes are presented in Table 10.7-1. As can be seen, the calculated input sodium concentration to the first rinse is variable from about 100 to 600 ppm with a single entry of about 2,500 ppm. Maximum activity concentration occurs when the Intermediate Heat Exchangers (IHX's) are processed. In this case, the concentration is about 19 μCi/cc. The largest sodium concentration occurs when the acid etch solution is neutralized. This is equivalent to 18,000 ppm of sodium.

Low activity waste, which is fed into the Liquid Radwaste System, has activity concentrations which are less than 10^{-4} μCi/cc. Production of these wastes is currently estimated as 850 gpd. This water, some of which comes from personnel showers, will be discharged after decontamination by processing through an evaporator and a demineralizer and will have activity levels which are as low as practicable at the discharge point.

A tentative selection of acceptable activity levels that are less than 2×10^{-8} μCi/cc (excluding tritium) in the effluent stream for discharge has been established.

Federal regulations require that planned releases of liquid wastes be less than the concentrations in effluents to unrestricted areas (discharge to the Clinch River) described in 10 CFR 20. Alternatives considered for the Liquid Radwaste System design are described in the following sections. The alternacives are immediately rejected if they do not meet Federal regulations. Alternatives that do not meet the plant process requirements are also rejected as discussed in Section 10.7.2. Cost-benefit comparisons are made for the remaining alternatives to support the recommended selection in subsequent sections.

10.7.1.2 IDENTIFICATION OF SELECTED SYSTEM

A flow diagram of the selected design, Alternative 7, is shown in Figure 10.7-1. As shown in this figure, the Liquid Radwaste System consists of two subsystems: an Intermediate Activity System to process liquid radwaste from decontaminating components
in the LCCV and the Small Component Autoclave (SCA) which remove 13
sodium, corrosion products and fission products; and a Low Activity System to process radwaste from plant drains.

The intermediate activity level liquid system collects and
processes aqueous effluents from the LCCV and the SCA. Liquids 13
of various quantities are pumped from the cleaning cells through a common header to collection tanks located in the Radioactive Waste Area of the Reactor Service Building (RSB).

While in the collection tanks, the pH of the liquid radwaste is 13
adjusted by the injection of a caustic or an acid solution. The liquid radwaste is then fed sequentially through the filters and an evaporator for concentration of dissolved solids and then to the demineralizer for purification of the distillate.

Decontaminated distillate is stored in tanks with a total storage capacity of 40,000 gallons. Small volumes of concentrated wastes (~2% of the evaporated volume) generated during evaporation are
transferred from the evaporator into a concentrated waste 13
collection tank. The condensate is sampled for radioactivity, for nuclide identity and

chemical purity. Sampling analysis results will determine whether the condensate is adequately decontaminated and available for reuse.

The low activity level system collects and processes the water effluents from the floor drains, decontamination shower drains and laboratory drains. Processing of low activity waste includes pH adjustment, anti-foaming, filtration, evaporation and demineralization similar to that described for the Intermediate Activity System. |13

It should also be noted that the concentrated liquid radwaste, which contains all but a negligible amount of the activity, will be transferred to the Solid Radwaste System which is described in Section 3.5. Concentrated liquid radwaste is solidified in cement and the cement is packaged in drums. The drums are capped, marked, monitored and transferred to a licensed contractor for disposal.

While discharge of liquid wastes to the Clinch River is not expected for the intermediate level activity stream, situations can be posulated which lead to a circumstance in which the requirements for resuable water are not sufficient and release is desirable. Such situations will not be part of normal operating procedure of the CRBRP. |13

10.7.1.3 IDENTIFICATION OF ALTERNATIVES

There are presently three principal methods used to process and decontaminate liquid waste streams in nuclear power reactors; (1) evaporation; (2) deionization (demineralization); and (3) reverse osmosis. These methods have various cost and performance capabilities which are utilized in the selection of a system design. They are frequently utilized in various combinations to obtain a given performance. Decontamination capability for an individual method is determined by monitoring the ratio of radioactivity of the feed to the effluent stream. The expected Decontamination Factors (DF) for each method are shown in Table 10.7-2. These estimates are based on experience reported by industry and summarized by the AEC in Docket No. RM-50-2.[2]

Evaporators decontaminate solutions by evaporating water containing little or no radioactivity from the solution. This eventually produces a concentrated salt solution containing most, if not all, of the radioactivity.

Ion exchange media (demineralizers) decontaminate fluids by exchange of the radioactive ions with non-radioactive stable ions of a different chemical species. Performance data on ion exchange are summarized below and DF's are listed in Table 10.7-2. DF's of 10^3 or greater are seldom observed in practice for radioactive species.

The low performance which has been observed for demineralizers (DI) is due partially to the existence of the feed solution of insoluble salts, complex ions, colloidal materials and improper selection. For this study DF's obtained from previous LWR experience will be considered representative of overall performance of demineralizer systems.

Reverse osmosis (RO) decontaminates solutions by permeation of some fraction of the solvent, in this case water, through a membrane leaving a more concentrated solution to be disposed of in some fashion. The concentrate stream varies from one to 50 percent of the input as a function of the feed salt concentration and purity requirements of permeate. DF's for RO units vary by as much as a factor of 15 for different radioactive species. It is reported in Docket RM-50-2 that a 20-stage unit may achieve a DF of 30.

In choosing the alternative designs, an attempt was made to include combinations of evaporation, reverse osmosis and demineralization which

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TABLE 10.7-3

CONCENTRATION OF SODIUM AND ACTIVITY

		Concentration After Processing				Discharge After Dilution		
Alternative	Process*	Sodium PPM	Limiting Criteria (PPM)	Activity (μCi/cc)	Limiting Criteria (μCi/cc)	Activity** (Ci)	Activity+ (μCi/cc)	Limiting Criteria (μCi/cc)
	Initial	18,000	5	18.8×10^{0}	.001	2860	18.8×10^{0}	2×10^{-8}
1	None	18,000		18.8×10^{0}		2860	8.9×10^{-4}	
2	RO 90% DI	180		1.4×10^{0}		20	6.2×10^{-6}	
3	DI	1800		18.8×10^{-1}		28.6	8.9×10^{-6}	
4	EVAP	1.8		18.8×10^{-4}		0.0286	8.9×10^{-9}	
5	RO 90% DI 10% EVAP			1.4×10^{0}		20	6.2×10^{-6}	
6	EVAP 90% DI	0.18		1.9×10^{-4}		0.00286	8.9×10^{-10}	
7	EVAP 99% DI	0.18		1.9×10^{-4}		0.00286	8.9×10^{-10}	

	DF's Utilized	
	Na Conc.	Activity
DI	10	10
RO (1 stage)	10	1.5
EVAP	10^{4}	10^{4}

*Percentages quoted indicate percent of fluid proceeding to stage indicated

**Alternatives 2 thru 7 assume a 10% release of the effluent stored

+A dilution stream of 3.2×10^{12} cc per year is assumed based on 2380 gpm cooling tower blowdown and a 68% plant capacity factor

TABLE 10.7-4

COMPARISON COST OF PROCESSING 40,000 GALLONS AT 18,000 ppm Na

	Alternative 6	Alternative 7
Low Activity Process*	DI	EV + DI
Int. Activity Process	EV + DI	EV + DI
Liquid Waste (Gallons)	6×10^3	6×10^3
Resin Solid Waste (FT^3)	60	60
COSTS ($,000)		
Processing**	0.35	0.35
Liquid Waste+	12	12
Resin Waste++	0.05	0.05
Operating	12	12
Capital	746	1,137	13

*Di - Deionizer
EV - Evaporator

**Includes only replacement resin cost and energy cost
+To concrete and ship low activity waste, multiply x 3 for high activity waste
++Resin disposal

