HOPE CREEK GENERATING STATION

APPLICANT'S ENVIRONMENTAL REPORT-OPERATING LICENSE STAGE

VOLUME 1

The Energy People

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HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT - OPERATING LICENSE STAGE

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NOTES TO THE USER

Summary of Changes Since Construction Permit Stage

On November 4, 1974, the Atomic Energy Commission issued Construction Permit CPPR-120 and CPPR-121 for HCGS, then planned as a two-unit boiling water reactor nuclear generating station at Artificial Island, Lower Alloways Creek Township, Salem County, New Jersey. On December 23, 1981, PSE&G's Board of Directors voted to cancel the second unit and develop HCGS as a single BWR unit. This represents the most significant project change since the CP stage, and the entire Operating License Stage Environmental Report reflects the single unit configuration.

Other changes since the CP stage arise from development of detailed station design, changes in environmental regulations and guidelines, and availability of up-to-date and/or more detailed information. These are acknowledged in the ER text as they occur.

The table on the next two pages highlights noteworthy changes since the CP, and it indicates the ER sections affected, giving the principal reason or reasons. The Applicant considers none individually, nor all collectively, to affect a finding that operation of HCGS is environmentally acceptable and in the public interest.

PRIMARY REASON(S) FOR CHANGE

Change	Unit 2 Cancel-lation	Design Development	Changes to Regulations	New Data	Affected ER Section(s)
Station Water Use	X	X		X	3.3, 3.4
Cooling Tower Blowdown Characteristics		X		X	3.3, 3.4 5.1.2
Addition of Fish Return Arrangement at Service Water Intake		X	X	X	3.4, 5.1.3
Deletion of Installed Chemical Waste Treatment System		X			3.6, 5.3
Single Natural Draft Cooling Tower	X				3.1, 3.4, 5.1.2
Deicing Arrangement		X			3.4
Cooling Tower Drift Rate Reduction		X	X		3.4, 5.1.4
Deletion of Hope Creek - Tuckerton Transmission Line		X			3.9, 5.5
Effects of Heat Dissipation System	X	X	X	X	5.1.2, 5.1.3 5.1.4
Plant External Appearance	X	X			2.1.1, 3.1, 5.1, 5.6
Doses and Dose Rates to Population Within 50 Miles	X	X		X	5.2.4, 5.2.5
Population Distribution and Characteristics				X	2.1
Liquid Radwaste System		X			3.5.2, 5.2

SUMMARY TABLE (Continued)

Change	Unit 2 Cancel-ation	Design Development	Changes to Regulations	New Data	Affected ER Section(s)
Solid Radwaste System	X	X	X		3.5.4, 5.2
Gaseous Radwaste System		X			3.5.3, 5.2
Sewage Treatment Plant		X		X	3.7, 5.4
Auxiliary Boilers		X			3.6, 5.4
Atmospheric Emissions	X	X			3.6, 5.4
Radiological Impacts	X	X		X	5.2.4, 5.2.5
Chemical Discharge Impacts		X	X		5.3
Environmental Impact of Accidents			X	X	7.1

CHAPTER 1

PURPOSE OF THE PROPOSED FACILITY AND ASSOCIATED TRANSMISSION

The Nuclear Regulatory Commission has amended its regulations (47 FR 12940, March 26, 1980) in Title 10 of the Code of Federal Regulations Part 51 (10 CFR 51), "Licensing and Regulatory Policy and Procedures for Environmental Protection." This amended regulation provides that, for NEPA purposes, Operating License applicants need not address "need for power" issues in environmental reports to the NRC (see 10 CFR 51.21, 51.23(e), and 51.53(c)).

CHAPTER 2

THE SITE AND ENVIRONMENTAL INTERFACES

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THE SITE AND ENVIRONMENTAL INTERFACES

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THE SITE AND ENVIRONMENTAL INTERFACES

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CHAPTER 2

THE SITE AND ENVIRONMENTAL INTERFACES

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification Of Location

HCGS is located on the southern portion of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. The formation of Artificial Island began early in the twentieth century when the U.S. Army Corps of Engineers disposed of hydraulic dredging spoils within a diked area established around a natural bar projecting into the Delaware River. Artificial Island, which is located on the east bank of the Delaware River, is connected to the mainland of New Jersey.

The station is 24 kilometers (15 miles) south of the Delaware Memorial Bridge, 29 kilometers (18 miles) south of Wilmington, Delaware, 48 kilometers (30 miles) southwest of Philadelphia, Pennsylvania and 13 kilometers (8 miles) southwest of Salem, New Jersey.

Figure 2.1.1 shows the site region within an 80 kilometer (50 mile) radius area. Figure 2.1.2 shows the eight kilometer (five mile) site vicinity.

The site center is located at 39 degrees, 27 minutes, 53 seconds north latitude and 75 degrees, 32 minutes, 12 seconds west longtitude. The corresponding Universal Transverse Mercator (UTM) coordinates are 4,368,307 meters north and 453,872 meters east, zone 18.

2.1.1.2 Site Area

The station is situated on approximately 62 hectares (153 acres) of the 300 hectare (740 acre) site that is owned, including mineral rights, by PSE&G. The remaining property at the site is divided between Salem Generating Station, which comprises 89 hectares (220 acres), and 149 hectares (367 acres) of uncommitted land. Figure 2.1-4 shows the HCGS property lines.

Section 3.1 describes the location and orientation of principal station structures, which are shown on Figure 2.1-3. The approximate grade of Artificial Island is 9 feet above MSL. The station is in an area of backfill, with an elevation of approximately 11 feet above MSL.

The land within the site area has been zoned industrial by the Lower Alloways Creek Township Planning Board (Reference 2.1-1); however, the only industrial structures located on site are those associated with HCGS and Salem Generating Station. There are no other industrial structures within the site boundary. A visitors center is located within the site boundary. Soil surveys conducted by the U.S. Department of Agriculture and summarized by the Salem County Planning Board (Reference 2.1-2) classified the soil on site, which is primarily dredging spoils, as being severely limited for agricultural purposes; therefore, the soil is neither prime nor unique and holds no statewide importance.

The boundary lines of the plant exclusion area, which are similar to the site boundary lines, appear in Figure 2.1-4. The minimum land distance from the reactor to the plant exclusion area boundary, accessible to man, is approximately 907 meters (2975 feet).

Access to the site is achieved via a private road constructed by PSE&G. Section 3.1 contains a description of the road; the road is shown in Figure 2.1-4. There are no major highways in New Jersey within eight kilometers (five miles) of the site. The nearest railway facility is a branch of the Conrail lines which terminates 13 kilometers (8 miles) northeast of the site, in Salem, New Jersey. Waterborne barge traffic has access to HCGS by way of the Delaware River shipping channel located approximately 1.6 kilometers (one mile) west of the site. The channel has a width of 244 meters (800 feet) opposite the site.

2.1.1.3 Boundaries for Establishing Effluent Release Limits

The boundary for establishing technical specification limits for release of gaseous radwaste effluents is the site boundary (exclusion area boundary), which defines land owned by PSE&G. The area within the boundary consists of lands, shown on Figure 2.1-4, which constitute a restricted area within the meaning of 10 CFR 20 (Reference 2.1-3). The Delaware River is adjacent to the western portion of the boundary line, as Figure 2.1-4 shows.

The boundary for establishing technical specification limits for release of liquid radwaste effluents is the cooling tower blowdown pipe outlet, located in the Delaware River. Figure 2.1-3 shows the location of the pipe as it enters the Delaware River.

Table 3.1-1 lists distances from the station's gaseous and liquid effluent release points to the boundary line.

2.1.2 POPULATION DISTRIBUTION

Population and population distribution for the 0 to 16 kilometer (0 to 10 mile) and 16 to 80 kilometer (10 to 50 mile) radius areas are keyed to sectors and zones. The 0 to 16 kilometer (0 to 10 mile) radius area is divided into concentric circles around the site center point, at distances of 1.6, 3.2, 4.8, 6.4, 8, and 16 kilometers (1, 2, 3, 4, 5 and 10 miles). The same was done for the 16 to 80 kilometer (10 to 50 mile) area, but at 16 kilometer (10 mile) intervals. The circles are divided into 22.5 degree segments with each segment centered on one of the 16 compass points.

2.1.2.1 Population within 16 Kilometers (10 Miles)

Figure 2.1-26 shows the county and sub-county boundary lines within 16 kilometers (10 miles) of the Artificial Island site (Reference 2.1-44).

Figure 2.1-5 shows current residential population within 16 kilometers (10 miles) of the Artificial Island site by ring and sector (References 2.1-4 and 2.1-5). Figure 2.1-6 shows the projected population for the first full year of station operation, in 1987. The projected population by sector and zone for each census decade from 1990 through the projected end of station life in 2030 is shown in Figures 2.1-4 through 2.1-8.

Field surveys were conducted to determine the number and distribution of population by ring and sector within 0 to eight kilometers (0 to five miles) of the site (Reference 2.1-6). Dwelling units within the 0 to eight kilometer (0 to five mile) radius area were identified in the field and noted on a map by ring and sector.A dwelling unit vacancy rate was applied to the dwelling units in each sector to determine the number of occupied dwelling units. A separate vacancy rate was established for New Jersey (Reference 2.1-4) and Delaware (Reference 2.1-5) sectors based on the 1980 Census of Housing. Following are the 1980 vacancy rates by county:

	Vacancy Rate
a. Cumberland County, NJ	6.7%
b. Salem County, NJ	6.8%
c. New Castle County, DE	5.9%

Having identified the 1980 distribution of occupied housing units in the 0 to eight kilometer (0 to five mile) radius area, an average household size was determined, based on the 1980 census (References 2.1-4 and 2.1-5), as follows:

	Average Household Size
a. Cumberland County, NJ	2.9
b. Salem County, NJ	2.9
c. New Castle County, DE	3.1

The number of occupied dwelling units was then multiplied by the average household size to determine the 1980 distribution of population by sector and ring within 0 to eight kilometers (0 to five miles) of the site.

Current 1980 census tract data was utilized to determine the number and distribution of population by ring and sector for the 8 to 16 kilometer (5 to 10 mile) radius area (Reference 2.1-7). Where census tract boundaries did not coincide with sector ring boundaries, it was assumed that population within the census tract was uniformly distributed. A land use comparison with the U.S.G.S. quadrangles and county master plans was conducted to identify both significant concentrations of population and large vacant undeveloped areas. In this way, the uniform distribution of population within each census tract was adjusted to reflect actual conditions.

The basis for the 0 to 16 kilometer (0 to 10 mile) population projections were field surveys (Reference 2.1-6), the 1980 Census of Population and Housing for New Jersey and Delaware, state and county projections for the years 1987 to 2010 (References 2.1-8 and 2.1-9), and federal projections by state for the years 2020 to 2030 (Reference 2.1-10). The federal projections were consistently lower than the state projections, so state projections were used in order to be conservative; however, the state projections for the year 2000 were consistently higher than federal projections for the year 2010. In order to avoid a "dip" or decline in population, it was assumed that the year 2000 and 2010 populations were stable. In the years 2020 and 2030, the federal projections were used. In this way, an artificial decrease in projected population does not occur during the transition period from state to federal projections.

The major difference between state and federal projections appears to be a more optimistic state view of growth compared with the federal approach, which is more balanced, particularly in terms of economic activity. New Jersey and Delaware both limit development in wetlands, therefore taking large acreages within 16 kilometers (10 miles) of the site out of potential development.

Table 2.1-1 shows the age distribution for the projected population within a 0 to 16 kilometer (0 to 10 mile) radius area for the midpoint of the station operating life, 2010 (References 2.1-4 and 2.1-5). The age distribution within this 16 kilometer (10 mile) radius area, based on past census trends, is not expected to change significantly from 1980 to 2010, so the 1980 age distribution was assumed for the midpoint year of plant life.

The states of Delaware and New Jersey age distributions are more representative of the site area than the generalized U.S. projections; therefore, Delaware and New Jersey age distributions were used for the 0 to 16 kilometer (0 to 10 mile) area around the Artificial Island site.

2.1.2.2 Population between 16 and 80 Kilometers (10 and 50 Miles)

Figure 2.1-12 shows current residential population within 16 to 80 kilometers (10 to 50 miles) of the Artificial Island site (References 2.1-4, 2.1-5, 2.1-11 and 2.1-12). Figure 2.1-13 shows the projected population for the first full year of station operation in 1987. Figures 2.1-14 through 2.1-18 show the projected population for each census decade from 1990 through the end of projected station life in 2030.

Current 1980 census data by municipality (MCD) were utilized to determine the number and distribution of population by sector and ring within the 16 to 80 kilometer (10 to 50 mile) radius area. Where an MCD was divided by a sector boundary, the population of the MCD was distributed to each sector on the basis of the geographic areal split of the MCD. Thus, if 20 percent of the area of an MCD were in one sector, then 20 percent of the population of that MCD was assigned to the sector.

The basis for the 16 to 80 kilometer (10 to 50 mile) population projections were the 1980 Census of Population and Housing for New Jersey, Delaware, Maryland and Pennsylvania (References 2.1-4, 2.1-5, 2.1-11 and 2.1-12), state projections by county for the years 1987 to 2010 (References 2.1-8, 2.1-13, 2.1-14, and 2.1-15) and federal projections by state for the years 2020 to 2030 (Reference 2.1-10). The federal projections were consistently lower than the state projections, so state projections were used in order to be conservative; however, the state projections for the year 2000 were consistently higher than federal projections for the year 2010. In order to avoid a "dip" or decline in population, it

was assumed that the year 2000 and 2010 populations were stable. In the year 2020 and 2030, the federal projections were used. In this way, an artificial decrease in projected population does not occur during the transition period from state to federal projections.

The major difference between state and federal projections appears to be the more optimistic state view of growth compared with the federal approach, which is more balanced, particularly in terms of economic activity.

Table 2.1-2 shows the age distribution for the projected population within the 16 to 80 kilometer (10 to 50 mile) radius area for the midpoint of the station operating life, 2010 (2006, rounded) (References 2.1-4, 2.1-5, 2.1-8, and 2.1-9). The age distribution within this 16 to 80 kilometer (10 to 50 mile) area, based on past census trends, is not expected to change significantly from 1980 to 2010, so the 1980 age distributions were assumed for the midpoint year of plant life.

The state age distributions for Delaware, New Jersey, Maryland and Pennsylvania are more representative of the site area than the generalized U.S. projections; therefore, the state distributions were used for the 16 to 80 kilometer (10 to 50 mile) radius area around the Artificial Island site.

2.1.2.3 Transient Population

Transient population is discussed below in terms of 0 to 16 and 16 to 80 kilometers (0 to 10 and 10 to 50 miles) from the Artificial Island site. It is noted that the transient population includes a substantial double-counting of the resident population.

Transient Population within 0 to 16 Kilometers (0 to 10 Miles)

Table 2.1-3 shows the distribution of transient and special facilities populations within 0 to 16 kilometers (0 to 10 miles) of the Artificial Island site. This distribution is based on the transient and special facilities populations identified in the Artificial Island site's Evacuation Time Estimates (Reference 2.1-16).

Employment concentration centers within 0 to 16 kilometers (0 to 10 miles) of the Artificial Island site (Reference 2.1-17) are:

	Employment Center	Location
a.	Delaware City Industrial Complex	16-16.8 kilometers NNW (10-10.5 miles)
b.	Middletown, DE	16 kilometers W (10.0 miles)
c.	Salem, NJ	12.8 kilometers NNE (8.0 miles)

Other than in the city of Salem, there are no major shopping centers within 0 to 16 kilometers (0 to 10 miles) of the site.

The Delaware City Industrial Complex consists of industries predominantly of the petrochemical classification. Approximately 2,000 persons are employed at this complex, of which about 1,000 are within 16 kilometers (10 miles) of the site. Employees travel to work from up to 40 miles distant, primarily on the west side of Delaware River (Reference 2.1-17).

Employment in Salem, New Jersey and Middletown, Delaware is more localized. Employees generally live within 8 to 24 kilometers (5 to 15 miles) of their place of work (Reference 2.1-17).

Table 2.1-4 shows the location of special facilities (Reference 2.1-6). Special facilities populations are included on Table 2.1-3 (Reference 2.1-16).

Annual visitations to parks and wildlife areas and other recreational facilities within 0 to 16 kilometers (0 to 10 miles) of the site are shown on Table 2.1-5 and Figures 2.1-19 and 2.1-20 (References 2.1-18, 2.1-19 and 2.1-20).

Within the 0-16 kilometers (0 to 10 mile) radius area there are transient populations related to the use of the Delaware River. Figure 2.1-21 shows ports of landing for both commercial and recreational salt water fishing (References 2.1-21 and 2.1-22).

The waters within the Delaware River are locations of both commercial and recreational fisheries and shellfisheries as shown on Figure 2.1-22 (References 2.1-21 and 2.1-22).