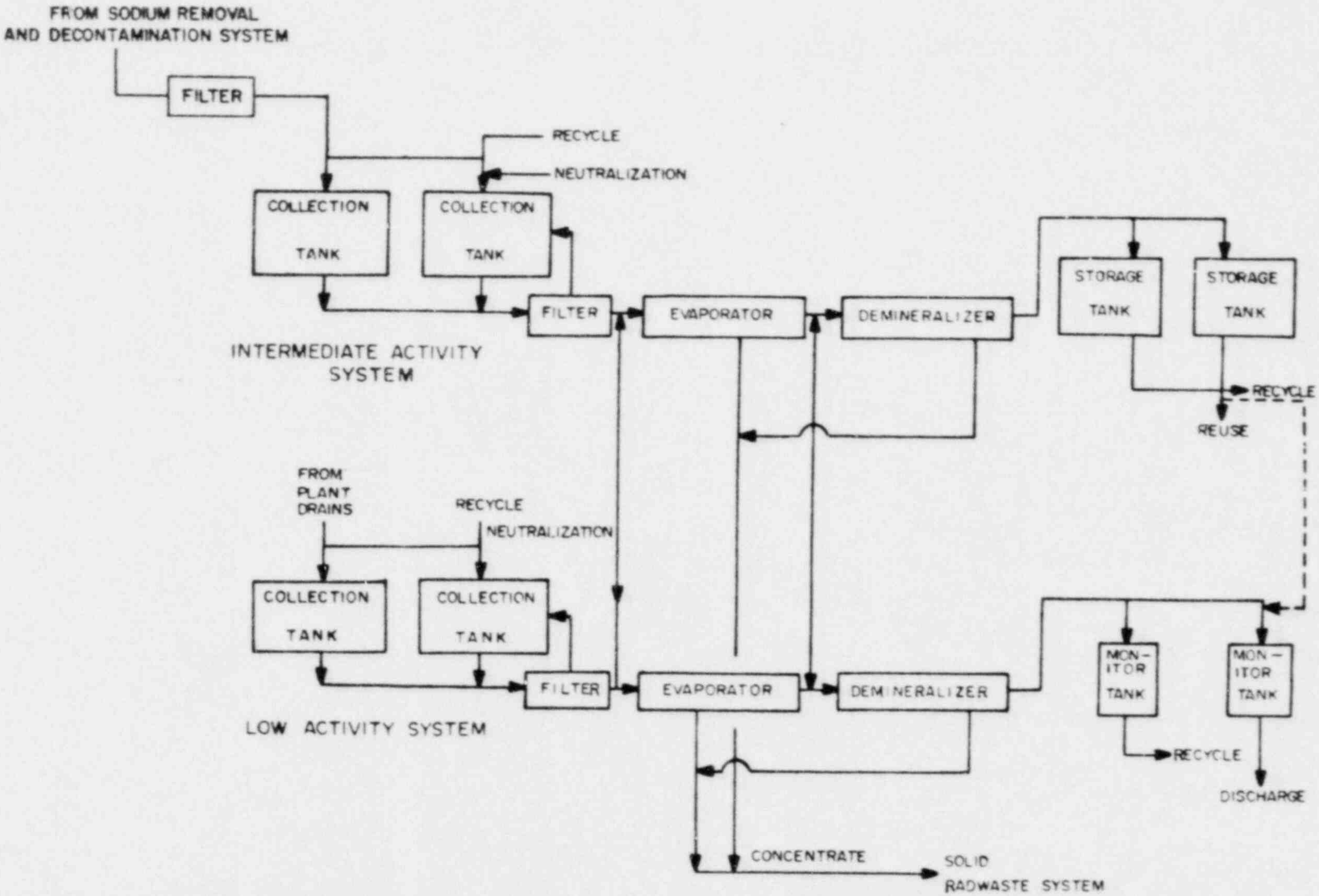

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Figure 10.7-1 LIQUID RADWASTE SYSTEM FLOW DIAGRAM

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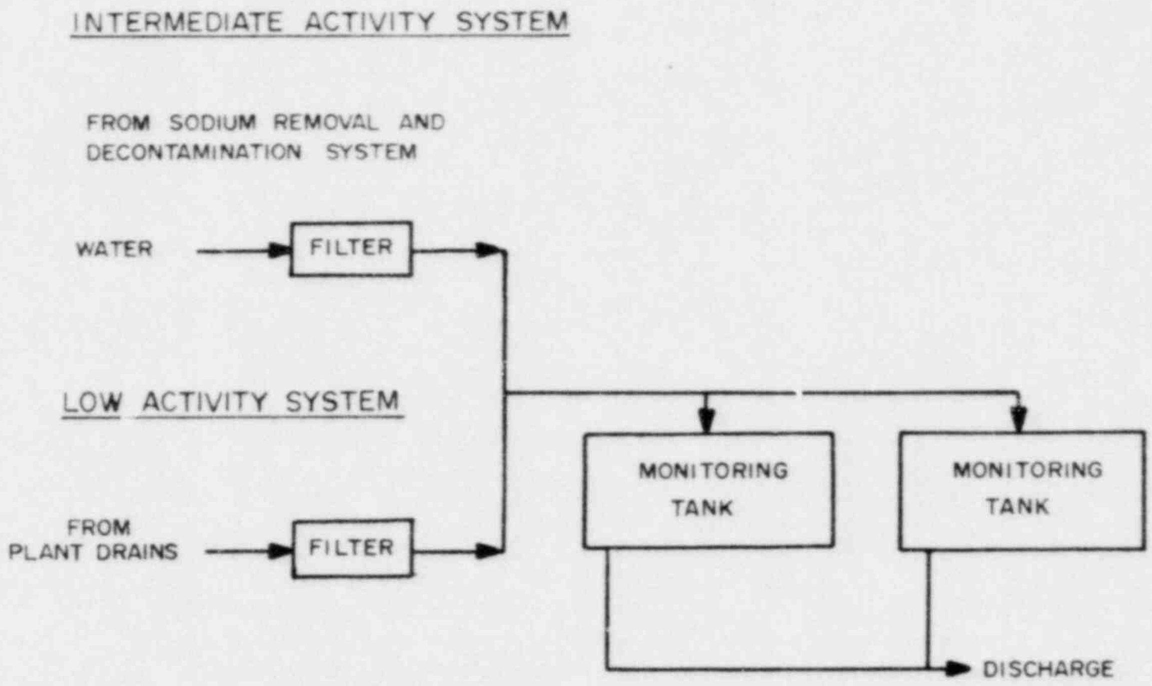

Figure 10.7-2 ALTERNATIVE 1, DISCHARGE OF RADWASTE WITHOUT PROCESSING

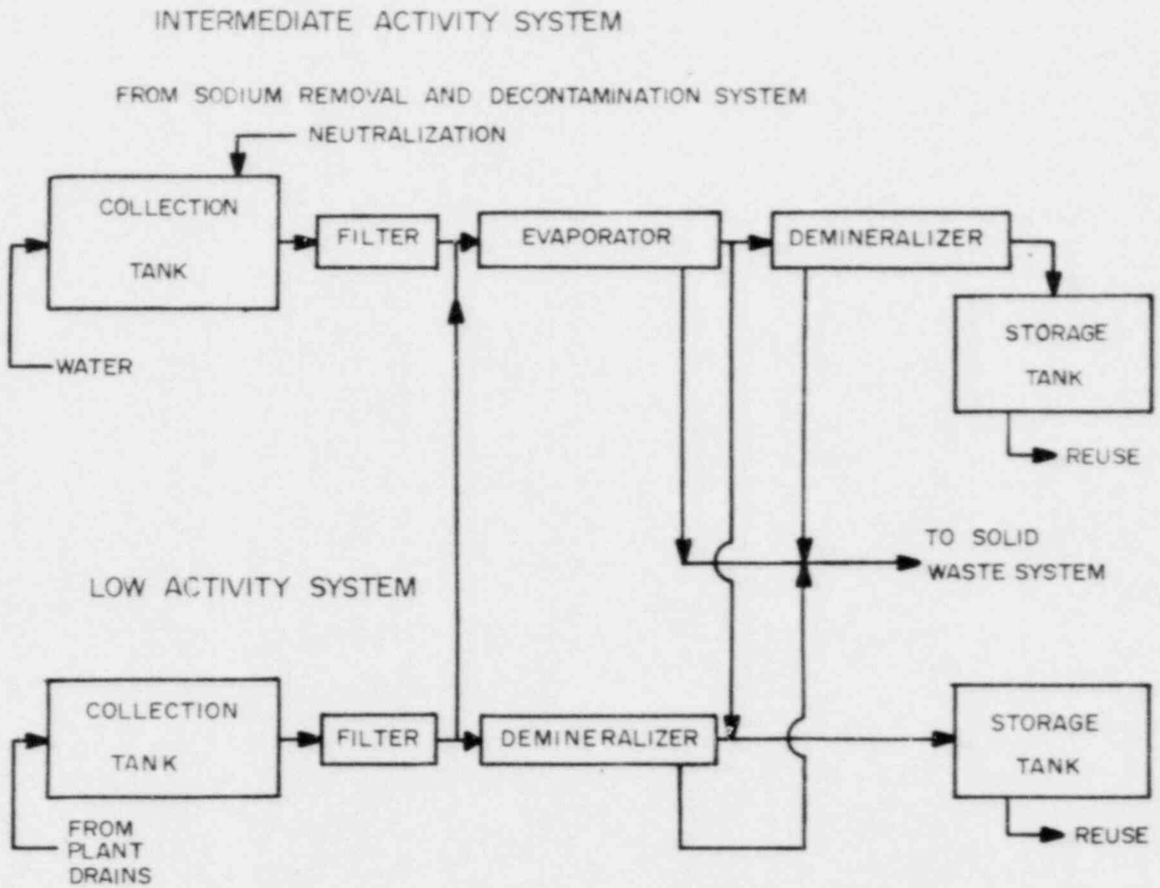

Figure 10.7-7 ALTERNATIVE 6, EVAPORATION AND/OR DEMINERALIZATION

10.8 GASEOUS RADIOACTIVE WASTE PROCESSING

Gaseous radioactive waste products generated in the CRBRP are to be contained and processed to assure that any gaseous radioactive release from the plant will not have an adverse effect on the environment. The processing sytem will therefore be designed to reduce to ALARA such releases from the plant and at all times assure that such releases are within the established permissible levels.

Radioactive gases are produced in the reactor fuel, in the sodium coolant and in the atmosphere surrounding the reactor. Isotopes of the noble gases, krypton and xenon, are produced within the fuel assemblies as fission products and may be released to the primary sodium and spent fuel storage sodium as a result of fuel cladding defects. For the analysis presented below, it is assumed that 0.1 percent of the fuel has cladding defects and the release to the coolant is in accordance with the Kayser empirical formulation.[1] The expected fuel cladding defect rate, based on LWR experience, is significantly lower; therefore, considerable conservatism exists in the design calculation. 13

A noble gas, Ne-23, is generated in the sodium in the reactor core as a result of the (n,p) reaction with Na-23. Radioactive argon (Ar-39 and Ar-41) is produced in the reactor from the (n,γ) and (n,2n) reactions with the argon cover gas and (n,p) reactions with impurities K-39 and K-41, in primary sodium.

Radioactive isotopes of carbon and nitrogen are generated in the nitrogen atmosphere surrounding the reactor guard vessel by (n,p) and (n,γ) reactions with nitrogen.

Tritium is generated in the boron carbide control rods by various neutron reactions and in the fuel by ternary fission, from which it diffuses through the cladding materials to the primary sodium

(100% release is assumed, again adding conservatism to the calculation). Tritium is also generated in the primary sodium due to the (n,α) reaction with lithium-6 impurity. Some of the tritium in the primary sodium will diffuse through the primary 13
piping into cell atmospheres and through the Intermediate Heat Exchanger (IHX) tubing into the intermediate system sodium. Once in the intermediate system, some of that tritium will diffuse through the steam generator tubing into the generator steam and a 13
small amount into the intermediate system piping cells. For purposes of added conservatism and for evaluation of the study of alternatives, the eventual 100 percent release of the tritium is assumed, apportioning the appropriate fraction of the total to 13
each release mechanism.

To optimize the selection of a gaseous waste producing system on a cost-benefit basis, various alternatives were analyzed. As a starting point for the alternatives study, a gas radwaste system was considered which would allow the CRBRP to meet a site boundary dose rate requirement. The initial system considered is the one developed for use at Fast Flux Test Facility (FFTF). The alternatives study was therefore a comparison of the site boundary dose rates and system costs for variations in the FFTF gas radwaste system.[2] System variations included the use of argon or helium cover gas, zero to 100 percent recycle of the cover gas, control of the various leakage paths and the effects of the use of various gas treatment units.

The production rates of radioisotopes of concern, assuming loss by decay only, are discussed in various subsections of Section 10.8. Values for these production rates are given in Table 3.5-6. Potential Site boundary rates for radioactivity from the various loss paths are presented in Table 10.8-1. The Site boundary χ/Q value originally used in this study is 2.5×10^{-5} sec/cubic meter consistent with the Site boundary (1,800 ft) and the average annual χ/Q for the SSW sector. This sector was chosen since it is expected to experience the least dispersion on an annual basis. The values reported in Table 10.8-1 assume the use of an efficient cover gas clean-up system with loss being released from the plant without futher processing (only volumetric delay times within the reactor buildings are considered).

Two gas processing subsystems are used in the CRBRP. One subsystem, the Cell Atmosphere Processing Subsystem (CAPS), processes radioactive gases prior to their discharge from the plant. The Radioactive Argon Processing Subsystems (RAPS) processes the reactor and primary pumps cover gases. In the selected configuration, shown in Figures 3.5-2 and 3.5-3, RAPS is designed for 100 percent recycle of the cover gas argon. | 13

Three classes of alternates were examined in detail relative to their impact on the release of radwaste gas and plant cost; a once through flow for the reactor cover gas, a recirculating argon reactor cover gas and a recirculating helium reactor cover gas. Since the gas radwaste systems considered consist of various configurations of processing components, a large number of cases for each class were examined for the varying processing component configuations and leakage controls. Results of the most promising options are reported in the alternatives study.

10.8.1 DESCRIPTION OF ALTERNATIVES

A number of possible alternatives were considered in the design selection study for the gas radwaste systems. All of the unit operations considered for gas processing utilize available technology.

The concentration of radionuclides in the various gas streams, whether for recycle or release, depends primarily upon such factors as; the appearance rate for each radionuclide in the system, the decontamination factors achieved in the primary processing systems, the release or leakage from the system and radioactive decay. Processing alternatives considered in the design selection study can be categorized as: (1) the cover gas (argon or helium) and the degree of recycle; (2) the treatment units used in the primary processing systems; and (3) the control placed on the various gas streams (discharge to Heating and Ventilation or process in one of the primary processing systems).

10.8.1.1 PRIMARY PROCESS SYSTEMS

The Radioactive Argon Processing Subsystem (RAPS) processes cover gases from the primary sodium circuit. These gases contain essentially the entire inventory of radioactive gases in the plant (excluding those left in the fuel assemblies) and while RAPS does not discharge gas directly to the environment, leakages from various seals in the system can occur. 13

10.8.1.1.1 CAPS

CAPS is designed to process the gaseous effluent from cells and spaces that are subject to potential contamination by radioactive gases. The processed effluent leaving CAPS is released to the control exhaust facility of the Heating and Ventilation System (H&V).

CAPS is divided into two main sections, the inlet complex and the processing section. The inlet complex collects the various influent streams, filters the gas to remove particulate material and passes the gas to a compressor and surge tank prior to its injection into the processing section. Removal of the radioactive gas by the processing section occurs as a result of the selected unit processing operation and by radioactive decay as a result of delay times within processing components. The degree of removal depends upon the processes and components selected, and is discussed in detail in later sections.

10.8.1.1.2 RAPS

RAPS is designed to process highly radioactive cover gas from the primary sodium system. In the selected RAPS configuration all the processed argon is recycled, although varying degrees of gas replacement have been analyzed. As with CAPS, RAPS is divided into two main sections, the inlet complex and the processing section. The RAPS inlet complex serves the same function as in CAPS. The purpose of the RAPS processing section is similar to that of CAPS, its performance depending upon the processes and components selected.