The Delaware River is the major route for barge and freight traffic between the Philadelphia area ports and the Atlantic Ocean. According to the Army Corps of Engineers, Philadelphia District, approximately 111,500 vessel trips were made past the Artificial Island site in 1979 carrying 1,443,570 persons (Reference 2.1-22).

Transient Population within 16 to 80 Kilometers (10 to 50 Miles) of the Site

Table 2.1-6 shows the major employment centers located within the 16 to 80 kilometer (10 to 50 mile) radius of HCGS. The estimated total employment for these centers is 888,900 persons (Reference 2.1-23).

These major employment centers include Philadelphia, which is the core of the Philadelphia Standard Metropolitan Statistical Area, as well as subregional centers such as Camden and Vineland, New Jersey; Wilmington, Newark and Dover, Delaware. Philadelphia generates employment for a large area that is outside of the 80 kilometer (50 mile) radius from the Artificial Island site; the other communities, however, attract employees from a relatively narrow area within the 80 kilometer (50 mile) radius. Philadelphia also generates the largest student population in the area due to its concentration of major colleges and universities. Students at colleges and universities are counted as year-round residents in their place of residence in February and March; therefore, virtually all students are permanent, not transient, residents.

Major shopping areas within the 16 to 80 kilometer (10 to 50 mile) radius area are Philadelphia, Pennsylvania; Wilmington and Newark, Delaware; and Camden (Cherry Hill), New Jersey.

The recreation and tourism areas within the 16 to 80 kilometer (10 to 50 mile) radius area are located along the New Jersey ocean shoreline, and along the Delaware and Chesapeake Bays in New Jersey, Delaware and Maryland (Reference 2.1-24).

The major seasonal recreation and tourist population concentrations are close to the New Jersey ocean shoreline, 64 to 80 kilometers (40 to 50 miles) E, ESE and SE from the Artificial Island site. Table 2.1-7 shows the population concentrations for this area (Reference 2.1-16).

State parks and forests and wildlife management areas are used predominantly from the spring through the fall months. Figures 2.1-19 and 2.1-20 show the locations of these areas as well as annual visitations (References 2.1-20 and 2.1-24).

Within the 16 to 80 kilometer (10 to 50 mile) radius area there are transient populations related to the use of Chesapeake Bay and the Delaware Bay and River. Figure 2.1-21 shows ports of landing for both commercial and recreational saltwater fishing (References 2.1-18 and 2.1-19).

The waters within the Chesapeake Bay and the Delaware Bay and River are locations of both commercial and recreational fisheries and shellfisheries as shown on Figure 2.1-19 (References 2.1-18 and 2.1-19).

2.1.3 USES OF ADJACENT LANDS AND WATERS

2.1.3.1 Artificial Island Site Land Use

Figure 2.1-23 shows existing land uses within the vicinity of the Artificial Island site (References 2.1-25, 2.1-26, and 2.1-27). See Sections 2.6 and 2.1.1 for additional, detailed information.

The location of PSE&G property and exclusion area boundaries are shown in Figure 2.1-4.

The total land area owned by PSE&G is 2,994,780 square meters (740 acres), of which 619,191 square meters (153 acres) are occupied by HCGS and its facilities. A visitor's center is also located on the utility property.

At the present time there are no plans for future site modifications.

2.1.3.2 Location of Nearest Milk Cow and Goat, Residence, Site Boundary and Vegetable Garden

Table 2.1-8 shows the distance from the site center point to the nearest milk cow and goat, residence, site boundary and vegetable garden for each of the 16 sectors within 0 to 8 kilometers (0 to 5 miles) of the Artificial Island site (Reference 2.1-28). The milk cow locations are not dairy operations. The selling of goat milk for human comsumption is prohibited in the states of Delaware and New Jersey. The majority of milk produced within the 8 kilometer (5 mile) area is used by persons within the 80 kilometer (50 mile) site area.

The fraction of milk at a typical dairy used for the various milk products, according to Dr. Cline, a dairy science specialist at Cook College, Rutgers University, New Brunswick, New Jersey (Reference 2.1-28), is as follows:

a.	Milk & cream	38.6%
b.	Cheese	27.4%
c.	Butter	19.8%
d.	Ice cream	9.3%
e.	Evaporated milk	3.3%
f.	Whey	1.6%
	Total	100%

2.1.3.3 Land Use within 8 Kilometers (5 Miles) of the Artificial Island Site

Existing and projected land uses within eight kilometers (five miles) of the Artificial Island site are shown on Figures 2.1-19 and 2.1-20, respectively (References 2.1-25, 2.1-26, and 2.1-27). The master plans for both Salem County and the Middletown-Odessa-Townsend Planning District show no projected changes in the 8 kilometer (5 mile) radius area except for a proposed but undeveloped industrial park 5.1 to 8 kilometers (3.2 to 5 miles) WSW from the Artificial Island site (Reference 2.1-29). Population in the area is expected to remain essentially stable because more than 60 percent of the area is either water, wetland, or publicly-owned parks and wildlife refuges, as shown in Figures 2.1-23, 2.1-19 and 2.1-20 (References 2.1-20, 2.1-25, 2.1-26, 2.1-30 and 2.1-36).

No major transportation routes are located in New Jersey within eight kilometers (five miles) of the Artificial Island site. Route 9, a designated scenic highway in Delaware (Reference 2.1-29), passes within 5.6 kilometers (3.5 miles) of the site.

Zoning in the eight kilometer (five mile) radius area of the Artificial Island site is shown in Figure 2.1-25 (References 2.1-25, 2.1-26 and 2.1-27). Artificial Island is zoned for industrial purposes, which include nuclear generating facilities. A large area four kilometers (2.5 miles) northeast of the site and a smaller area adjacent to the site's northern boundary are also zoned for industrial uses. Most of these areas are wetlands; these will not be developed due to state and federal legislation prohibiting development within these area. The Salem County Comprehensive Plan, Figure 2.1-23 (Reference 2.1-27), shows the remaining area to be agricultural and open space. Except for a small residentially zoned area near Hancocks' Bridge, the rest of the eight kilometer (five mile) radius area is zoned agricultural, rural residential and open space (Figure 2.1-25).

2.1.3.4 Annual Agricultural Production

Tables 2.1-9 through 2.1-11 show annual meat, milk and truck farming production and distribution within 0 to 80 kilometers (0 to 50 miles) of the Artificial Island site (References 2.1-31, 2.1-32, 2.1-33 and 2.1-34).

Table 2.1-12 shows crops grown within the 0 to 80 kilometer (0 to 50 mile) area (References 2.1-28, 2.1-29, 2.1-30 and 2.1-31).

Feeding regimens for cattle in the 80 kilometer (50 mile) radius area of the Artificial Island site vary with the season of the year (Reference 2.1-28). During the winter months, cattle are fed primarily corn silage along with grain concentrates and hay. During the summer months, the primary feed is grain concentrates, hay and grasses. These are the common feeding regimens in the four-state area within 80 kilometers (50 miles) of the site. The mean absolute humidity from January 1977 through December 1981 at the Artificial Island site is 8.1 grams per cubic meter.

Harvested forage crops in the 80 kilometer (50 mile) radius area are primarily hay and alfalfa. The yield for these crops (References 2.1-31, 2.1-32, 2.1-33 and 2.1-34) is generally as follows:

	Crop	kg/m^2	lb/ft^2
a.	Hay	0.44 - 0.47	0.090 to 0.096
b.	Alfalfa	0.43 - 0.46	0.088 to 0.094

2.1.3.5 Commercial and Recreational Fish and Shellfish Catch

Commercial Catch

Table 2.1-13 shows the commercial fish and shellfish catch for the years 1976 through 1980 within 0 to 80 kilometers (0 to 50 miles) downstream of the Artificial Island site (References 2.1-35 and 2.1-42). The limited commercial fin-fish fishery in this region of Delaware Bay concentrates on the American shad, striped bass, white perch and carp (Reference 2.1-38). Other important species, as indicated by landings in the region, include bluefish, flounder, sea trout and whiting (References 2.1-35 and 2.1-37); however, catch data based on landings can be misleading since commercial fishermen bring their catch in to the dock offering the best prices, and they do not necessarily catch these fish in nearby waters.

The most important commercial fisheries in the Delaware Bay are for blue crab and oysters. Fishing has been observed on both sides of the channel as far north as the mouth of Alloway Creek, New Jersey (Reference 2.1-38). From 1976 to 1980, oysters and blue crabs ranked first and second in kilograms (pounds) harvested within this region of Delaware Bay (Reference 2.1-38).

Figure 2.1-22 shows the commercial fishing and shellfishing areas with 0 to 80 kilometers (0 to 50 miles) downstream of the Artificial Island site (References 2.1-21 and 2.1-22). Both the New Jersey shore and the Delaware shore of the estuary contribute to the commercial catch. The protected

bays and lagoons, where salt and fresh water mix, are especially productive; however, poor water quality, overfishing, and a growing recreational fishery competing for the resource, have led to a dramatic decline in harvest (Reference 2.1-39).

Figure 2.1-18 illustrates the principal ports of landing for commercial and recreational salt water fishing. Ports 1 through 10, 25, 26 and 27 are outside the 0 to 80 kilometer (0 to 50 mile) radius downstream area, and most fish landed at these ports probably would not come from the area immediately downstream of Artificial Island. Port Norris and the town of Bivalve are the center of the shellfish industry in the Delaware Bay. Oyster and blue crab comprise 95 percent of the annual landings at this port (Reference 2.1-39).

The major areas of consumption for the commercial fish and shellfish catch are the densely populated areas of Philadelphia, Pennsylvania; Newark and Wilmington, Delaware; Baltimore, Maryland; and Camden, New Jersey (Reference 2.1-22). All these metropolian areas are within the 80 kilometer (50 mile) radius of the Artificial Island site.

Humans consume most of the commercial fish and shellfish catch, except for eels, carp, alewives and menhaden. The Atlantic menhaden is the only important industrial fishery in New Jersey. The menhaden, along with carp and alewives, are used in the production of oil, paint and other industrial products. The populations of southern Europe and Asia consider eels to be a delicacy; therefore, the majority of the catch is exported to Europe (References 2.1-22 and 2.1-39). A small percentage of the eel catch is used as bait for landing other species, such as crabs.

Recreational Catch

The saltwater recreational fisheries in the 0 to 80 kilometer (0 to 50 mile) area downstream of Artificial Island are not well known, and there is no reliable data on the volumes of recreational marine fish and shellfish caught; however, weakfish, bluefish and summer flounder are the primary species in the recreational catch (Reference 2.1-41). Other major recreational species caught (References 2.1-20, 21, 22, 24 and 42) in this area include:

a. Morone americana (White perch)
b. Leiostomus xanthurus (Spot)
c. Limanda ferruginea (Yellowtail flounder)
d. Pseudopleuronectes americanus (Winter flounder)
e. Scophthalmus aquosus (Windowpane)
f. Scomber scombrus (Mackerel)

g. Cynoscion regalis (Sea trout, weakfish)
h. Alosa sapidissima (American shad)
i. Morone saxatilis (Striped bass)
j. Merluccius bilinearis (Whiting)
k. Callinectes sapidus (Blue crab)
l. Spisula solidissima (Surf clam)
m. Mercenaria mercenaria (Hard clam)
n. Crassostrea virginica (Oysters)

Many of these species contribute to the catch on a seasonal basis. During summer and early fall, there is an active sport fishery for blue crab; similarly, American shad are important only during spring.

In 1974, an estimate was made of the recreational catch, but only for the State of Delaware. This catch consisted of weakfish (about 1.6 million kilograms (3.5 million pounds)), bluefish (227,000 kilograms (500,000 pounds)), sharks (84,000 kilograms (190,000 pounds)), summer flounder (69,500 kilograms (153,000 pounds)), other fishes (227,000 kilograms (500,000 pounds)), hard clam (about 1.0 million kilograms (2.2 million pounds)), and soft clam (about 820,000 kilograms (1,800,000 pounds)). These figures are substantially higher than for the commercial catch (Reference 2.1-40).

The recreational catch in 1977 was estimated at about 5.8 million fishes, plus considerable quantities of blue crab and hard clam. By weight, this is about 3.4 million kilograms (7.5 million pounds), which was three times as great as the commercial catch (Reference 2.1-43).

Although these data are probably not very accurate, and they do not include New Jersey, they do indicate that the recreational catch in the 0 to 80 kilometer (0 to 50 mile) radius area downstream of Artificial Island is greater than the commercial catch listed in Table 2.1-13.

Recreational catch and effort statistics are also useful for obtaining some indication of the recreational harvest. Based on the catch data from Delaware (References 2.1-42 and 2.1-43), weakfish comprised 77 percent of the recreational catch in 1981, and 80 percent in 1980. The average catch of weakfish per man-hour in these years was 1.02 and 0.53, respectively (Table 2.1-14).

Although a sizable recreational fishery exists in the Delaware Bay downstream of Artificial Island, there has been an overall decline in the catch rates during the last decade (Reference 2.1-42). Table 2.1-15 presents the data on weakfish recreational catch rates in Delaware Bay for the past 13 years,

where available. Other important species exhibit similar declines. Recreational catch rates peaked in the early 1970's; since then, the catch rates for the species have been declining while their average size has been increasing, a situation which indicates that recruitment has been poor over the last several years (Reference 2.1-42).

According to recreational catch data collected at four access areas in Delaware (Table 2.1-15), the major catch locations and corresponding distances from Artificial Island vary depending on the species. During 1981, weakfish catch rates were highest at Bowers Beach (43.4 kilometers (27 miles) downstream of Artificial Island), followed by Port Mahon (33.7 kilometers (21 miles) downstream), Cedar Creek (61.1 kilometers (38 miles) downstream) and Lewes (78.8 kilometers (49 miles) downstream). Figure 2.1-21 illustrates these recreational access areas. A similar trend for weakfish occurred in 1980. Summer flounder catch rates were greatest at the Lewes access area (78.8 kilometers (49 miles) downstream) during 1980 and 1981 (Reference 2.1-42). No consistent trend in catch rates between access areas exists for bluefish.

2.1.3.6 Principal Uses of Land and Water Adjacent to the Artificial Island Site

The principal uses of land adjacent to the Artificial Island site are vacant wetlands and agricultural (Reference 2.1-27). The Delaware River extends along the western site boundary. The primary use of the river is barge and freight traffic between the Atlantic Ocean and ports within the Philadelphia, Pennsylvania area.

Plant operations at the Artificial Island site are self-contained within the utility property. There are no required off-site access corridors for the cooling water conveyance, future roads or other cultural features relating to the principal purpose of the facility. Also, there are no plans for future plant expansion at the present time.

2.1.3.7 Surface and Groundwater Usage

Water supplies which could be affected by HCGS effluents are limited to the area within approximately 4.8 kilometers (3 miles) downstream of the Artificial Island site and about 2.4 kilometers (1.5 miles) miles upstream, due to tidal influence. The dilution factor of the Delaware River decreases the area potentially affected from an 80 kilometer (50 mile) radius to a 4.8 kilometer (3 mile) radius.

Within the 0 to 4.8 kilometer (0 to 3 mile) radius area, no population centers are taking water from the Delaware River (Reference 2.1-29). No river bank wells exist in this area. There are no down stream public water supplies.

Consumptive water use by the station during periods of low river flow could have an effect on regional supplies; therefore, the applicant, in conjunction with other Delaware Basin electric utilities, is participating in the Merrill Creek Reservoir Project (see Section 3.3). At the present time, PSE&G does not have plans for future expansion, so the projected effects on regional water use by the station is expected to be minimal.

See Section 2.4 for additional, more detailed, information on surface and groundwater usage.

REFERENCES

2.1-1 B. B. Friedlander, T. A. Clark, Rev. 1, Master Plan Lower Alloways Creek Township New Jersey, December, 1978.

2.1-2 Salem County Planning Board, A Plan for Comprehensive Development, November, 1970.

2.1-3 10 CFR Part 20, Section 20.3, Paragraph 14.

2.1-4 U.S. Bureau of the Census, 1980 Census of Population and Housing, New Jersey, Advance Reports, PHC80-V-32, U.S. Department of Commerce, March, 1981.

2.1-5 U.S. Bureau of the Census, 1980 Census of Population and Housing, Delaware, Advance Reports, PHC80-V-9, U.S. Department of Commerce, February, 1981.

2.1-6 Field Surveys by Dresdner Associates conducted during May and June, 1982.

2.1-7 Unpublished U.S. Bureau of Census tract data and maps available at county planning departments. Census tract data and maps were reviewed at the planning department offices of Cumberland and Salem Counties, New Castle and Kent Counties, Delaware.

2.1-8 New Jersey Department of Labor and Industry, New Jersey Population Projection 1980-2000, February, 1982.

2.1-9 New Castle County Planning Board, Population Projections 1980-2000, March, 1982.

2.1-10 U.S. Department of Commerce, 1980 OBERS BEA Regional Projections, February, 1982.