10.8.1.2 COVER GAS ALTERNATIVES

Cover gas alternatives include the possible use of either argon or helium as cover gas. Degree of recycle affects both dose rates and system costs, therefore alternatives studied included both gases with varying degrees of recycle for the argon case. Since helium is identified as a national resource, details of the helium-once-through option were not considered, gas utilization being too high. Three classes of alternatives are reported: (1) argon once-through for the reactor cover gas; (2) argon reactor cover gas with varying degrees of recycle; and (3) helium reactor cover gas.

In the argon once-through option no cover gas is recycled, all the gas being bottled for disposal.

In the other argon reactor cover gas options considered, the cover gas is processed and varying amounts of gas are periodically bottled for disposal or are discharged.

Helium reactor cover gas options are similar to the argon reactor cover gas options. However, since there is an increased capability of separating radioactive noble gases from the helium, no helium bottling cases were considered (100% recycle of helium in all options considered).

10.8.1.3 GAS LEAKAGE CONTROL

Various alternatives are available to collect and process gas leakage:

1. Primary Pump Purge Leakage Control - Design of the primary pumps permits the collection and processing of the gas that is used to purge the pump seals. The purge gas passes through the oil seal and is led to a separator which removes oil mist from the gas. The gas is then fed to RAPS; and

2. Head Loss Control (Reactor Buffer Seal and Reactor Cover Gas Leakage) - Reactor buffer seals recycle gas and the cover gas can leak into the reactor head access area. Head access area control could be added by enclosing the head access area and processing the gas atmosphere in CAPS. This option is discussed in Section 10.8.3.

10.8.2 ENVIRONMENTAL COST

10.8.2.1 RELEASE OF RADIOACTIVE GASES

Release of radioactive gases for the system options considered are summarized in Table 10.8-2. These options are:

1. FFTF developed system as originally designed.*

*Present FFTF system is converted to a once-through to get rid of oxygen in-leakage in negative pressure threaded pipe sections of RAPS. 13

2. A system in which no argon is recycled but rather is used on a once-through basis:

3. A system similar to System 1 except helium is used as cover gas and the pump seal purge is processed by CAPS rather than being directly discharged to H&V;

4. A system similar to System 1 except the pump seal purge is recycled to RAPS and a tritium removal unit is added to CAPS;

5. System 4 with head loss control.

6. System 4 with a modified Tritium Unit, and no charcoal delay beds or radioactive noble gas bottling station. 13

These systems are discussed in detail in Section 10.8.3.1.

10.8.2.2 WASTES PRODUCED BY ALTERNATIVE SYSTEMS

Gas radwaste systems considered will produce radioactive and non-radioactive wastes. These include cell atmosphere gases (nitrogen and air), cover gases in those cases where recycle is less than 100 percent, radioactive liquids and solids and various non-radioactive waste materials.

10.8.2.2.1 RADIOACTIVE BY-PRODUCTS

The purpose of the Gaseous Radwaste System is to process radioactive gases so that any radioactivity released is as low as is reasonably achievable. In performing this function, certain 13
radioactive by-products are produced. These must be considered an environmental cost imposed by the gas rad-waste system alternatives.

Radioactive wastes can be categorized as follows:

1. Radioactive Gas Waste - In several of the options, gas containing radioisotopes of argon and krypton is bottled. Quantities produced and the frequency of shipment will depend upon the option selected and the operating modes used. Bottling of gas waste in the alternatives studied is not an item of discussion which distinguishes any alternative as being clearly suitable or unsuitable as the system of choice;

2. Radioactive Liquid Waste - All options include a dryer in CAPS to reduce the water content of the process gas to a dew point of -100 degrees F. Total rate of liquid waste generation (and the only routine one for the gas rad-waste system) is estimated to be six pounds per day. Tritium content of the water will depend on whether or not a tritium oxidizer is included in the processing stream.

   When a tritium oxidizer is included (as in the selected configuration), the tritium content of the water waste is estimated to be 2.8×10^{-4} Ci/lb H_2O; and 13

3. Radioactive Solid Waste - Radioactive solid waste is produced by the gaseous radwaste system. This includes spent absorber, loaded gas filters, vapor traps and failed components such as compressors and heat exchangers.

10.8.2.2.2 NON-RADIOACTIVE MATERIALS

Only non-radioactive wastes generated on a routine basis are nitrogen from cryogenic cooling operations and certain cell purges, and vapor traps from the Intermediate Heat Transport System. Wastes generated through component failure and the need to replace them would be from such items as valves and liquid gas storage vessels. The total weight (and volume) of this type of component is small; therefore, details of these wastes are not included.

10.8.3 COMPARISON OF ALTERNATIVES

10.8.3.1 DIRECT COMPARISON OF ALTERNATIVES

10.8.3.1.1 SYSTEM 1 - FFTF ORIGINAL DESIGN |13

System 1 is essentially identical to the gas radwaste system originally developed for use in the FFTF. The cover gas diffusion |13 leakages, the buffered seal leakage and the primary pump seal purges are released directly to the H&V System for discharge without processing (except for cell delay). The reactor cover gas is processed in RAPS; first, using cryogenic delay beds, and then, using a cryostill. The recycled argon is mixed with makeup gas in the recycle gas storage vessel and is then fed to the reactor and primary pumps cover gas spaces. Primary piping leakages, process component leakage and various cell purges are processed in CAPS; first, in a dryer to remove water vapor, and then, in cryogenic delay beds. Using CRBRP design basis parameters, the estimated Site boundary dose rate is 0.62 mrem/yr. Estimated capital cost of the system is $3,300,000 and the estimated operating cost is $18,000 per year. Operating costs include only those costs directly associated with operation of the system. Such costs as return of capital investments are not included.

10.8.3.1.2 SYSTEM 2 - ONCE-THROUGH ARGON

In System 2 fresh argon is used. After its passage through the reactor or primary pump, the argon is bottled for disposal. In this system, the cover gas diffusion losses and the buffered seal leakage is discharged through the H&V discharge without further processing. Pump purge, primary piping and processing component leakages and the cell purges are processed through CAPS. For this system, extended delay beds (nominally -300^{O}F) were selected primarily to assure low release rates of radioactive (R/A) noble gases. Estimated site boundary dose rate for System 2 is 0.21 mrem/yr. Capital cost of this system is lowest of all the systems estimated ($3,120,000) because no RAPS processing is utilized. High operating cost, $3,156,000 per year, is related to the high cost of purchasing, bottling and disposing of the argon.

10.8.3.1.3 SYSTEM 3 - HELIUM

System 3 is similar to the modified FFTF design (System 4) in that pump purges are processed in RAPs rather than being processed in CAPS or discharged directly to H&V. Cryogenic or room temperature absorption beds are used in RAPS to remove essentially all noble gas activity from the recycle helium. Primary piping and processing component leakages and cell purges are processed; first, in a tritium removal unit and then in delay beds. Estimated site boundary dose rate is 0.19 mrem/yr. Estimated operating cost ($26,000 per year) is slightly higher than the comparable argon system (System 2) because there are higher costs related to bottling and disposal of more R/A noble gases.

Helium Research and Development effort can be categorized as a need for study in at least three areas: (1) vapor trap performance tests for both continuous flow trap and filter vapor trap; (2) seal leakage rate tests; and (3) verification of absorption coefficients. The total cost of such a program is estimated to be $1 million.

10.8.3.1.4 SYSTEM 4 - MODIFIED FFTF (ORIGINALLY SELECTED FOR CRBRP) 13

System 4, Figure 10.8-1, is similar to the original FFTF system (1) except the pump seal purges are processed in RAPS and a tritium removal unit is added to CAPS. The tritium removal unit consists of a tritium oxidizer, a condenser and a molecular sieve dryer. In the tritium oxidizer, tritium is oxidized to a tritiated water. The dryer removes water to a dew point of -100 degrees F, effectively decontaminating this gas stream of tritium. The dryer is periodically regenerated: the tritiated water is processed in the liquid radwaste system. Estimated capital cost is $3,650,000 and the estimated operating cost is $20,000 per year. Estimated Site boundary dose rate is 0.21 mrem/yr. Low Site boundary dose rate and low overall costs were the reasons for the original selection of this system for CRBRP. 13

10.8.3.1.5 SYSTEM 5 - MODIFIED FFTF + HLC

System 5 is similar to System 4 except that reactor head access area loss control is added. Estimate site boundary dose rate is .0036 mrem/yr.

Cost associated with the addition of head loss control is significant in both its operational cost and capital cost impacts. Capital cost investment for the head cavity supports, seals, etc. is estimated to be $2 million. This figure is conservative in not taking into account the necessity for head compartment cooling systems. Effect of head loss control on operating costs can be estimated by assuming a one day per year additional down time for refueling (8 hrs-estimated time removal cf head; 8 hrs-estimated time replacement of head; 8 hrs-estimated time for leak testing procedures). Estimated annual cost of this additional down-time is $50,000/year.

These estimated costs for the addition of head loss control will be characteristic of their use in association with any of the alternatives under consideration. As such, the economic impact of HLC will be significant. Alternative 5 to Alternative 4 comparison is offered as representative of the effect of head loss control on the cost of radwaste systems.

10.8.3.1.6 SYSTEM 6 - SELECTED DESIGN

System 6 is similar to system 4 with a modified tritium removal unit and no charcoal delay beds in RAPS; no bypass around CAPS delay beds and elimination of the radioactive noble gas bottling station. The description of the current design is given in Section 3.5.2, and the associated curies per year released are given in Table 3.5-8. Schematic diagrams of RAPS and CAPS are given in Figures 3.5-2, and 3.5-3. 13

10.8.3.2 BASIS FOR CHOICE OF SELECTED SYSTEM

The choice of the radwaste system is based on utilization of a system that will be consistent with the requirements resulting in an "as low as reasonably achievable" Site boundary dose rate for 13 normal operations.

The original alternatives were compared in their ability to satisfy that requirement at a reasonable economic cost. An original summary of the costs of each alternative is presented in 13 Table 10.8-3. The alternative originally selected, System 4 -

the modified FFTF system, results in a low Site boundary dose rate (0.21 mrem/yr) at a cost comparable to or favorable with other options.

Figure 10.8-2 shows an original comparison of costs and estimated Site boundary dose rates. As can be seen, the only option capable of significant reduction in the Site boundary dose rate involves enclosing the head access area (System 5).

Relative assessments of the most promising of all the alternatives considered are presented in Table 10.8-4. It is seen that the "FFTF" and the "modified FFTF" alternatives have the most favorable assessments. On an "as low as reasonably achievable" basis the "modified FFTF" was originally selected as 13
the Gas Radwaste System. The Site boundary dose rate is reduced by a factor of three at a cost of $400,000 when the two most favorable systems are compared.

Incorporated in Figure 10.8-2 is a value of 110 millirem/yr as an estimate of natural background radiation at the Clinch River Site, as discussed in Section 2.8. The magnitude of this number as compared to the radiation levels associated with the alternative gaseous radwaste systems being considered graphically illustrates the need for the balance between the cost consideration of the particular alternative system and its impact on the environment of the CRBRP surrounding area relative to other radiological contributors.

The bases for the present choice of System 6 are discussed in the footnotes to Tables 10.8-2 and 10.8-3. The estimated Site boundary radiation dose (while not directly comparable to other values given in Table 10.8-2) is well within 10CFR Part 50, 13
Appendix I limits, and is only about 2% of the assumed background

radiation dose level. System 6 was chosen over the previously
selected System 4 based upon a favorable cost-benefit analysis 13
evaluating the dose to the population.

10.8.3.3 DESIRED SYSTEM BASED ON ALTERNATIVES STUDY

10.8.3.3.1 CONTROL OF RELEASES

The CRBRP is following "as low as reasonably achievable"
guideline for the evaluation of alternative systems. One of the
purposes of the alternative study was to identify leakage paths
and assess their effects on Site boundary dose rates. As can be
seen in Table 10.8-1 for the "modified FFTF" case, the most 13
significant potential Site boundary dose rates are associated
with unprocessed primary piping losses, RAPS piping and
processing component leakages, primary pump seal purges, cover
gas losses through reactor seals, and to a much lower extent,
buffered seal gas leakage and Intermediate Heat Transport System
losses. The alternative study has shown that normal releases can
be effectively and economically controlled.

Control of the resulting Site boundary doses to a factor of about 5,000 lower than 10 CFR 20 limitations is achievable. Control of cover gas through reactor seals and buffered seal gas by the enclosure of the reactor head access area and the subsequent processing of the head access area gas results in reduction of Site boundary doses already well below Federal regulations but it imposes economic impacts on the plant in both operating and capital cost areas. The head loss control alternative was not chosen for purposes of a gaseous radwaste alternative on the basis of as low as practicable considerations.

An additional consideration relative to the anticipated Site boundary dose rate is that over 85 percent of the Site boundary dose rate is associated with three fission gas radioisotopes of reactor cover gas diffusing through various head seals. Radioisotopes, Xe-135, Kr-87 and Kr-88, have sufficiently short half-lives that if the mean seal residence time for the cover gas is one day rather than the assumed (and highly conservative) five minutes, the design basis Site boundary dose rate would be reduced by a factor of 8.5. Further, it has been assumed the reactor would be operating continuously with one percent failed fuel. The design basis assumption that one percent of the fuel could have cladding failures is extreme; a more realistic value would be a value of 0.1 percent. Therefore, the Site boundary doses presented for all alternatives are highly conservative estimates.

10.8.4 BALANCE OF PLANT CONSIDERATIONS

Tritium, produced in the fuel and control rods, is present in the steam-water system as a result of its diffusivity through stainless steel; it is conservatively assumed to be in the form of tritiated water. The condenser off-gas system removes non-condensable gases (vapors) from the condensing steam. Water vapor including tritium present in the off-gas flow constitutes the only expected gaseous release contribution from the balance of plant (BOP). Selection of a BOP radwaste system design is based on meeting an "as low as practicable" philosophy regarding the release of any radioactivity. For all alternatives in any event

TABLE 10.8-2

RELEASE OF RADIOACTIVITY FOR VARIOUS ALTERNATIVES

System	Dose Rate at Site Boundary (mrem/yr) Noble Gas	Tritium	Total
1. FFTF	0.603	0.015	0.618
2. Argon, Once-through	0.208	0.001	0.209
3. [illegible]ium	0.188	0.001	0.189
4. Modified FFTF*	0.211	0.001	0.212
5. System 4 + HLC	0.0022	0.0014	0.0036
6. System 4 with Cryostill Only	2.14	0.0004	2.14**

13

* System originally selected for CRBRP; the finally selected design, System 6, is similar to System 4 without the RAPS delay beds or radioactive gas bottling station.

** Dose rates at the site boundary for the selected system design are based on the most recently established $^{X}/Q$ of 5.1×10^{-5} sec./m^3. These doses cannot be directly compared to those for the other five options since a different calculational basis was used (including $^{X}/Q$) at the time (~ 1975) when this table was prepared. Deletion of the radioactive noble gas bottling station resulted in a higher site boundary dose since the long lived radioactive gases are now processed by CAPS and vented to H&V instead of being stored in bottles for off-site release. However, System 6 still results in an annual dose which is less than the limit given in 10 CFR 50, App. I; and a favorable cost-benefit analysis when evaluating the dose to the population. 13

TABLE 10.8-3

MONETARY COSTS FOR VARIOUS OPTIONS

System	Cost (1974 Dollars) Capital ($000)	Operating ($000/yr)	Total Over Plant Life ($000)
1. FFTF	3,300	18	3,840
2. Argon, once through	3,120	3,156	97,800
3. Helium	4,420*	26	5,200
4. Modified FFTF**	3,650	20	4,250
5. System 4 + HLC	5,830	70	7,930

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*Includes $1 million R&D effort

**System originally selected for the CRBRP; the finally selected design is similar to this system. It is not costed due to the incompatability of the present costing basis with that used in the original cost comparison. However, deletion of the delay beds and the radioactive noble gas bottling station constituted a significant reduction in comparative cost relative to the modified FFTF design, System 4. 13