2.1-11 U.S. Bureau of the Census, 1980 Census of Population and Housing, Maryland, Advance Reports, PHC80-V-22, March, 1981.

2.1-12 U.S. Bureau of the Census, 1980 Census of Population and Housing, Pennsylvania, Advance Reports, PHC80-V-40, March, 1981.

2.1-13 Delaware Department of Health and Social Services, Population Projections by County and City 1975-2000, February, 1980.

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2.1-14 Maryland Department of State Planning, Interim Population Projections for Maryland Political Subdivision 1980-2000, June, 1981.

2.1-15 Pennsylvania Office of State Planning and Development, Pennsylvania Projection Series 1980-2000, Summary Report, 78 PPS-1, June, 1978.

2.1-16 Parsons, Brinckerhoff, Quade and Douglas, Evacuation Time Estimates, February, 1981.

2.1-17 Delaware Directory of Commerce and Industry, 1979. Also, personal communications with:

D. Timmens, Technical Supervisor, Diamond Shamrock, May 28, 1982.
L. Fleming, Manager, Schargen Gas Co., May 28, 1982.
D. Press, Public Affairs, Getty Refining and Manufacturing Co., May 25, 1982.
M. Morris, Manager, Stauffer Chemical Co., May 26, 1982.
J. Butler, American Hoechst Corp., May 28, 1982.
L. Evo, Standard Chlorine of Delaware, Inc., May 26, 1982.
H. McFadden, Plant Manager, Chloromone Corp., June 4, 1982.
G. Hobbie, Plant Manager, Cardox, June 2, 1982.

2.1-18 New Jersey Department of Labor and Industry, Boat Basins in New Jersey, 1978.

2.1-19 Sea Grant Advisory Service, A Guide to Delaware's Coastline Marinas, 1979.

2.1-20 Personal communications with officials of:

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Delaware Division of Parks and Recreation, June 23, 1982.
Delaware Division of Fish and Wildlife, June 23, 1982.

2.1-21 R. Townsend, Guide to New Jersey's Saltwater Fishing, 1974.

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2.1-22 Personal communications with:

D. Christian, National Marine Fisheries Service, June 21, 1982.
M. Carson, U.S. Army Corps of Engineers, Philadelphia District, June 21, 1982.

2.1-23 Personal communications with:

R. Alzarski, Economist, Pennsylvania Department of Labor, June 25, 1982.
J. Major, Principal Labor Market Analyst, New Jersey Department of Labor and Industry, June 24, 1982.
E. Simmons, Planning and Research, Pennsylvania Department of Labor, June 25, 1982.

2.1-24 Personal communications with employees of:

Maryland State Park and Recreation Service, June 24, 1982.
Pennsylvania Bureau of State Parks, June 24, 1982.

2.1-25 New Castle County Planning Board, The Red Lion Planning District Plan, 1995, September, 1973.

2.1-26 New Castle County Planning Board, The Middletown-Odessa-Townsend Planning District Plan 1995, September, 1973.

2.1-27 Salem County Planning Board Staff, A Plan for Comprehensive Development, November, 1970.

2.1-28 Personal communication with:

Dr. Cline, Dairy Science, Cook College, Rutgers University, June 8, 1982.
M. Smith, Goat Breeder, New Castle County, Delaware, June 17, 1982.
H. Towers, Director, Delaware Department of Agriculture, June 17, 1982.
S. Hitchner, Vice President, Alloway Creek 4-H Club, Alloway Creek, New Jersey, June 16, 1982.

2.1-29 Personal communications with:

REFERENCES (Continued)

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C. Warren, Salem County Department of Planning, May 20, 1982.

2.1-30 U.S. Department of Agriculture, South Jersey Resource Conservation & Development Area Plan, April, 1979.

2.1-31 New Jersey Department of Agriculture, New Jersey Agricultural Statistics 1981, October, 1981.

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2.1-33 Pennsylvania Department of Agriculture, Pennsylvania Crop and Livestock Annual Summary 1980, June, 1980.

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2.1-35 National Marine Fisheries Service, Data Management and Statistic Division, Annual Landings by Year, State County, and Species 1980, June, 1982.

2.1-36 Personal communications with:

Maryland Wildlife Administration, June 7, 1982.

2.1-37 National Oceanic and Atmospheric Administration, Current Fisheries Statistics No. 7213, New Jersey Landings Annual Summary 1976, June, 1977.

2.1-38 Ichthyological Associates, Inc., An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the Period January through December, 1972, May, 1974.

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2.1-40 J. L. McHugh, Marine Fisheries of Delaware, Fishery Bulletin, 79, 4, 1981.

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2.1-42 R. J. Seagraves, 1981 Annual Report of Catch and Effort Statistics, Part II, Delaware Divison of Fish and Wildlife.

2.1-43 R. W. Miller, Marine Recreational Fishing in Delaware, Bureau of Archives and Records, Hall of Records, Dover, Delaware, 1978.

2.1-44 Personal Communications with:

R. Reed, Kent County Planning Board, January 25, 1983.

TABLE 2.1-1

AGE DISTRIBUTION FOR MIDPOINT
OF STATION OPERATING LIFE, 0-16 KILOMETERS (0-10 MILES)
2010

	AGE (years)	% TOTAL POPULATION
Delaware[1]	0-12	18.9
	13-18	11.4
	>18	69.7
TOTAL		100.0
New Jersey[2]	0-12	18.1
	13-18	10.7
	>18	71.2
TOTAL		100.0

(1) 1980 Census Population Characteristics for Delaware, Maryland, and Pennsylvania, February, 1982.

(2) New Jersey 1980 Census of Population and Housing, County profiles, January, 1982.

TABLE 2.1-2

AGE DISTRIBUTION FOR MIDPOINT
OF STATION OPERATING LIFE, 16-80 KILOMETERS (10-50 MILES)
2010

	AGE (years)	% TOTAL POPULATION
Delaware(1)	0-12	18.9
	13-18	11.4
	>18	69.7
TOTAL		100.0
New Jersey(2)	0-12	18.1
	13-18	10.7
	>18	71.2
TOTAL		100.0
Maryland(1)	0-12	17.6
	13-18	10.0
	>18	72.4
TOTAL		100.0
Pennsylvania(1)	0-12	16.9
	13-18	7.0
	>18	76.1
TOTAL		100.0

(1) 1980 Census Population Characteristics for Delaware, Maryland, and Pennsylvania, February, 1982.

(2) New Jersey 1980 Census of Population and Housing, County profiles, January, 1982.

TABLE 2.1-3

TRANSIENT AND SPECIAL FACILITIES POPULATION
WITHIN 0-16 KILOMETERS (0-10 MILES) OF THE
ARTIFICIAL ISLAND SITE
1981

Sector	0-3.2 km (0-2 mi)	3.2-8 km (2-5 mi)	8-16 km (5-10 mi)	Total
N	0	7	141	148
NNE	0	0	3,569	3,569
NE	0	0	384	384
ENE	0	0	0	0
E	0	0	285	285
ESE	0	0	0	0
SE	2	8	8	18
SSE	2	8	58	68
S	2	2	0	4
SSW	2	0	1,011	1,013
SW	2	0	0	2
WSW	2	0	484	4°6
W	2	0	2,754	2,756
WNW	2	3	0	5
NW	2	3	1,341	1,346
NNW	2	10	1,391	1,403
TOTAL	20	41	11,426	11,487

Source: Parson, Brinckerhoff, Quade & Douglas, Evacuation Time Estimates, February 27, 1981.

TABLE 2.1-4 (Page 1 of 2)
LOCATION OF SPECIAL FACILITIES WITHIN
0-16 KILOMETERS (0-10 MILES)
OF THE ARTIFICIAL ISLAND SITE
1982

DELAWARE SCHOOLS	LOCATION
Silver Lake - Elementary (Middletown)	15.2 km (9.5 mi) W
Middletown - High School (Middletown)	15.2 km (9.5 mi) W
Redding - Middle (Middletown)	15.2 km (9.5 mi) W
Broad Meadow School - Private Middle & Elementary (Middletown)	15.2 km (9.5 mi) W
St. Andrews - Private Protestant High School (all boys) (Middletown)	15.2 km (9.5 mi) W
Townsend - Elementary (Townsend)	15.7 km (9.8 mi) SW
Commodore MacDonough - Elementary (St. Georges)	14.0 km (8.8 mi) SW
Delaware City - Elementary (Delaware City)	12.8 km (8.0 mi) NNW
Gunning Bedford - Middle (Delaware City)	12.8 km (8.0 mi) NNW
Corbit - Elementary (Odessa)	10.4 km (6.5 mi) W
Au Clair - Elementary (St. Georges)	14.4 km (9.0 mi) NW
NEW JERSEY SCHOOLS	
Quinton Township - Elementary (Quinton)	13.6 km (8.5 mi) NE
John Fenwick - Elementary (Salem)	12.8 km (8.0 mi) NE

TABLE 2.1-4 (Continued) (Page 2 of 2)

NEW JERSEY SCHOOLS	LOCATION
Salem Day Care Center (Salem)	12.8 km (8.0 mi) NE
Salem - Middle (Salem)	12.8 km (8.0 mi) NE
Salem - High School (Salem)	12.8 km (8.0 mi) NE
Lower Alloways Creek - Elementary (Hancocks' Bridge)	7.8 km (4.9 mi) NE
Elsinboro - Elementary (Elsinboro)	11.2 km (7.0 mi) NNE
Stow Creek - Elementary (Stow Creek)	15.8 km (9.9 mi) E
Woodland Country Day School - Pre-School to Elementary (Stow Creek)	15.5 km (9.7 mi) E
St. Marys' - Elementary (Salem)	12.8 km (8.0 mi) NNE
HOSPITALS	
Salem County Memorial, NJ	12.8 km (8.0 mi) NE
Salem County Nursing and Convalescent Center, NJ	12.8 km (8.0 mi) NE
Governor Bacon Health Center, DE	12.8 km (8.0 mi) NNW
JAILS	
Salem County Jail, NJ	12.8 km (8.0 mi) NE

Source: Survey by Dresdner Associates, May, 1982.

TABLE 2.1-5
RECREATION AND TOURISM WITHIN 0-16 KILOMETERS (0-10 MILES)
OF THE ARTIFICIAL ISLAND SITE
1981

PARKS	LOCATION(8)	ANNUAL VISITATIONS
Fort Delaware Park, DE	14.4 km NNW	12,200(1)
Fort Mott State Park, NJ	16.0 km N	45,700(2)
WILDLIFE REFUGES & MANAGEMENT AREAS		
Mad Horse Creek Wildlife Management Area, NJ	3.2-12.8 km SE	1,000(2)
Appoquinimink Wildlife Area, DE	3.2- 8.0 km WSW	100(3)
Reedy Island Wildlife Refuge, DE	6.4 km MMW	500(3)
Augustine Creek Wildlife Area, DE	7.2-12.8 km NNW	500(3)
Woodland Beach Wildlife Area, DE	11.2-16.0 km SSE	1,200(3)
Canal National Wildlife Refuge, DE	12.8-16.0 km NNW	2,000(3)
Maskells Mill Pond Wildlife Management Area, NJ	11.2 km ENE	800(2)
Killcohook National Wildlife Refuge, NJ	16.0 km N	500(2)
BEACHES		
Augustine Beach, DE	6.4 km NNW	Not available
Bay View Beach, DE	5.6 km WNW	Not available
Woodland Beach, DE	16.0 km SSE	Not available
Oakwood Beach, NJ	10.4 km N	Not available
COUNTRY CLUBS		
Country Club of Salem, NJ	10.4 km N	11,250(4)
Wild Oaks Country Club, NJ	12.0 km NE	20,000(5)
BOAT MARINAS AND LAUNCHES		
Marboro Marina, NJ	12.8 km NNE	4,000(6)
Delaware City Marina, DE	12.8 km NNW	2,600(7)
Delaware City Launching Ramp, DE	12.8 km NNW	3,000(7)
Port Penn Launching Ramp, DE	6.7 km NNW	2,100(7)
Woodland Beach Launching Ramp, DE	15.7 km SSE	2,000(7)

(1) Delaware Division of Parks and Recreation, June 23, 1982.
(2) New Jersey Division of Parks and Forestry, June 23, 1982.
(3) Delaware Division of Fish and Wildlife, June 23, 1982.
(4) J. Stradley, President, Country Club of Salem, Salem, New Jersey, June 21, 1982.
(5) J. Hasler, President, Wild Oaks Country Club, Salem, New Jersey, June 21, 1982.
(6) New Jersey Department of Labor and Industry, Division of Travel and Tourism, Boat Basins in New Jersey, 1978.
(7) Sea Grant Advisory Service, A Guide to Delaware's Coastline Marinas, 1979.
(8) 1 mile = 1.61 kilometers.

TABLE 2.1-6
MAJOR EMPLOYMENT CENTERS LOCATED
WITHIN 16-80 KILOMETERS (10-50 MILES)
OF THE ARTIFICIAL ISLAND SITE
1981

	TOTAL EMPLOYMENT	LOCATION
Philadelphia, PA	775,700(1)	56-80.0 km (35-50 mi) NNE
Camden, NJ	40,900(2)	64.0 km (40 mi) NE
Wilmington, DE	32,800(3)	32.0 km (20 mi) N
Vineland, NJ	19,400(2)	38.4 km (24 mi) E
Newark, DE	10,500(3)	30.4 km (19 mi) NW
Dover, DE	9,700(3)	35.2 km (22 mi) S
TOTAL	889,000	

(1) Bob Alzarski, Economist, Pennsylvania Department of Labor, Bureau of Labor Statistics, June 25, 1982.

(2) Jim Major, Principal Labor Market Analyst, New Jersey State Department of Labor and Industry, June 24, 1982.

(3) Ed Simmons, Planning & Research, Delaware Department of Labor, June 25, 1982.

TABLE 2.1-7
SEASONAL AND TOURIST POPULATION,
NEW JERSEY SHORELINE,
64-80 KILOMETERS (40-50 MILES)

AVERAGE SUMMER DAY POPULATION

	Seasonal
E	17,190
ESE	66,690
SE	191,020

Sources: Dames and Moore, New Jersey Shore Area Seasonal Population Study, 1973.

Dresdner Associates, Reevaluations of AGS PSAR Population Projections, 1977.

TABLE 2.1-8

LOCATION OF NEAREST MILK COW, MILK GOAT, RESIDENT,
SITE BOUNDARY, AND VEGETABLE GARDEN
1982

	Milk Cow[1] km/(mi)	Dairy[1] Operation (km/mi)	Milk Goat[2,3] km/(mi)	Residence[4] km/(mi)	Site Boundary[4] km/(mi)	Vegetable[4] Garden km/(mi)
N	-	-	-	-	0.6(0.4)	-
NNE	7.2(4.5)	(5)	-	8.0(5.0)	0.6(0.4)	8.0(5.0)
NE	7.5(4.6)	(5)	-	6.4(4.0)	0.8(0.5)	7.2(4.5)
ENE	-	-	-	5.6(3.5)	0.8(0.5)	5.6(3.5)
E	-	-	-	-	1.0(0.6)	-
ESE	-	-	-	-	1.3(0.8)	-
SE	-	-	-	-	0.5(0.3)	-
SSE	-	-	-	-	0.3(0.3)	-
S	-	-	-	6.4(4.0)	0.3(0.2)	6.7(4.2)
SSW	-	-	-	5.6(3.5)	0.3(0.2)	6.1(3.8)
SW	-	-	-	7.2(4.5)	0.3(0.2)	7.2(4.5)
WSW	-	-	-	7.2(4.5)	0.3(0.2)	7.2(4.5)
W	-	-	-	4.8(3.0)	0.3(0.2)	-
WNW	-	-	-	5.2(3.2)	0.5(0.3)	5.6(3.5)
NW	-	-	-	5.6(3.5)	0.6(0.4)	6.4(4.0)
NNW	-	-	-	6.4(4.0)	0.6(0.4)	6.9(4.3)

(1) H. Towers, Director, Delaware Department of Agriculture, June 17, 1982.
(2) M. Smith, Goat Breeder, New Castle County, Delaware, June 17, 1982.
(3) S. Hitcher, Vice President, Alloway Creek 4-H Club, Alloway Creek, New Jersey, June 18, 1982.
(4) Survey by Dresdner Associates, June 18, 1982.
(5) Not used by adults and children.