TABLE 10.8-8

COMPARISON OF BOP TRITIUM ALTERNATIVES

	Direct Discharge	Cooled Discharge 35°F	Cooled Discharge -40°F	Storage
Release compatibility with 10 CFR 20 limits	Yes	Yes	Yes	Yes
Potential land use impact	None	None	None	Significant
Capital cost	Very low	Low	High	Very high
Operating cost	Very low	Very low	Very low	Very low
Associated Waste disposal considerations	No	Yes	Yes	Yes
Perturbation to balance of plant design	None	Yes	Yes	Yes

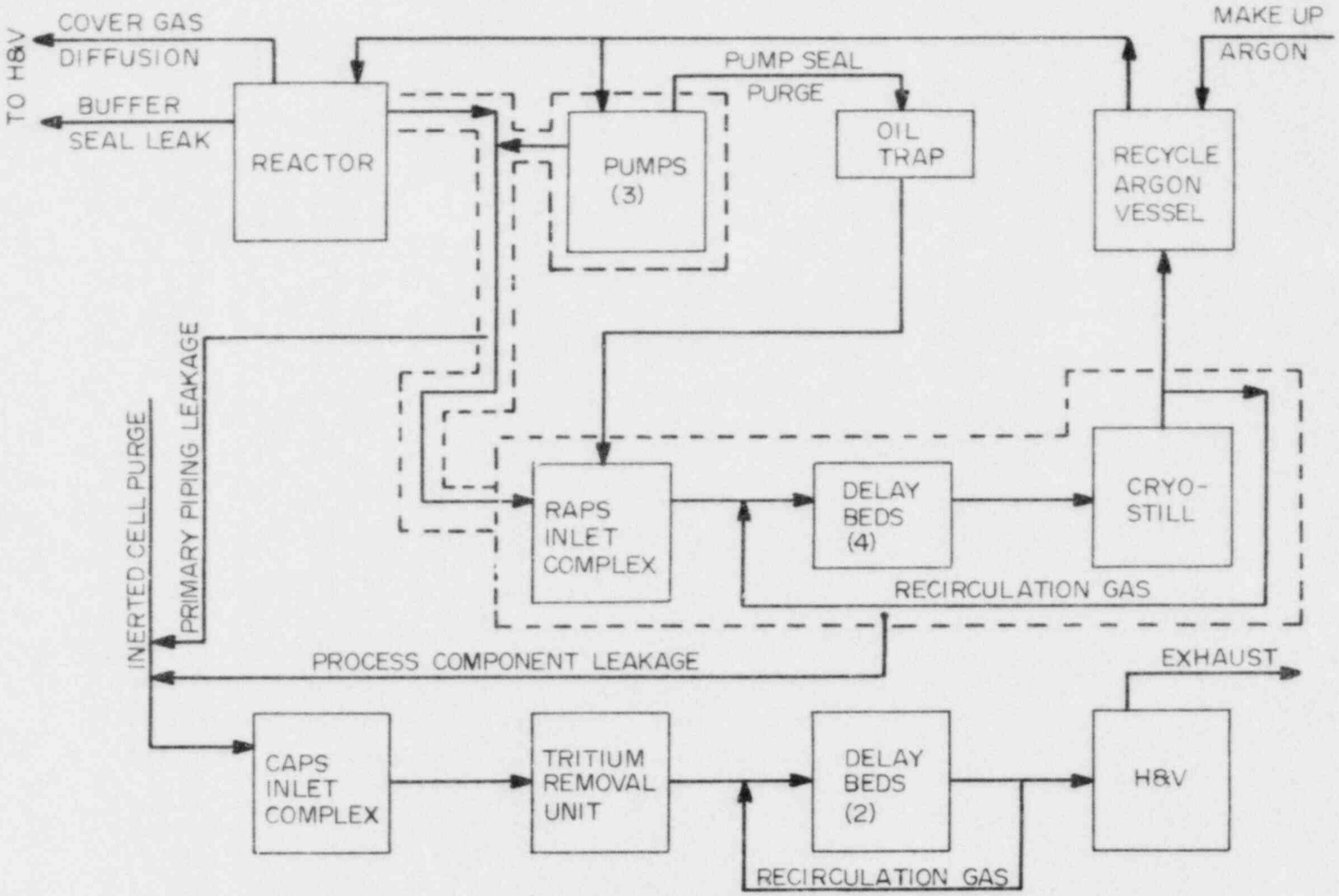

Figure 10.8-1 ORIGINALLY SELECTED CONFIGURATION FOR GAS RADWASTE SYSTEM (SYSTEM 4) WHICH INCLUDES DELAY BEDS

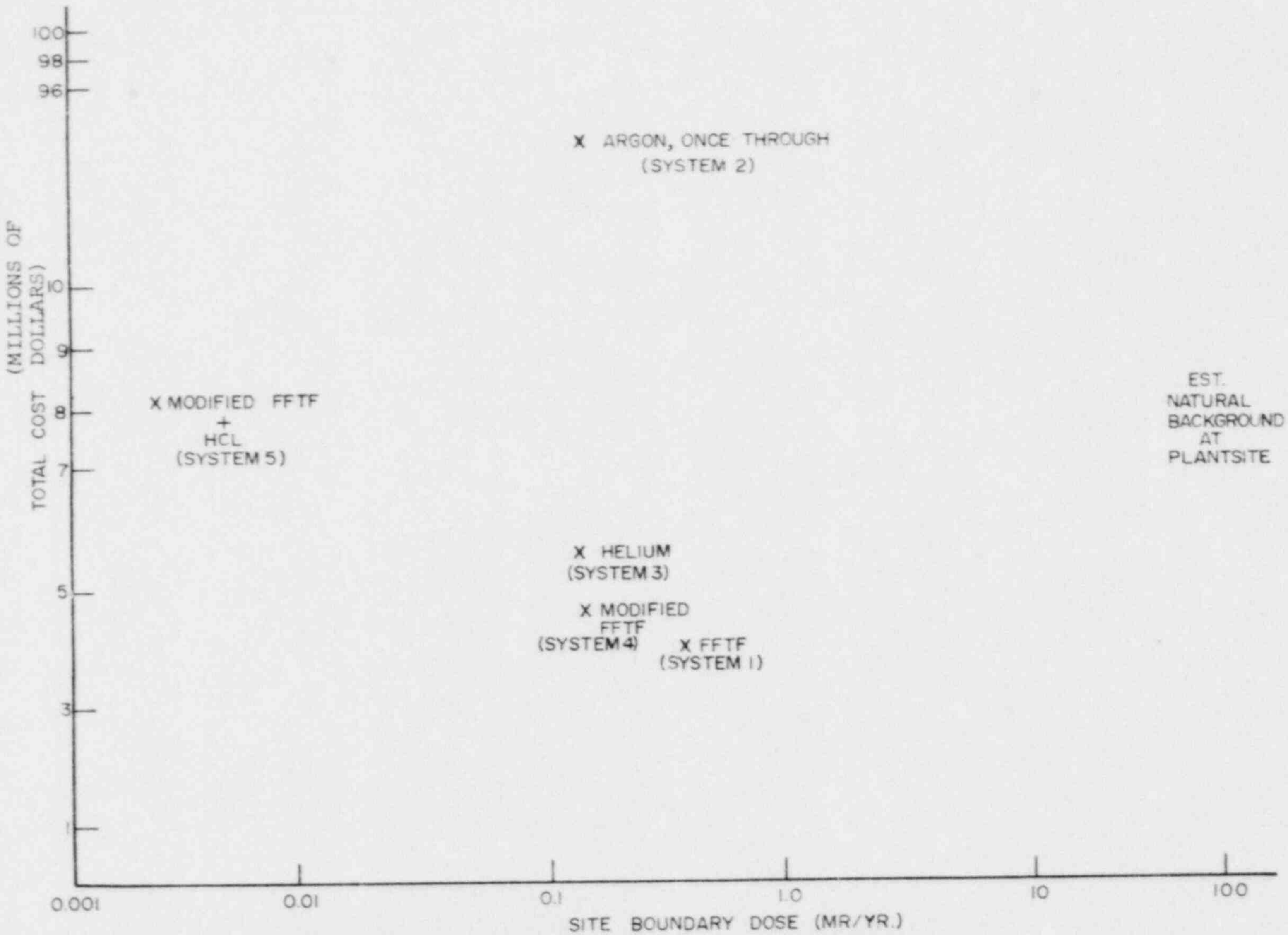

Figure 10.8-2 ORIGINAL COMPARISON OF COSTS AND ESTIMATED SITE BOUNDARY DOSES

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10.9 TRANSMISSION FACILITIES

Transmission facilities are required to transmit generated electricty into the TVA 161-kV transmission network and to provide reliable, redundant electrical interconnections that will guarantee off-site power to the CRBRP. The CRBRP will be connected to the AEC-owned Ft. Loudoun K31 161-kV transmission line were it passes the plant switchyard, requiring no new transmission corridor. A second transmission connection to an independent transmission circuit will be required. A second circuit available nearby, TVA-owned Ft. Loudoun K-31 161-kV transmission line, will require approximately three miles of transmission corridor. The proposed route is described in Section 3.9. An alternative segment was evaluated for a portion of this corridor.