TABLE 2.1-9

ANNUAL MEAT PRODUCTION[1] WITHIN 0-80 KILOMETERS (0-50 MILES)
OF THE ARTIFICIAL ISLAND SITE
1980

Sector	0-1.6 km (0-1 mi) (1,000 kg)	1.6-3.2 km (1-2 mi) (1,000 kg)	3.2-4.8 km (2-3 mi) (1,000 kg)	4.8-6.4 km (3-4 mi) (1,000 kg)	6.4-8.0 km (4-5 mi) (1,000 kg)	8-16 km (5-10 mi) (1,000 kg)	16-32 km (10-20 mi) (1,000 kg)	32-48 km (20-30 mi) (1,000 kg)	48-64 km (30-40 mi) (1,000 kg)	64-80 km (40-50 mi) (1,000 kg)
N	-	-	-	-	-	-	262.5	1,899.4	4,952.3	7,804.9
NNE	-	-	-	-	1.4	127.9	1,366.9	833.8	619.2	863.2
NE	-	-	-	-	0.1	132.5	2,108.6	748.6	8,848.1	353.3
ENE	-	-	-	-	-	125.8	905.9	675.4	909.4	471.3
E	-	-	-	-	-	109.3	305.2	494.4	295.1	114.9
ESE	-	-	-	-	-	117.2	242.1	156.6	288.1	205.2
SE	-	-	-	-	-	-	-	-	-	-
SSE	-	-	-	-	-	-	-	-	-	733.5
S	-	-	-	-	-	-	1,042.1	1,619.4	3,174.8	420.7
SSW	-	-	-	-	-	150.2	1,114.8	1,182.5	123.9	1,323.6
SW	-	-	-	-	-	149.9	984.9	5,498.4	5,831.6	12.9
WSW	-	-	-	-	-	157.9	683.6	291.1	29.8	1.5
W	-	-	-	-	1.8	156.4	69.8	3.8	6.0	10.3
WNW	-	-	-	-	0.7	-	65.8	9.9	28.6	317.4
NW	-	-	-	-	-	-	55.8	5,008.5	15,122.3	28,821.4
NNW	-	-	-	-	-	-	11.1	159.2	182.5	4,454.6

[1] 1 pound = 0.454 kilogram.

Sources: New Jersey Department of Agriculture, New Jersey Agricultural Statistics 1981, October, 1981.
Maryland Department of Agriculture, Maryland Agricultural Statistics 1980, July, 1981.
Pennsylvania Department of Agriculture, Pennsylvania Crop and Livestock Annual Summary 1980, June, 1980.
Delaware Department of Agricultural Economics, Delaware Farm Income 1980, February, 1982.

TABLE 2.1-10

ANNUAL MILK PRODUCTION[1] AND DISTRIBUTION
WITHIN 0-80 KILOMETERS (0-50 MILES)
1980

Sector	0-1.6 km (0-1 mi) (1,000 l)	1.6-3.2 km (1-2 mi) (1,000 l)	3.2-4.8 km (2-3 mi) (1,000 l)	4.8-6.4 km (3-4 mi) (1,000 l)	6.4-8.0 km (4-5 mi) (1,000 l)	8-16 km (5-10 mi) (1,000 l)	16-32 km (10-20 mi) (1,000 l)	32-48 km (20-30 mi) (1,000 l)	48-64 km (30-40 mi) (1,000 l)	64-80 km (40-50 mi) (1,000 l)
N	-	-	-	-	-	-	2,430	1,955	29	49
NNE	-	-	-	-	14	2,145	8,100	3,733	2	4
NE	-	-	-	-	6	1,706	8,100	2,929	1,303	2,499
ENE	-	-	-	-	-	6,825	5,551	4,550	1,359	2,979
E	-	-	-	-	-	1,428	1,216	2,431	734	216
ESE	-	-	-	-	-	-	810	524	803	261
SE	-	-	-	-	-	-	-	-	-	3
SSE	-	-	-	-	-	-	-	-	-	326
S	-	-	-	-	-	-	3,126	4,682	8,130	4,752
SSW	-	-	-	-	-	7	8,899	5,334	11,972	13,911
SW	-	-	-	-	7	459	6,709	7,400	7,519	5,127
WSW	-	-	-	-	-	2,478	6,725	34,232	9,562	1,594
W	-	-	-	-	445	348	1,945	3,986	10,478	11,314
WNW	-	-	-	-	513	2,228	2,046	1,992	16.457	30,927
NW	-	-	-	-	-	1,699	1,998	9,974	57	126
NNW	-	-	-	-	-	-	972	2,936	1,973	69

[1] 1 gallon = 3.785 liters.

Sources: New Jersey Department of Agriculture, New Jersey Agricultural Statistics 1981, October, 1981.
Maryland Department of Agriculture, Maryland Agricultural Statistics 1980, July, 1981.
Pennsylvania Department of Agriculture, Pennsylvania Crop and Livestock Annual Summary 1980, June, 1980.
Delaware Department of Agricultural Economics, Delaware Farm Income 1980, February, 1982.

TABLE 2.1-11

ANNUAL TRUCK FARMING PRODUCTION(1) WITHIN
0-80 KILOMETERS (0-50 MILES) OF THE
ARTIFICIAL ISLAND SITE
1980

Sector	0-1.6 km (0-1 mi) (kg/yr)	1.6-3.2 km (1-2 mi) (kg/yr)	3.2-4.8 km (2-3 mi) (kg/yr)	4.8-6.4 km (3-4 mi) (kg/yr)	6.4-8.0 km (4-5 mi) (kg/yr)	8-16 km (5-10 mi) (kg/yr)	16-32 km (10-20 mi) (kg/yr)	32-48 km (20-30 mi) (kg/yr)	48-64 km (30-40 mi) (kg/yr)	64-80 km (40-50 mi) (kg/yr)
N	-	-	-	-	-	-	1,505,484	2,836,974	752,742	1,270,758
NNE	-	-	-	-	-	262,664	2,018,280	1,420,497	104,700	388,512
NE	-	-	-	-	-	295,040	2,038,515	1,489,296	2,379,636	1,517,625
ENE	-	-	-	-	-	254,570	3,261,882	2,764,107	5,677,159	3,876,244
E	-	-	-	-	-	578,330	2,516,452	3,269,194	5,977,028	4,252,224
ESE	-	-	-	-	-	862,011	505,484	501,828	1,359,792	3,633,424
SE	-	-	-	-	-	-	-	-	323,760	-
SSE	-	-	-	-	-	-	-	-	-	1,003,656
S	-	-	-	-	-	-	3,030,421	4,547,655	11,581,732	7,060,842
SSW	-	-	-	-	-	125,457	3,537,249	5,134,470	15,548,758	13,629,514
SW	-	-	-	-	-	169,974	4,588,125	5,320,632	7,057,186	12,984,477
WSW	-	-	-	-	-	145,692	3,309,664	6,343,741	3,591,001	930,810
W	-	-	-	-	-	161,880	2,768,148	125,457	1,675,458	1,233,944
WNW	-	-	-	-	-	-	2,638,644	513,969	2,573,892	8,743,084
NW	-	-	-	-	-	-	2,513,187	214,491	1,756,398	2,010,968
NNW	-	-	-	-	-	-	428,982	3,771,804	3,156,660	1,614,753

(1) 1 pound = 0.454 kilogram.

Sources: New Jersey Department of Agriculture, New Jersey Agricultural Statistics 1981, October, 1981.
Maryland Department of Agriculture, Maryland Agricultural Statistics 1980, July, 1981.
Pennsylvania Department of Agriculture, Pennsylvania Crop and Livestock Annual Summary 1980, June, 1980.
Delaware Department of Agricultural Economics, Delaware Farm Income 1980, February, 1982.

TABLE 2.1-12

CROPS GROWN WITHIN 0-80 KILOMETERS (0-50 MILES)
OF THE ARTIFICIAL ISLAND SITE
1980

CROP	QUANTITY (kg)(1)	YIELD (kg/m^2)(2)
Soybeans	2,789,389	1.8
Wheat	21,375,152	3.6
Barley	71,983,278	4.5
Hay	23,841,414	0.2
Oats	9,831,086	2.6
Rye	1,090,353	0.4
Tobacco	2,829,802	0.2
Peaches	33,745,310	0.3
Apples	24,894,020	0.5
Blueberries	8,989,300	0.3
Strawberries	834,028	0.4
Watermelon	3,357,000	1.4
Cranberries	397,916	0.9
Eggplant	279,750	0.1
Green Peas	4,895,252	0.3
Cucumbers	1,320,420	0.8
Cabbage	1,367,045	0.1
Beans	4,364,846	0.4
Mushrooms	6,605,998	0.1
Potatoes	1,181,974	2.1
Tomatoes	13,022,400	1.1
Asparagus	42,895	0.1
Lettuce	1,288,715	0.2
Peppers	885,875	0.7
Onions	739,875	1.0
Spinach	182,770	0.7

(1) 1 pound = 0.454 kilogram.
(2) pound/square foot = 0.454 kilogram/0.9 square meter

Sources: New Jersey Department of Agriculture,
New Jersey Agricultural Statistics 1981, October, 1981.

Maryland Department of Agriculture,
Maryland Agricultural Statistics 1980, July, 1981.

Pennsylvania Department of Agriculture,
Pennsylvania Crop and Livestock Annual Summary 1980,
June, 1980.

Delaware Department of Agricultural Economics,
Delaware Farm Income 1980, February, 1982.

TABLE 2.1-13

COMMERCIAL FISH AND SHELLFISH CATCH[4] WITHIN 0-80 KILOMETERS (0-50 MILES) DOWNSTREAM OF THE ARTIFICIAL ISLAND SITE

Species	1976[1] (kg)	1977[2] (kg)	1978[2] (kg)	1979[2] (kg)	1980[2] (kg)	Mean[2] (kg)
Pomatomus saltatrix (Bluefish)	7,234	20,975	24,788	24,607	22,428	23,200
Pogonias cromis (Black Drum)	-[3]	4,449	2,724	136	1,271	2,145
Cyprinus carpio (Carp)	21,017	28,466	17,116	18,653	14,483	19,681
Alosa pseudoharengus (Alewives)	-	454	454	4,268	6,992	3,042
Ictalurus nebulosus (Brown Bullhead) Ictalurus punctatus (Channel Catfish) Anarhichas lupus (Atlantic Wolffish) Arius felis (Hardhead Catfish)	1,029	6,220	7,491	11,577	10,805	9,023
Peprilus triacanthus (Butterfish)	-	45	-	45	91	60
Anguilla rostrata (American Eel)	12,685	51,075	72,958	108,143	49,486	70,416
Scophthalmus aquosus (Windowpane) Paralichthys dentatus (Summer Flounder) Pseudopleuronectes americanus (Winter Flounder) Limanda ferruginea (Yellowtail Flounder)	-	2,179	772	3,587	1,135	1,918
Cyroscion regalis (Sea Trout, Weakfish)	89,290	157,175	138,470	214,470	785,148	323,816
Alosa sapidissima (American Shad)	8,526	36,229	36,138	40,588	50,439	40,848
Brevoortia tyrannus (Menhaden)	93,170	22,473	51,484	32,643	104,919	52,880
Morone saxatilis (Striped Bass)	863	15,027	8,581	4,222	7,037	8,717
Morone americana (White Perch)	3,171	15,481	15,527	17,025	16,661	16,174
Merluccius bilinearis (Whiting)	-	-	45	-	-	45
Callinectes sapidus (Blue Crabs) Callinectes similis (Blue Crabs)	788,362	320,161	490,865	435,295	730,849	494,293
Mercenaria mercenaria (Hard Clam) Mya arenaria (Soft Clam)	-	-	-	4,994	17,660	11,327
Chelydra serpentina (Turtle, Snapper)	4,965	10,851	9,216	1,952	681	5,675
Crassotrea virginica (Oysters)	630,970	610,948	722,405	760,132	561,734	663,805

(1) National Oceanic and Atmopsheric Administration, Current Fisheries Statistics No. 7213, New Jersey Landings Annual Summary 1976, Cumberland County, NJ, June, 1977.

(2) National Marine Fisheries Service, Data Management and Statistical Division, Annual Landing by Year, State County, and Species 1977, 1978, 1979, 1980, Kent Co., DE; New Castle Co., DE; Cumberland Co., NJ; Salem Co., NJ.

(3) No data available.

(4) 1 pound = 0.454 kilogram.

TABLE 2.1-14

RECREATIONAL CATCH AND EFFORT STATISTICS COLLECTED DURING JULY AND AUGUST, 1980 AND 1981, IN DELAWARE

ACCESS AREA	YEAR	NO. BOATS	NO. FISHERMAN	TOTAL MAN-HOURS	TOTAL CATCH BY SPECIES		
					WEAKFISH	BLUEFISH	S. FLOUNDER
Port Mahon	1980	26	75	507	499	25	19
	1981	77	226	1,134	579	12	35
Bowers Beach	1980	19	52	302	537	73	23
	1981	33	95	491	628	53	63
Cedar Creek	1980	31	93	622	590	56	76
	1981	54	141	662	316	12	39
Lewes	1980	20	59	275	112	9	141
	1981	43	140	707	78	93	105
Total	1980	96	279	1,706	1,738	163	259
	1981	207	602	2,994	1,601	170	242
Average catch per man-hour	1980	-	-	-	1.02	0.09	0.15
	1981	-	-	-	0.53	0.06	0.08

Sources: R. J. Seagraves, 1980 Annual Report of Catch and Effort Statistics, Part II, Delaware Division of Fish and Wildlife.

R. J. Seagraves, 1981 Annual Report of Catch and Effort Statistics, Part II, Delaware Division of Fish and Wildlife.

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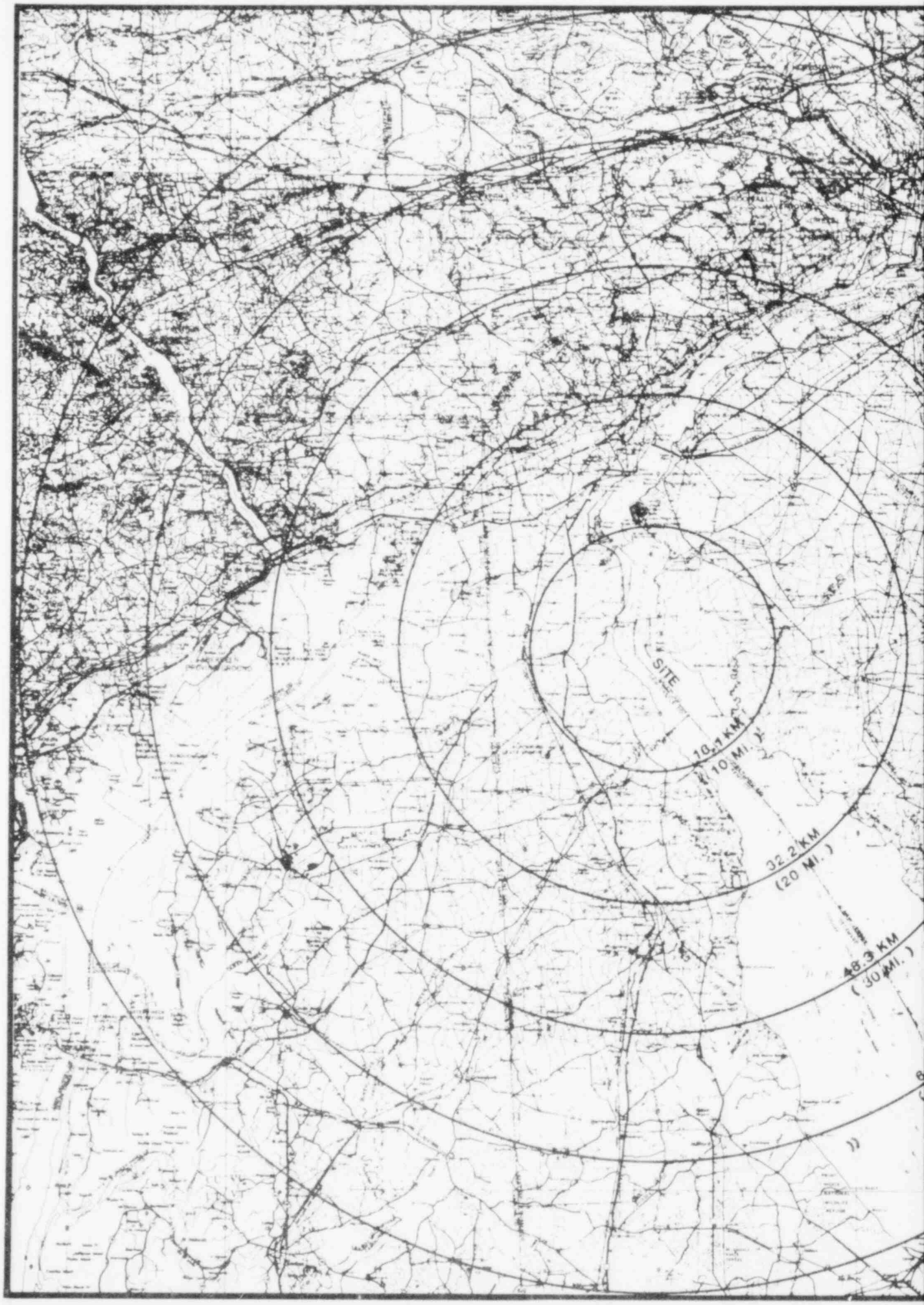
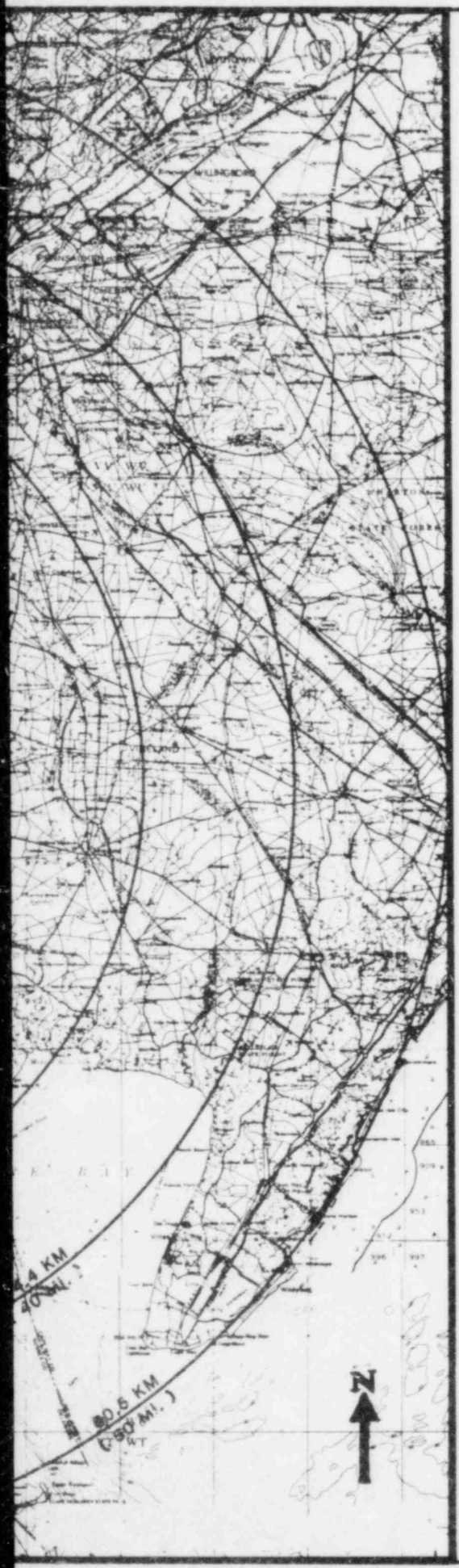
TABLE 2.1-15

NUMBER OF WEAKFISH TAKEN PER ANGLER PER DAY DURING YEARS OF MARINE RECREATIONAL FISHING SURVEYS IN DELAWARE

Year	Number of weakfish taken per angler/day
1968	5.6
1971	7.1
1972	3.7
1973	2.8
1976	3.9
1978	2.1
1979	2.7
1980	3.5
1981	1.7

Source: R. J. Seagraves, 1981 Annual Report of Catch and Effort Statistics, Part II, Delaware Division of Fish and Wildlife.


SITE
10.1 KM
(10 MI.)
32.2 KM
(20 MI.)
48.3 KM
(30 MI.)



SCALE

5 0 5 10 15 20 25 30

STATUE MILES

5 0 10 20 30 35

KILOMETERS

CONTOUR INTERVAL 50 FEET

U. S. GEOLOGICAL SURVEY

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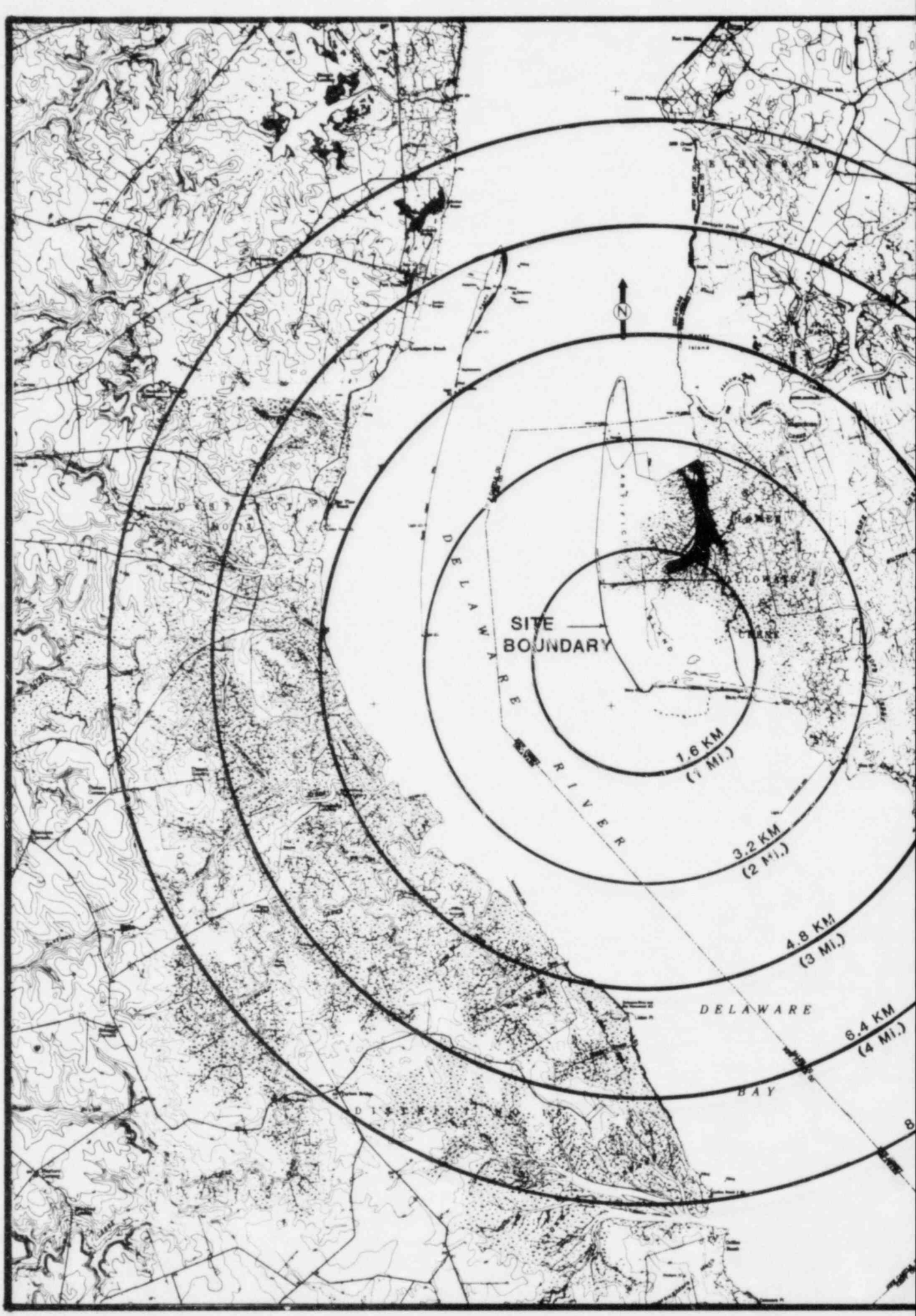
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SITE REGION WITHIN
80 KILOMETERS (50 MI.)

FIGURE 2.1 - 1

8306290435 -01


N
SITE
BOUNDARY
DELAWARE RIVER
1.6 KM
(1 MI.)
3.2 KM
(2 MI.)
4.8 KM
(3 MI.)
6.4 KM
(4 MI.)
DELAWARE
BAY

SCALE

1 0 1 2 3

MILES

1 0 1 2 3 4 5

KILOMETERS

CONTOUR INTERVAL 10 FEET

U. S. GEOLOGICAL SURVEY

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APERTURE
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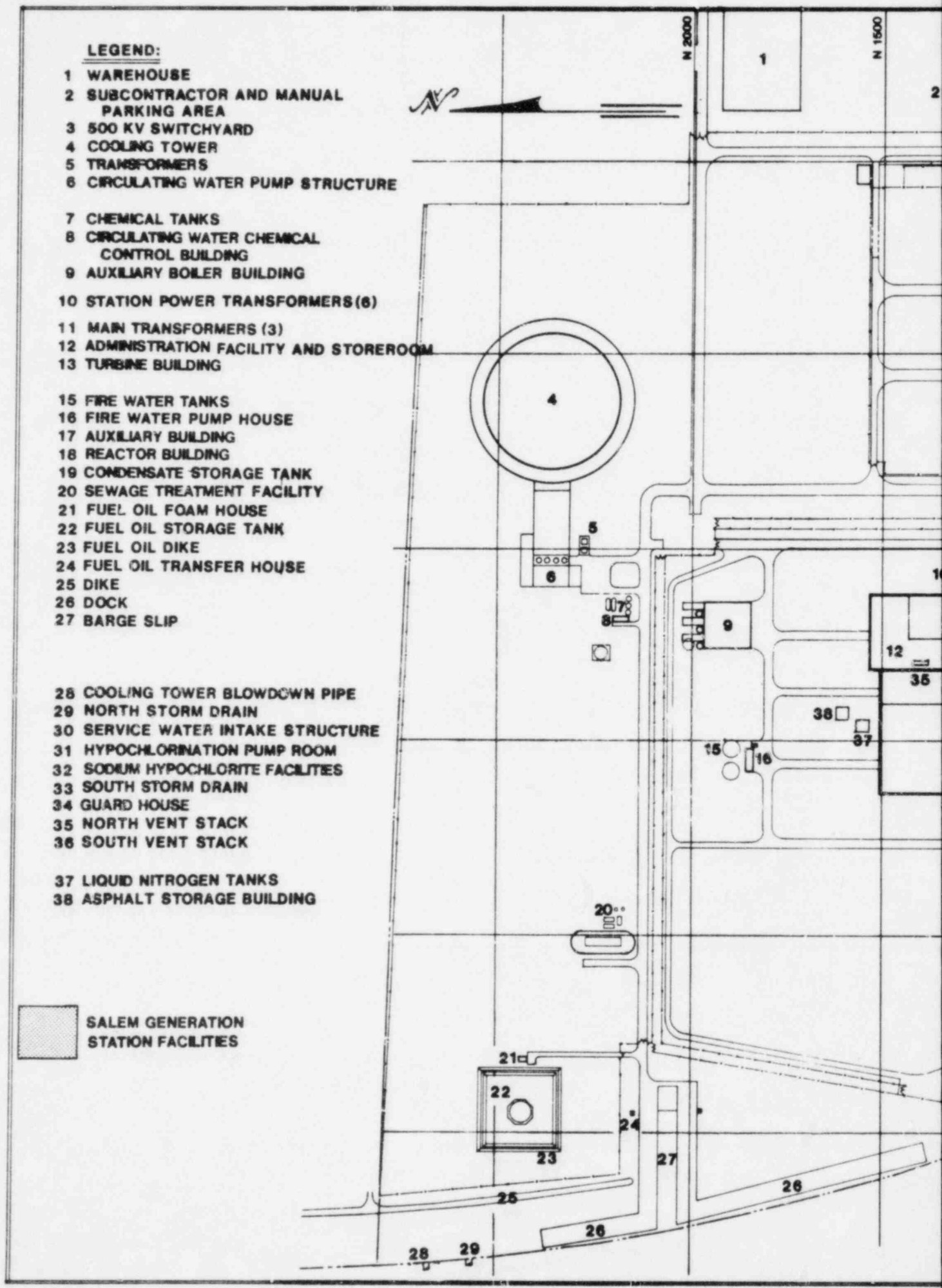
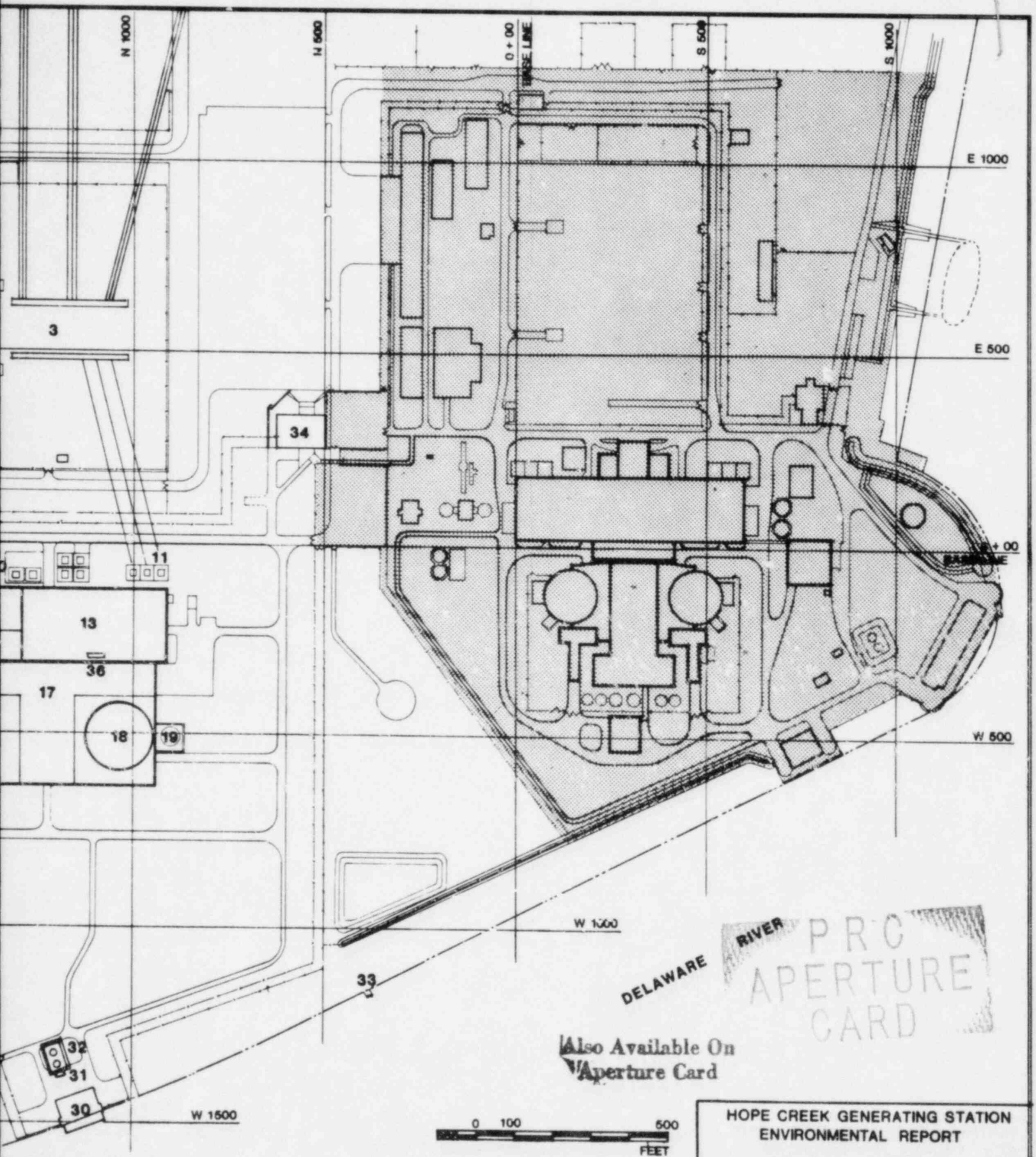
OPERATING LICENSE STAGE

SITE VICINITY
WITHIN 8 KILOMETERS (5 Mi.)