10.9.1 DESCRIPTION OF ALTERNATIVE SEGMENT

The alternative segment, D-B on Figure 10.9-1, follows an abandoned 50-foot wide right-of-way from TVA's Ft. Loudoun-K31 161-kV line, beginning approximately 600 feet west of the intersection of White Wing Road and Bethel Valley Road to the intersection of the abandoned corridor with the 500-kV transmission line at Point B. A corridor, previously occupied by AEC's Wheat Project-Clinton Laboratories 13.2-kV transmission line, has been abandoned for a number of years and contains nearly a continuous growth of 10-foot tall saplings, although shrubs and herbs are common on the corridor. Segment D-B would require clearing an additional 125-foot wide corridor adjacent and parallel to the vacant AEC right-of-way. A 75-foot separation would be maintained between the proposed loop connection.

The general soils and land use discussions for the proposed route, described in Sections 3.9.2 and 3.9.3, apply to the alternate segment; however, the specific soils and biotic communities will be different as discussed below.

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Figure 10.9-1 PROPOSED AND ALTERNATE TRANSMISSION LINE ROUTES OF THE CRBRP SITE AREA

10.10 OTHER SYSTEMS

Several other major systems, as discussed below, were investigated and found to create no significant adverse environmental impact. Therefore, alternatives for these systems were not considered. These systems include the emergency diesel generators and diesel fire pump, steam generator and emergency cooling towers.

10.10.1 EMERGENCY DIESEL GENERATORS AND DIESEL FIRE PUMP

The CRBRP will maintain three diesel generators and two diesel fire pumps for emergency use during outside power loss. These are required for safety reasons and, except for routine testing, are not utilized during normal operation. Environmental effects of diesel operation are discussed in Section 5.5. 13

10.10.2 AUXILIARY STEAM GENERATOR

An electric auxiliary steam generator will be used to supply steam for plant operations when it is not available by extraction from the turbine-generator. This generator will be used for initial plant startup and infrequent occasions when the unit is down. No gases will be emitted and, consequently, no adverse environmental impact will be associated with the generator operation.

10.10.3 EMERGENCY COOLING TOWERS

The emergency cooling system supplies cooling water to all safety-related equipment after a casualty event. It consists of a supply basin and small cooling towers. The entire system operates on a closed cycle with no routine releases to the environment; therefore, no adverse environmental impacts are expected.

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(Next Page is 13.0-5)

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TABLE OF CONTENTS

APPENDICES

14.1 APPENDIX TO SECTION 2.5

14.4 APPENDIX TO SECTIONS 5.2 AND 5.3

The dose calculation models for the assessment of radiological impact on man and biota under normal operating conditions are addressed in Section 5.2. Therefore pages 14.4-2 through 14.4-62 are deleted by Amendment XIII. 13

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During the years of plant operation the stabilized population is expected to have a similar distribution. It is estimated that about 45 percent of the population will reside in Knox County (basically the West Knox County Area), about 25 percent will live in Roane County, about 20 percent in Anderson County, with the remaining 10 percent in Loudon County. Project-related population in the area rises and falls rapidly during the seven years of the construction phase (refer to Table 1-1).

A similar pattern is repeated by the population resulting from the project under migration condition B (Table 1-2). However, the project-related population rises to a higher peak of about 5,040 persons by the fourth year after the start of site preparation. This estimate was derived by 10
utilizing the same assumptions used to estimate the influx for migration condition A (i.e., 70 percent of the movers bringing families, an average family size of 3.2, and .7 school age children per family). Thus, during 13
the peak year, there is estimated to be about 1,390 movers with family, 600 movers without family, 980 school age children, and 680 non-school age children.

Under migration condition B, Knox County will receive a population influx of 2,270 persons followed by Roane County (1,260 people), Anderson County (1,010 people), and Loudon County (500 people). Oak Ridge and the Kingston area are the two areas in the study area that will receive the largest population influx with 760 people each. No other community in the project area is expected to receive more than 500 people.

The project-related population influx at no time contributes significantly to the total population of the study area. The greatest project-related increment (5,040) is only about 3 percent of the estimated 1980 study area population, suggesting that project effects at the area level are likely to be slight. At the county level, the project-related population in Anderson, Knox, and Loudon Counties is expected to be less than 2 percent with the population influx in Roane County expected to be 10
about 2.5 percent.

TABLE 1-1

AREA POPULATION RESULTING FROM CRBRP DIRECT EMPLOYMENT FOR MIGRATION CONDITION A

Place	Construction Phase (Year After Start)+							Typical Year Of++ Plant Operation
	1	2	3	4	5	6	7	1
Anderson County*	30	50	130	160	160	80	30	20
Oak Ridge	80	150	390	480	470	230	80	50
Knox County	230	440	1180	1450	1400	700	230	140
Loudon County	50	100	260	320	310	160	50	30
Roane County	130	240	660	800	780	390	130	80
Four County Area	520	980	2620	3210	3120	1560	520	320

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+Site preparation projected to begin in 1981.

++Plant operation projected to begin in 1988. Area population resulting from CRBRP direct employment for migration Condition A is the same for all years after the first year of plant operation.

*Outside of Oak Ridge.

Amend. X
Dec. 1981

2.6 WASTE DISPOSAL REQUIREMENTS

Waste disposal requirements include wastewater collection and treatment and solid waste collection and disposal. Estimates of wastewater and solid waste generated by the project-related populations in the area for migration conditions A and B are reported in this section. Waste-water generation is based upon a rate of 100 gpd per person and solid waste generation upon a rate of four pounds-per-day (ppd) per person.*

Forecasts for wastewater generation for the peak year of plant construction and a typical year of plant operation are reported for condition A in Table 2.6-1 and for condition B in Table 2.6-2. At peak construction, about 320 thousand gpd of wastewater is generated in the area for condition A (Table 2.6-1) and about 500 thousand gpd for condition B (Table 2.6-2). During plant operation, the corresponding figure is 32 gpd. 10

All of the wastewater utility districts in the study area have excess capacities. More over, Oak Ridge, Kingston, and Harriman plan increases for their wastewater treatment facilities between 1980 and 1985. Oak Ridge presently has under construction a new 12 mgd plant that should be completed by 1983 to provide tertiary treatment. Kingston and Harriman are both planning new plants that would give them secondary treatment capabilities. All of the utility systems that are not proposing increases have excess capacities. Refer to section 8.1.3.3.2 and Table 8.1-17 for information on wastewater system treatment capacity, average daily flow, and facility expansion plans.

*These rates apply to the Knoxville SMSA.

The wastewater utilities have enough excess capacities to accommodate additional growth. Problems may arise, however, in the collection service. Most of the wastewater service systems are associated with municipalities, while most of the rural areas must rely on septic tanks and disposal fields. However, much of the soil in these counties is not suitable for these subsurface systems. Therefore, because of the distribution of the peak year project-related population throughout the four-county area, it seems unlikely that areas unsuited for septic tank use would experience large numbers of inmovers to the point where collection disposal systems would be required.