FIGURE 2.1 - 2

8306290435 - 02


LEGEND:
1 WAREHOUSE
2 SUBCONTRACTOR AND MANUAL PARKING AREA
3 500 KV SWITCHYARD
4 COOLING TOWER
5 TRANSFORMERS
6 CIRCULATING WATER PUMP STRUCTURE
7 CHEMICAL TANKS
8 CIRCULATING WATER CHEMICAL CONTROL BUILDING
9 AUXILIARY BOILER BUILDING
10 STATION POWER TRANSFORMERS (6)
11 MAIN TRANSFORMERS (3)
12 ADMINISTRATION FACILITY AND STOREROOM
13 TURBINE BUILDING
15 FIRE WATER TANKS
16 FIRE WATER PUMP HOUSE
17 AUXILIARY BUILDING
18 REACTOR BUILDING
19 CONDENSATE STORAGE TANK
20 SEWAGE TREATMENT FACILITY
21 FUEL OIL FOAM HOUSE
22 FUEL OIL STORAGE TANK
23 FUEL OIL DIKE
24 FUEL OIL TRANSFER HOUSE
25 DIKE
26 DOCK
27 BARGE SLIP
28 COOLING TOWER BLOWDOWN PIPE
29 NORTH STORM DRAIN
30 SERVICE WATER INTAKE STRUCTURE
31 HYPOCHLORINATION PUMP ROOM
32 SODIUM HYPOCHLORITE FACILITIES
33 SOUTH STORM DRAIN
34 GUARD HOUSE
35 NORTH VENT STACK
36 SOUTH VENT STACK
37 LIQUID NITROGEN TANKS
38 ASPHALT STORAGE BUILDING
SALEM GENERATION STATION FACILITIES
N 2000
N 1500
N
1
2
4
5
6
7
8
9
10
12
35
38
37
15
16
20
21
22
23
24
25
26
27
28
29



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NOTE:
COORDINATES USED ARE FROM PSE&G COORDINATE SYSTEM

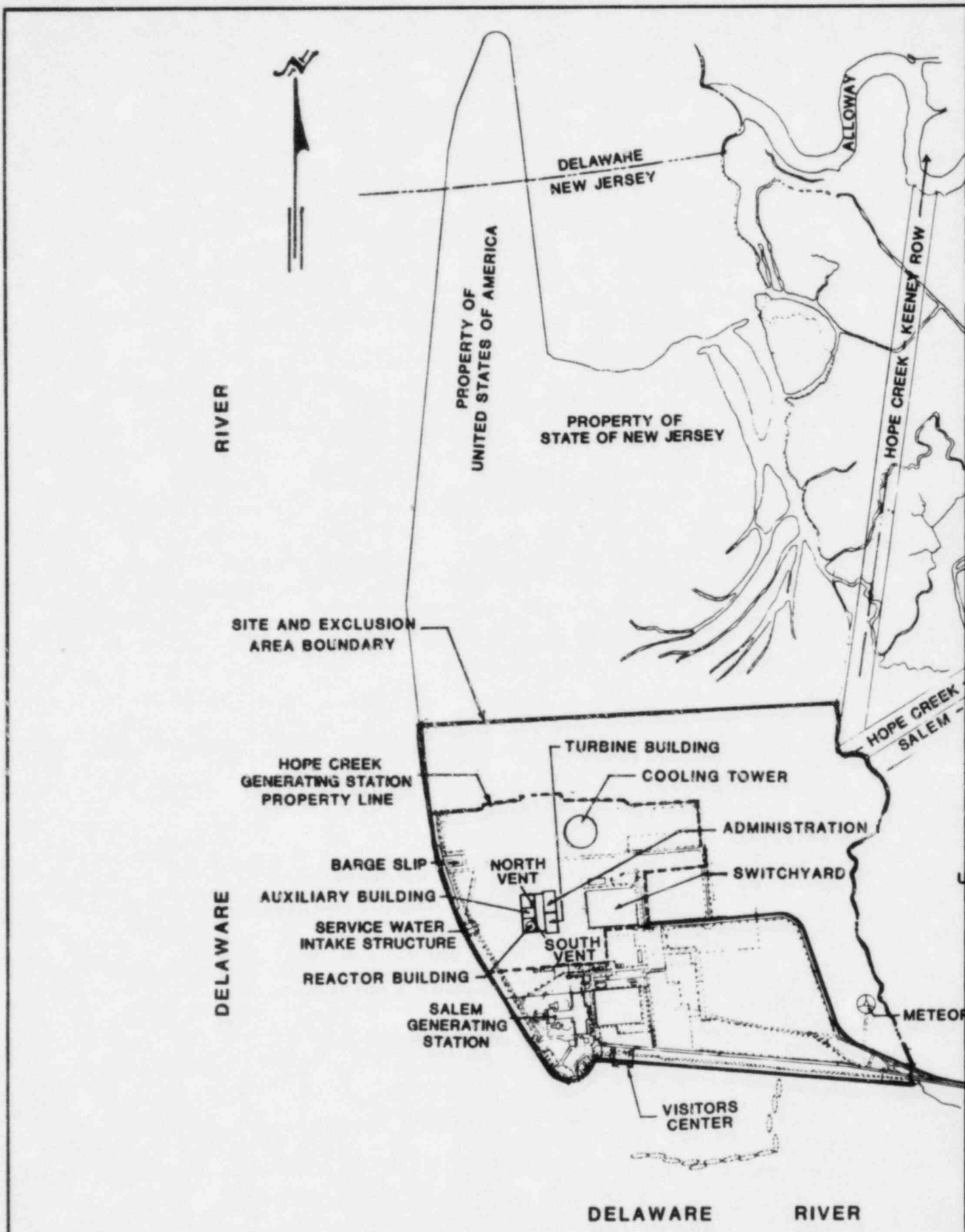
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

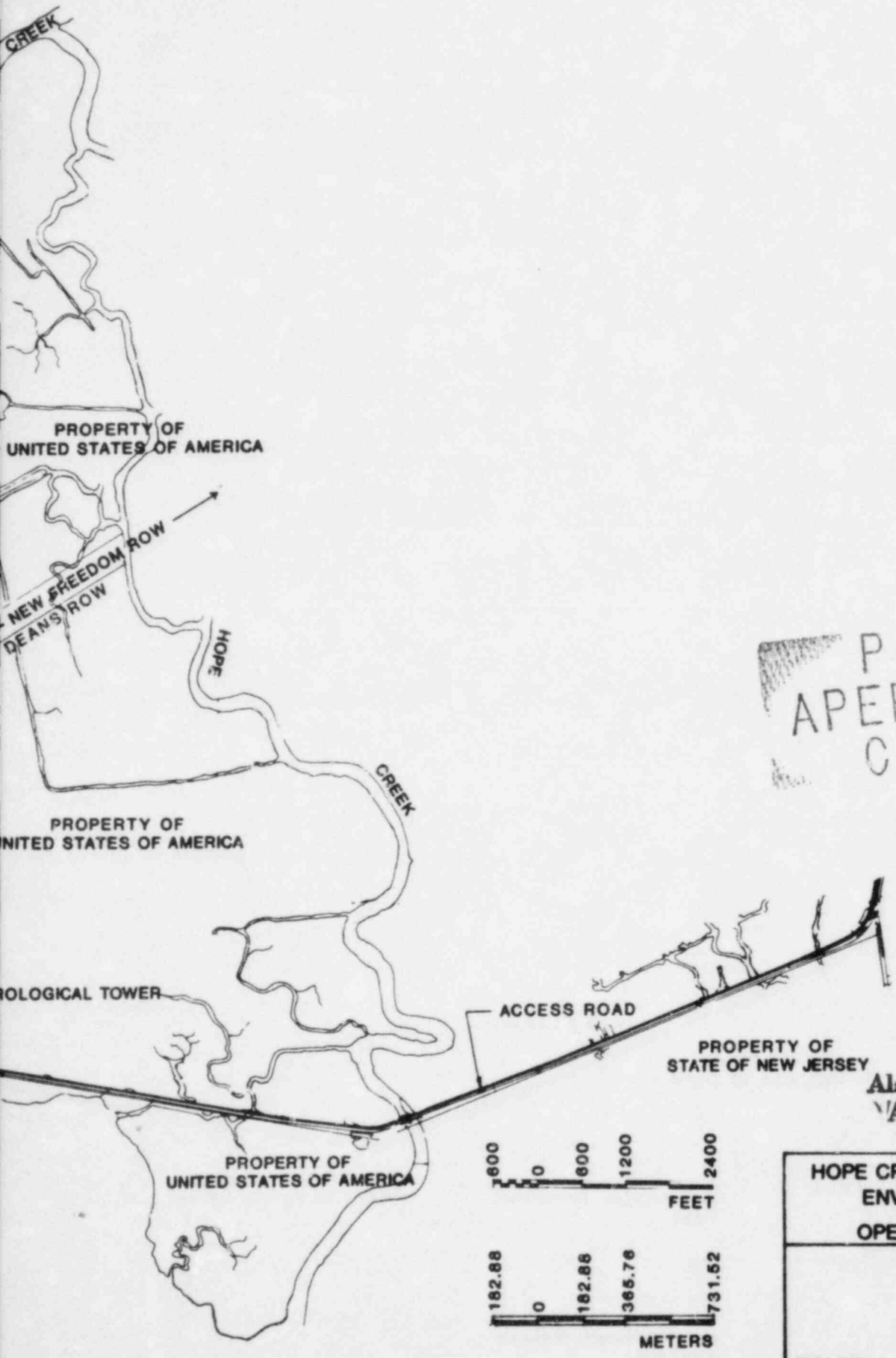
OPERATING LICENSE STAGE

STATION LAYOUT

FIGURE 2.1 - 3

8306290435 -03


DELAWARE
NEW JERSEY
ALLOWAY
PROPERTY OF
UNITED STATES OF AMERICA
RIVER
PROPERTY OF
STATE OF NEW JERSEY
HOPE CREEK - KEENEY ROW
SITE AND EXCLUSION
AREA BOUNDARY
HOPE CREEK
SALEM
TURBINE BUILDING
HOPE CREEK
GENERATING STATION
PROPERTY LINE
COOLING TOWER
ADMINISTRATION
BARGE SLIP
NORTH
VENT
SWITCHYARD
AUXILIARY BUILDING
SERVICE WATER
INTAKE STRUCTURE
SOUTH
VENT
REACTOR BUILDING
SALEM
GENERATING
STATION
METEOR
VISITORS
CENTER
DELAWARE
RIVER
DELAWARE



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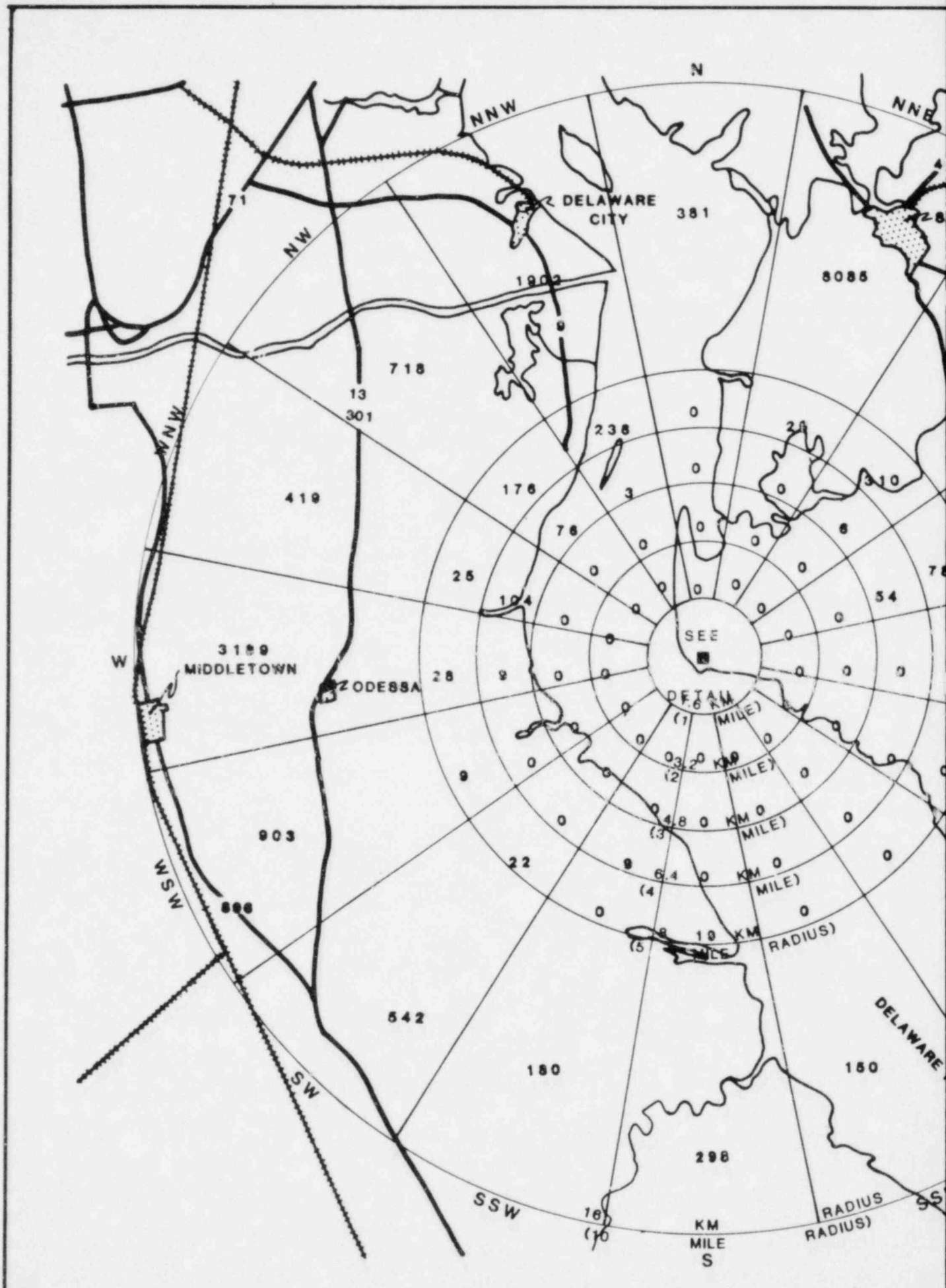
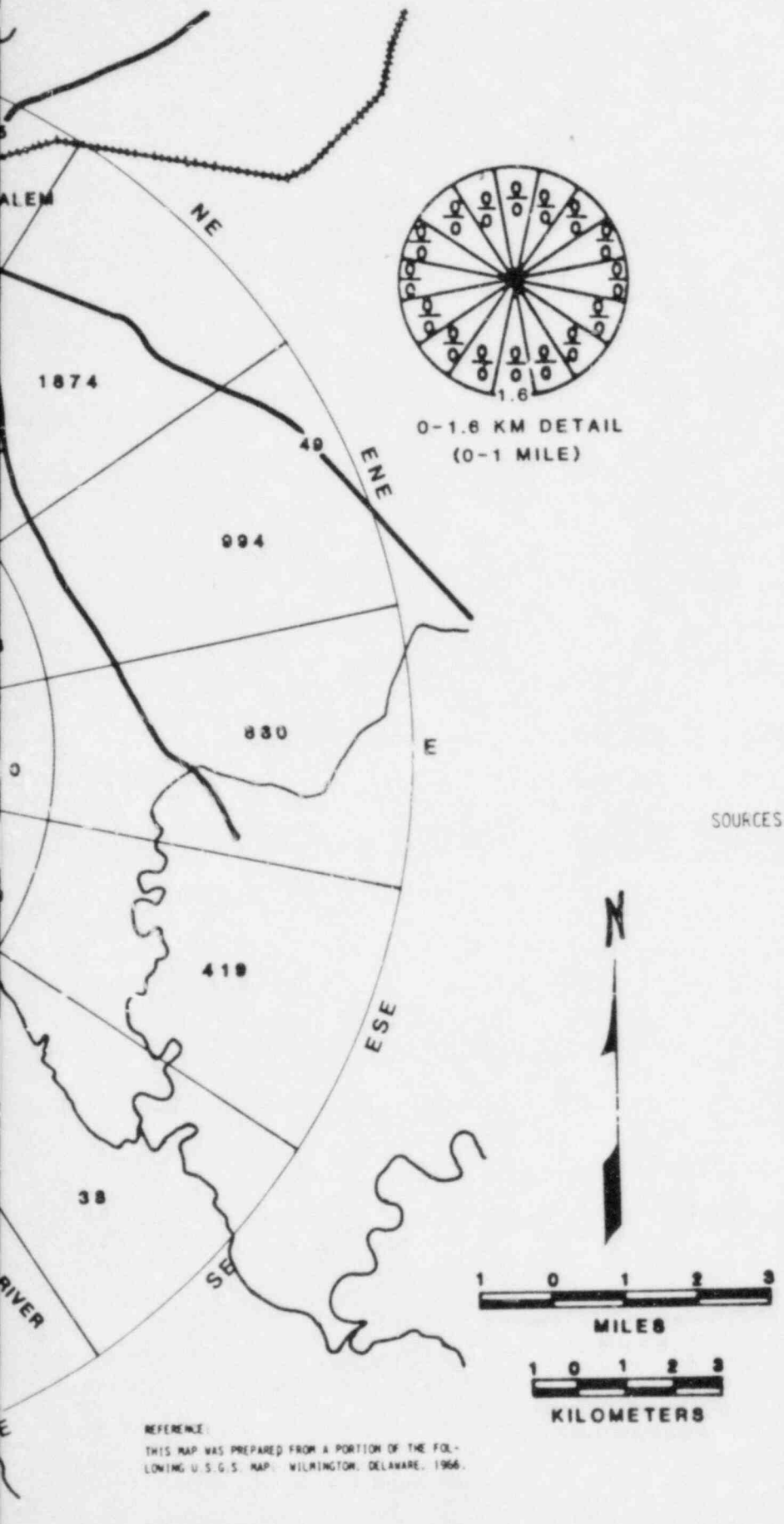
OPERATING LICENSE STAGE

SITE AREA

FIGURE 2.1 - 4

8306290435 - 04


N
NNW
NNE
NW
W
WSW
SW
SSW
S
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
DELAWARE
381
8085
718
419
3189
903
542
180
298
150
1902
238
176
76
25
104
28
22
310
54
71
13
301
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
19 KM (5 MILE RADIUS)
16 (10 KM MILE RADIUS)



SOURCES: 1980 CENSUS OF POPULATION & HOUSING
FOR NEW JERSEY AND DELAWARE

REFERENCE:
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

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HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

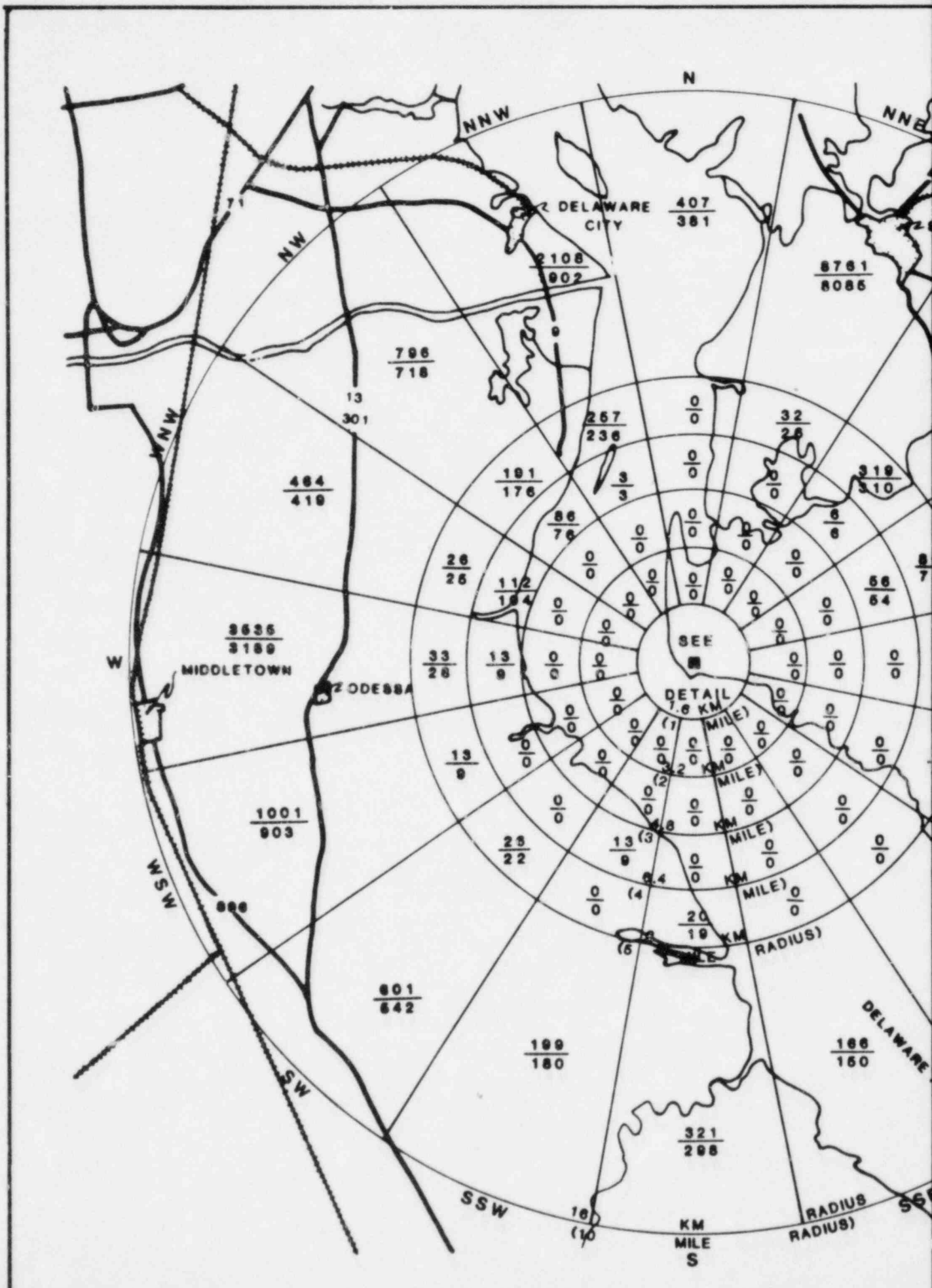
OPERATING LICENSE STAGE

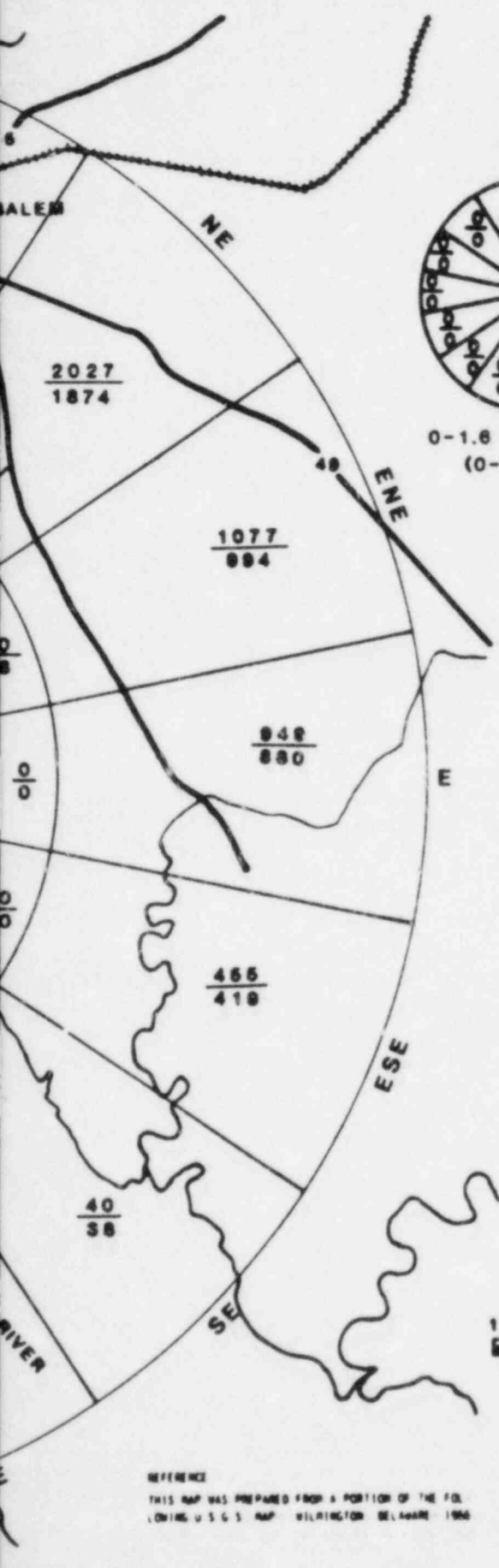
POPULATION DISTRIBUTION 1980

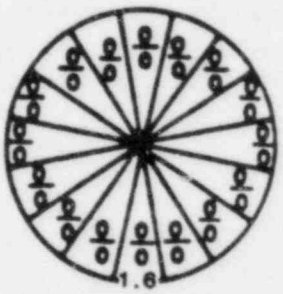
WITHIN 0 - 16 KILOMETERS
(0 - 10 MILES)

FIGURE 2.1 - 5

8809290435 -05


N
NNW
NNE
NW
WNW
W
WSW
SW
SSW
S
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
20 19 KM (5 MILE RADIUS)
16 (10 KM MILE RADIUS)
407 381
2108 902
8761 8085
796 718
13 301
257 236
32 26
464 419
191 176
3 3
319 310
86 76
6 6
26 25
112 104
56 54
3535 3189
33 28
13 9
13 9
1001 903
25 22
13 9
601 642
199 180
166 150
321 298
DELAWARE
71
9
886





0-1.6 KM DETAIL
(0-1 MILE)

KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	407 381	407 381
NNE	–	–	–	–	32 26	8761 8085	8793 8111
NE	–	–	–	6 6	319 310	2027 1874	2352 2190
ENE	–	–	–	56 54	80 78	1077 994	1213 1126
E	–	–	–	–	–	949 880	949 880
ESE	–	–	–	–	–	455 419	455 419
SE	–	–	–	–	–	40 38	40 38
SSE	–	–	–	–	–	166 150	166 150
S	–	–	–	–	20 19	321 298	341 317
SSW	–	–	–	13 9	–	199 180	212 189
SW	–	–	–	–	26 22	601 542	627 564
WSW	–	–	–	–	13 9	1001 903	1014 912
W	–	–	–	13 9	33 28	3535 3189	3581 3226
WNW	–	–	–	112 104	26 25	464 419	602 548
NW	–	–	–	86 76	131 176	596 718	813 970
NNW	–	–	–	3 3	257 236	2108 1902	2368 2141
TOTAL	–	–	–	289 261	997 929	22907 20972	24193 22162

1987 POPULATION / 1980 POPULATION — PROJECTED / EXISTING

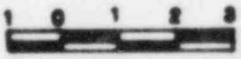
RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	1987	–	–	–	239	1286	24193
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS (1980-2020), FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.



REFERENCE
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON DELAWARE 1966

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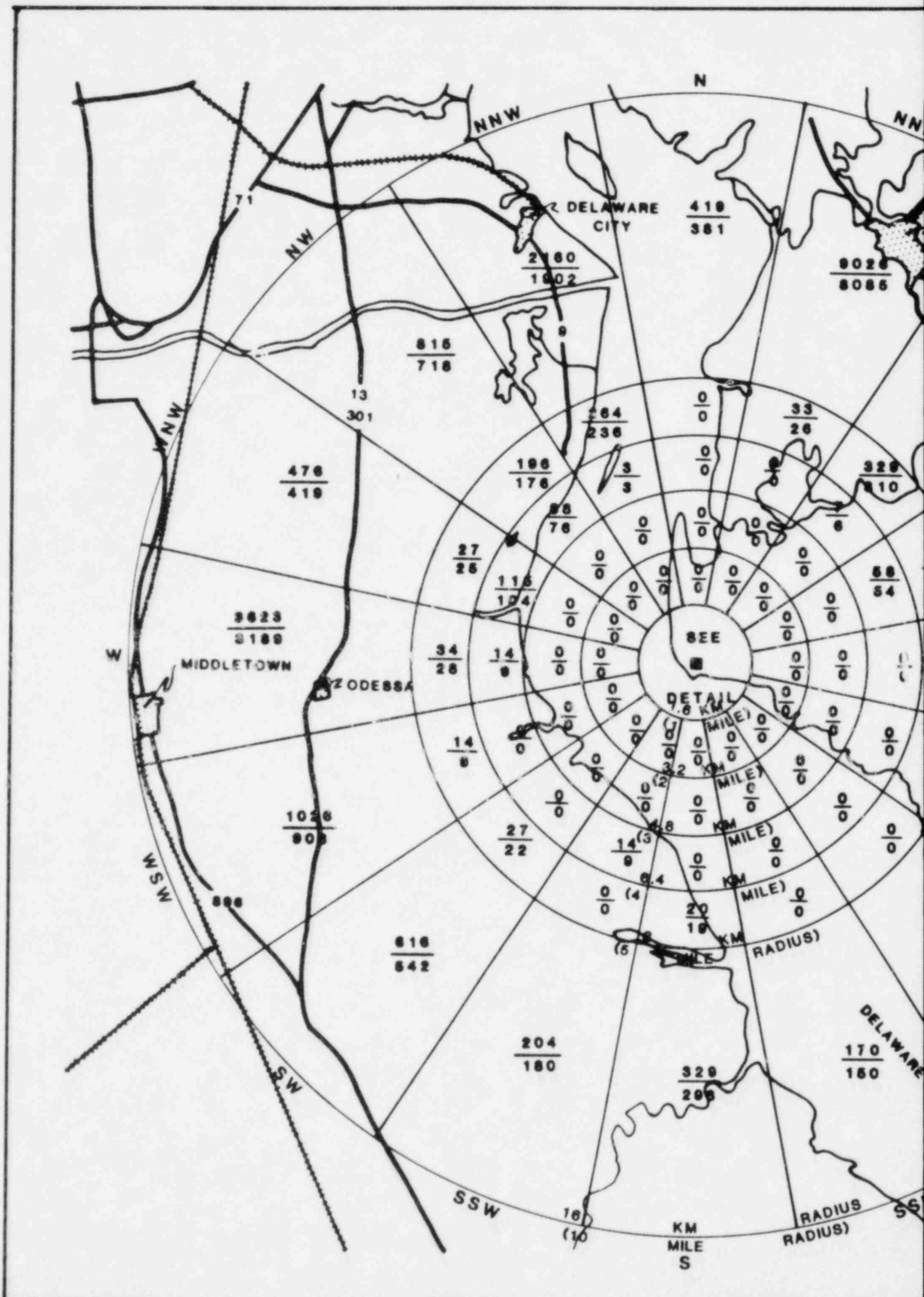
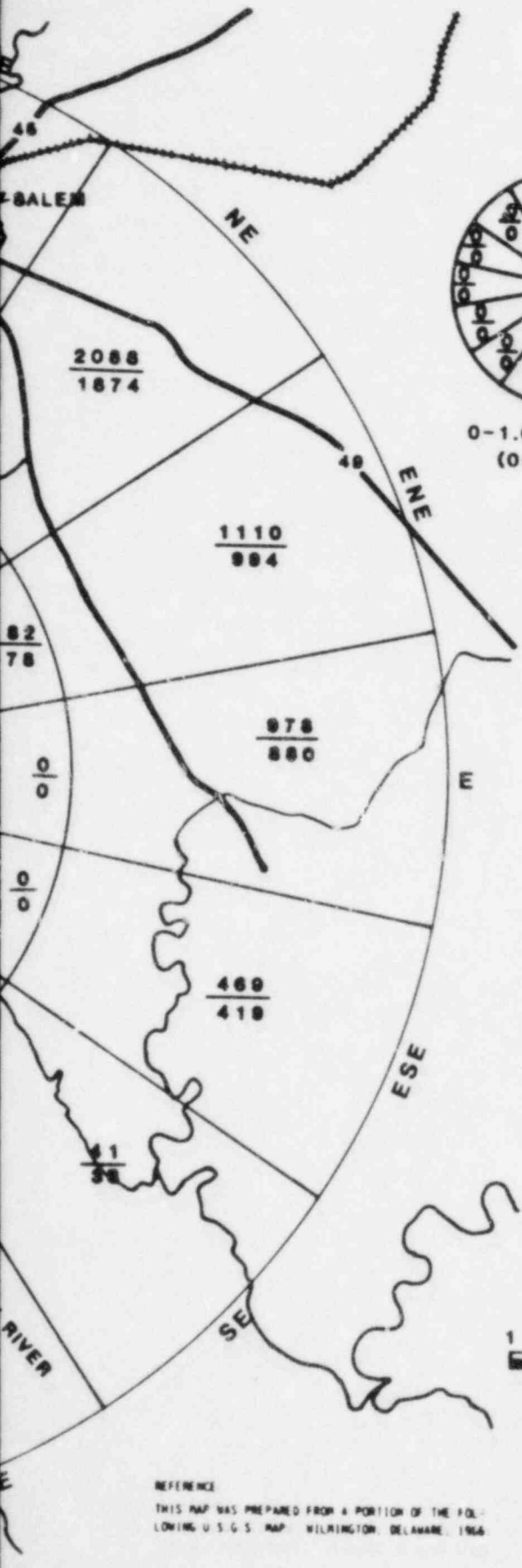
OPERATING LICENSE STAGE

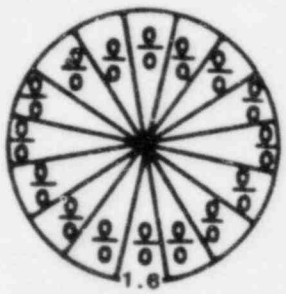
POPULATION PROJECTIONS
AND DISTRIBUTION 1987
WITHIN 0 - 16 KILOMETERS
(0 - 10 MILES)

FIGURE 2.1 - 6

8306290435 - 06


N
NNW
NW
WNW
W
WSW
SW
SSW
S
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
DELAWARE
419
381
2160
1902
9026
8085
815
718
13
301
71
476
419
3623
3189
1026
908
616
542
204
180
329
298
170
150
264
236
196
176
33
26
329
310
58
54
34
28
27
25
27
22
14
9
20
19
16
(10
KM
MILE
RADIUS)
RADIUS
KM
MILE
(1
(2
(3
(4
(5
3.2
4.8
6.4





0-1.6 KM DETAIL
(0-1 MILE)

KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	419 381	419 381
NNE	–	–	–	–	33 26	9026 8085	9059 8111
NE	–	–	–	7 6	329 310	2088 1874	2424 2190
ENE	–	–	–	58 54	82 78	1110 994	1250 1126
E	–	–	–	–	–	978 880	978 880
ESE	–	–	–	–	–	469 419	469 419
SE	–	–	–	–	–	41 36	41 36
SSE	–	–	–	–	–	170 150	170 150
S	–	–	–	–	20 19	329 298	349 317
SSW	–	–	–	14 9	–	204 180	218 189
SW	–	–	–	–	27 22	616 542	643 564
WSW	–	–	–	–	14 9	1026 903	1040 912
W	–	–	–	14 9	34 28	3623 3189	3671 3226
WNW	–	–	–	115 104	27 25	476 419	618 548
NW	–	–	–	88 76	196 176	815 718	1099 970
NNW	–	–	–	3 3	264 236	2160 1902	2427 2141
TOTAL	–	–	–	299 261	1026 929	23550 20972	24875 22162

1990 POPULATION PROJECTED
1980 POPULATION EXISTING

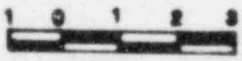
RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	1990	–	–	–	299	1325	24875
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.