Forecasts for solid waste generation for both the peak year of plant construction and a typical year of plant operation area reported for condition A in Table 2.6-3 and for condition B in Table 2.6-4. For both conditions A and B the amount of solid waste generated is approximately 1,300 ppd during plant operation. The amount varies between about 13,000 and 20,000 ppd at peak construction for conditions A and B, respectively. The projected amounts are insignificant
in relation to the current amount of waste handled per day in the four 10
counties (about 525 tons). 13

During peak construction there should be about 17,000 ppd of solid waste generated at the construction site. This waste will be hauled away by a
private contractor, to be selected later, for disposal. The total amount is 13
insignificant in relation to the current amount of waste handled per day in the four counties. Since the disposal location is unkown, it is not possible to determine if an impact would occur at one of the area landfills.

2.7 COMMUTER TRAFFIC

Table 2.7-1 provides a perspective as to the day shift commuter traffic effects on the five key state highway segments in the study area anticipated to be significantly impacted by the CRBRP commuter traffic for both migration conditions A and B. The existing levels of service for the hour in which the CRBRP commuter traffic will be added to existing traffic volumes are either B or C except for State Route 95 (SR 95) between I-40 and Bear Creek Road which currently has a D level of service. (Refer to the Highway Capacity Manual, Highway Research Board Special Report 87, pages 80-81 published in 1965 for complete definitions of the different traffic levels of service.) 13

The levels of service for each significantly impacted state highway segment will be the same for both migration conditions during the peak year of construction. Movers are anticipated to relocate in areas outside the impacted highway network surrounding the plant site and travel the same impacted highway segments that they would were they not to relocate. Therefore, the number of commuters traveling the significantly impacted highway segments will remain essentially the same regardless of the percent of movers.

During the peak year of construction for both migration conditions, commuters will experience a level of service of D or better on all segments near the Site except for SR 95 between 1-40 and Bear Creek Road where the level of service is anticipated to be level E. 10

Level of service D represents a condition in which tolerable operating speeds can be maintained, though this may be considerably affected by fluctuations in traffic volume which may in turn cause substantial drops in operating speeds. Level of service E represents a condition of lower operating speeds than in level D with traffic volumes at or near the capacity of the highway. Throughout the construction period, commuters traveling along SR 95 between I-40 13
and Bear Creek Road will experience unstable flow with stoppages of momentary duration being possible during the daily project peak commuting hours.

CRBRP commuter traffic impacts during the plant operation period are anticipated to be minimal. During the peak commuting hour of 13
a typical year of plant operation, the levels of service experienced by commuters for the five key highway segments near the Site is anticipated to be identical to the levels of service that would exist for the same hour without the CRBRP traffic included (refer to Table 2.7-1). During a typical year of plant operation, less than 6 percent of the commuting peak hour traffic volumes on the impacted state highway segments are estimated to be CRBRP project-related.

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TABLE 2.7-1

CRBRP COMMUTER TRAFFIC IMPACTS ON KEY HIGHWAY SEGMENTS FOR MIGRATION CONDITIONS A AND B[+]

Highway Segment	Existing[++] Peak Hour Level of Service	Existing Level of[++] Service for Hour Which CRBRP Commuter Traffic Contributes	Projected Level of Service for Hour Which CRBRP Commuter Traffic Contributes for Migration Condition A	Projected Level of Service for Hour Which CRBRP Commuter Traffic Contributes for Migration Condition B	Projected Level of[+++] Service for Hour Which CRBRP Commuter Traffic Contributes During a Typical Year of Plant Operation (1994)
1. State Route 58 between I-40 and Bear Creek Road (CRBRP Access Road)	D	C	D	D	E
2. State Route 58 Between Bear Creek Road (CRBRP Access Road) and ORGDP	D	B	D	D	E
3. State Route 58 Between ORGDP and Intersection State Route 95	D	B	C	C	D
4. State Route 95 from Intersection State Route 58 to Beginning of 4-Lane in Oak Ridge	E	C	D	D	F
5. State Route 95 Between I-40 and Bear Creek Road (CRBRP Access Road)	E	D	E	E	F

[+] Peak year of construction expected to occur in 1985. Plant operation expected to begin in 1988.
[++] Based on Tennessee Department of Transportation hourly traffic counts for 1978-1981.
[+++] Projected service levels are the same with or without the CRBRP traffic. Operation workforce is expected to commute to and from the plant during the existing peak hour. 10

Note: Assumptions used in evaluating the traffic situation include.

1. No sponsored van and bus program.
2. Commuter vehicle occupancy = 2.0 for migration conditions A and B and 1.5 for CRBRP operation workforce commuters.
3. No truck deliveries to construction site during shift commuting hours.
4. CRBRP construction work shift hours will be staggered such that CRBRP commuting traffic will not coincide with the existing non-CRBRP related peak hour traffic.
5. Intersections SR95 and SR58, SR58 and Bear Creek Road, and SR95 and Bear Creek Road to be upgraded prior to significant construction employment buildup.
6. Annual increase in non-CRBRP related traffic volumes = 2 percent
7. Operation workforce day shift equals 200 employees.
8. Peak year of construction = 1985.

10 | 13

3.0 ANALYSIS OF EXPENDITURES AND REVENUES

3.1 OVERVIEW

Project-related revenues to local governments can be derived from five basic sources:

1. Financial assistance payments by DOE pursuant to the Atomic Energy Community Act of 1955, as amended (42 U.S.C. Sec. 2301, <u>et</u> <u>seq</u>.)

2. In lieu of tax payments by TVA pursuant to the Tennessee Valley Authority Act of 1933 (42 U.S.C. Sec. 831, <u>et</u> <u>seq</u>.) at such time as TVA may pay for and take permanent custody of the CRBRP and thereafter own and operate it as part of its power system. Such a transfer from DOE to TVA is not anticipated before 1995 at the earliest.

3. Sales or use taxes on materials, supplies and equipment acquired for use in constructing the plant, but which do not become a component of the plant itself or of the related distribution system; 10

4. Federal school impact aid from P.L. 81-874. Appropriations for FY 1982 are currently under Congressional review, and the future of such payments is in question;

5. Direct and indirect taxes on or resulting from additional wages and salaries, business activities and private property values attributable to employment and expenditures related to construction and operation of the plant

AMENDMENT XIII

Additional Information for Detailed Environmental Assessment of the Clinch River Breeder Reactor Plant (CRBRP) Site

AMENDMENT XIII	Revisions Resulting from Additional or Updated Information and Minor Corrections.
Chapter 1	Updated to reflect the most recent information concerning the Purpose of and the need for the CRBRP as discussed in the LMFBR Program Final Supplemental Environmental Impact Statement (4/82).
Section 2.2	Provides agriculture discussion of the CRBRP region.
Section 2.3	Provides discussion of the Historical, Archeological, Cultural investigation performed in 1982.
Section 2.6	Provides Miscellaneous changes to Meteorological text and tables.
Section 2.7	Provides update listing of CRBRP site Forest Cover Type and Acreage.
Sections 3.1, 3.5, and 6.2	Provides update to building exhaust points.
Section 3.5	Provides update to CRBRP fuel and waste handling activities.
Sections 3.9 and 4.2	Updated to reflect revision to the proposed transmission corridor clearing and tower construction.
Section 4.1	Updated to reflect construction facility descriptions and activity impacts including site acreage, impoundment pond controls, concrete batching and mixing, and water use.
Section 5.2	Updated to evaluate radiological impacts to man and biota from routine plant releases based on: current radiological source term, most recent on site meteorological data, and 1980 population data. This section now incorporates information previously discussed in Sections 5.3 and 14.4 which are now deleted.

Section 5.5	Updates air emission releases from emergency diesel generators and diesel fire pumps.
Section 8.3	Updated to include description of highway traffic level of service.
Chapter 10	Updated to reflect the current description of the selected plant system designs in the alternative comparisons.
Chapter 13	Updated to provide appropriate references.
Appendix C	Updated to identify distribution of inmover family members (migration condition B) and solid waste disposal during construction.