REFERENCE
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966

PRC
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CARD

Also Available On
Aperture Card

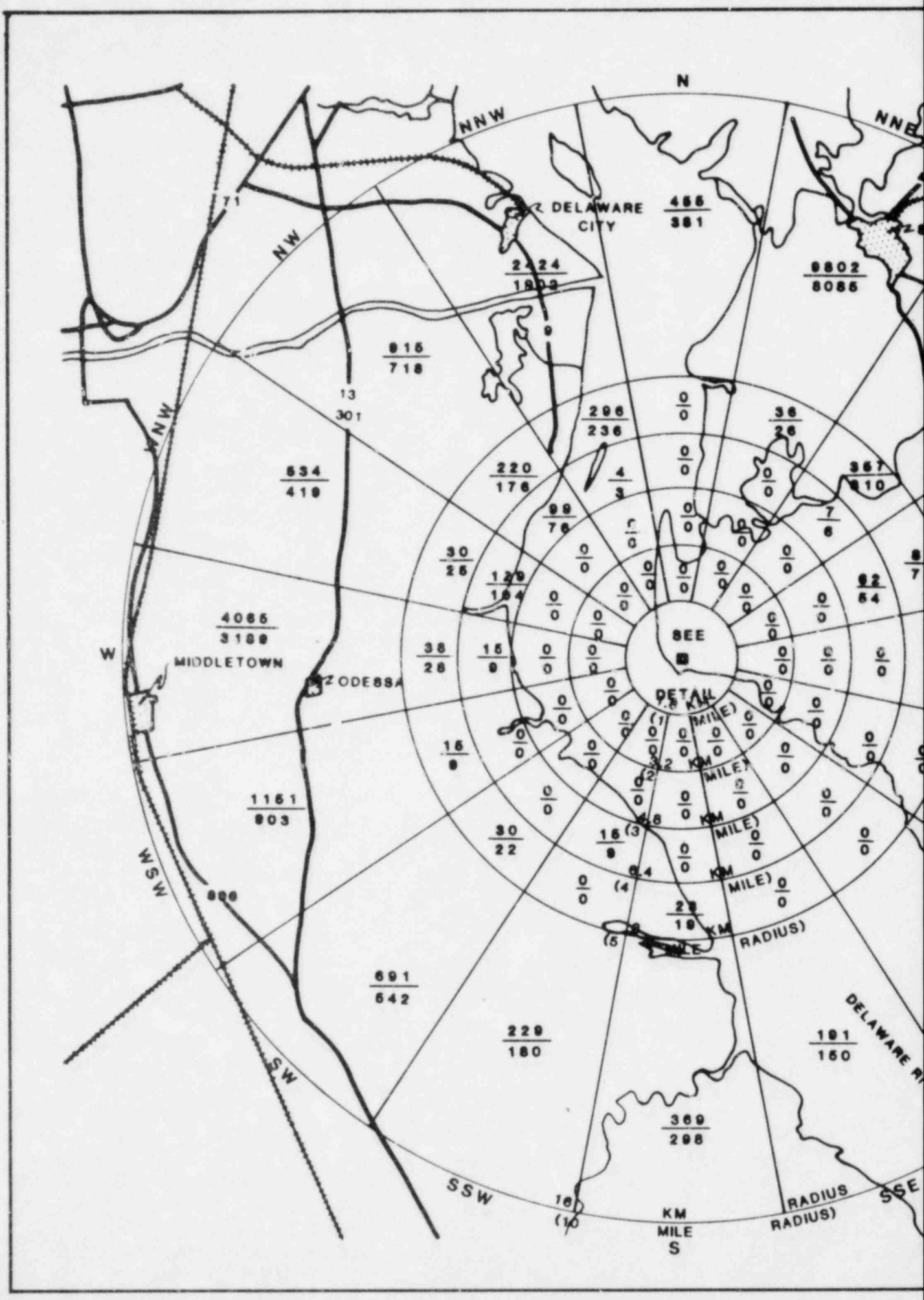
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

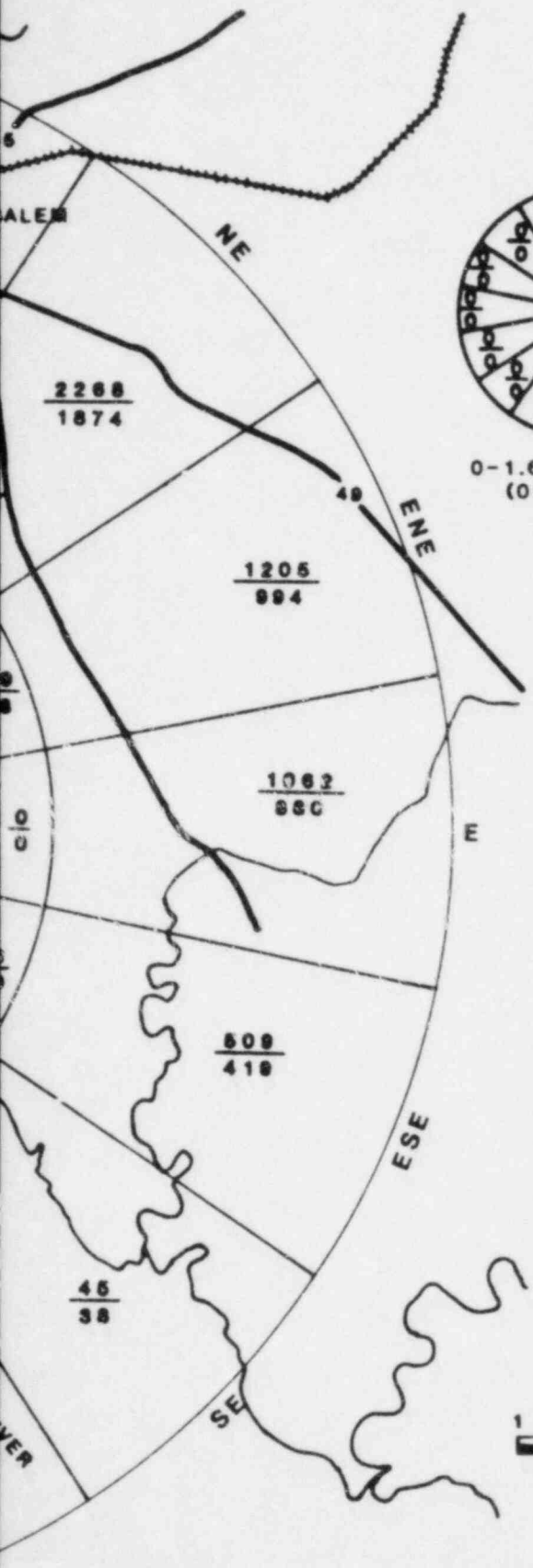
OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 1990 WITHIN 0 - 16 KILOMETERS (0 - 10 MILES)

FIGURE 2.1 - 7

8306290435 -07


N
NNW
NNE
NW
WNW
W
WSW
SW
SSW
SSE
S
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
DELAWARE RI
KM
MILE
RADIUS)
455
381
2424
1803
9802
8085
915
718
13
301
71
296
236
36
26
534
419
220
176
4
3
357
810
99
76
7
6
30
25
129
104
62
54
4065
3189
38
28
15
9
15
9
1151
903
30
22
15
9
691
542
229
180
191
150
369
298



KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	455 / 381	455 / 381
NNE	–	–	–	–	36 / 26	5807 / 8085	5818 / 8111
NE	–	–	–	6	357 / 310	2268 / 1874	2632 / 2190
ENE	–	–	–	62 / 54	89 / 78	1205 / 994	1356 / 1126
E	–	–	–	–	–	1062 / 880	1062 / 880
ESE	–	–	–	–	–	509 / 419	509 / 419
SE	–	–	–	–	–	45 / 38	45 / 38
SSE	–	–	–	–	–	191 / 150	191 / 150
S	–	–	–	–	23 / 19	369 / 298	392 / 317
SSW	–	–	–	15 / 9	–	229 / 180	244 / 189
SW	–	–	–	–	30 / 22	691 / 542	721 / 564
WSW	–	–	–	–	15 / 9	1151 / 903	1166 / 912
W	–	–	–	15 / 9	38 / 28	4065 / 3189	4118 / 3226
WNW	–	–	–	129 / 104	30 / 25	534 / 419	693 / 548
NW	–	–	–	99 / 76	220 / 176	915 / 718	1234 / 970
NNW	–	–	–	4 / 3	296 / 236	2424 / 1902	2724 / 2141
TOTAL	–	–	–	331 / 261	1134 / 929	25915 / 20972	27380 / 22162

2000 POPULATION PROJECTED
1980 POPULATION EXISTING

RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	2000	–	–	–	331	1465	27380
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

REFERENCE

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1956.

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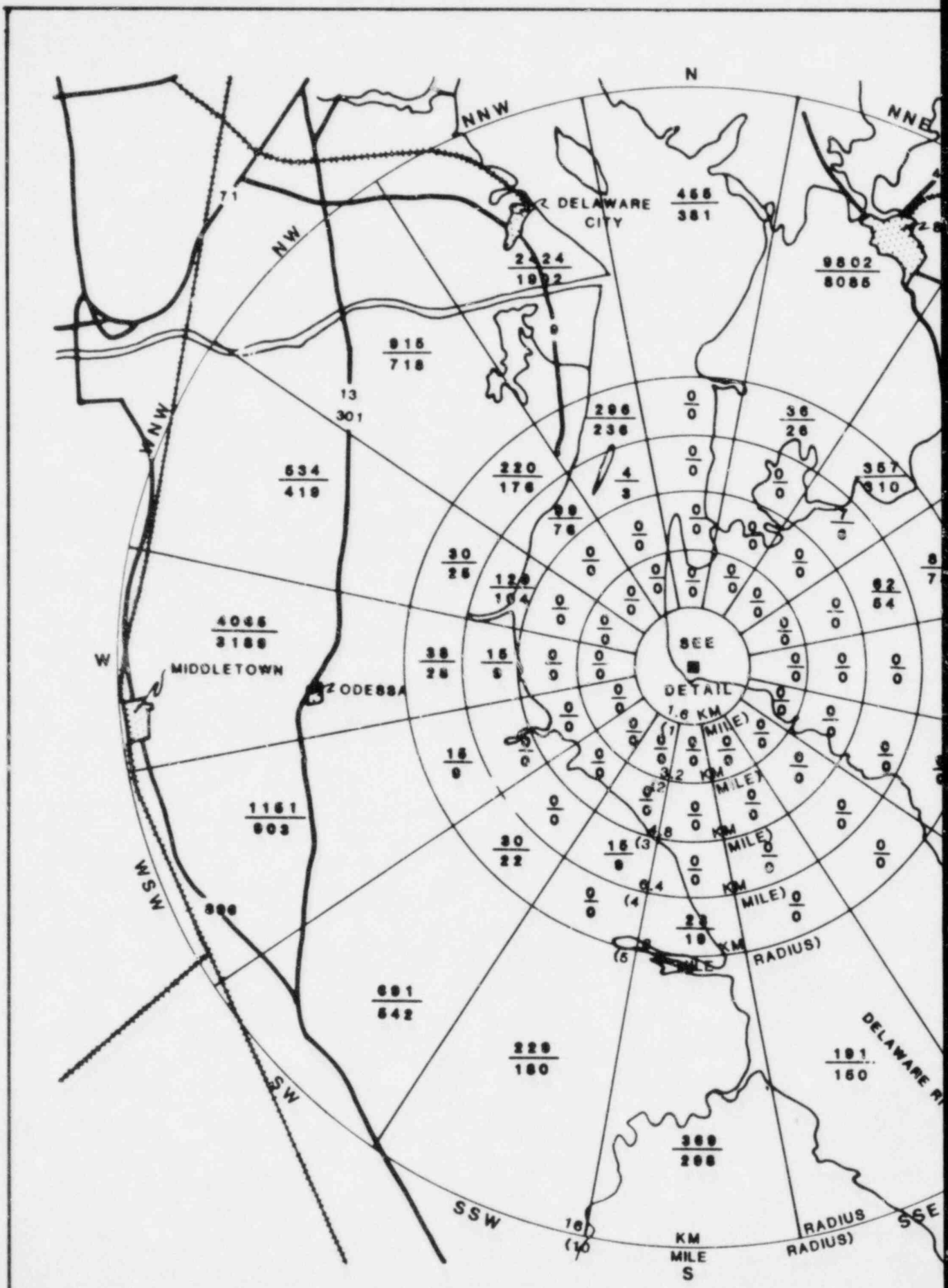
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

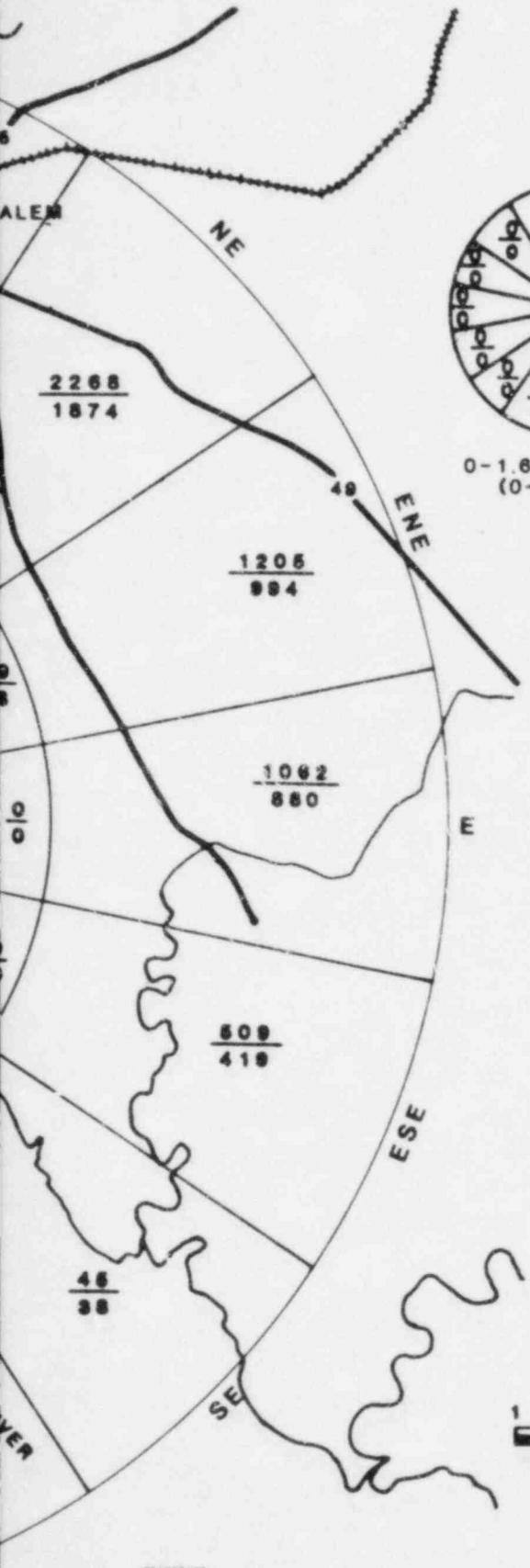
OPERATING LICENSE STAGE

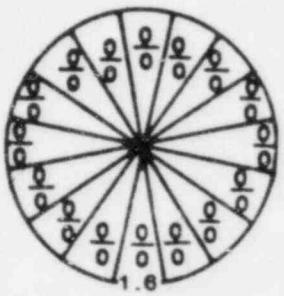
POPULATION PROJECTIONS AND DISTRIBUTION 2000 WITHIN 0 - 16 KILOMETERS (0 - 10 MILES)

FIGURE 2.1 - 8

8306290435 – 08


N
NNW
NNE
NW
WNW
W
WSW
SW
SSW
SSE
S
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
(5 KM MILE RADIUS)
DELAWARE R
71
13
301
896
455
381
2424
1992
9802
8085
915
718
296
236
36
26
534
419
220
176
4
3
357
310
99
76
30
25
129
104
62
54
4065
3189
38
28
15
9
1151
903
30
22
691
542
229
180
191
150
369
298
16
(10 KM MILE RADIUS)





0-1.6 KM DETAIL
(0-1 MILE)

KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	455 / 381	455 / 381
NNE	–	–	–	–	16 / 26	8802 / 8085	8818 / 8111
NE	–	–	–	7 / 6	357 / 310	2268 / 1874	2632 / 2190
ENE	–	–	–	62 / 54	89 / 78	1205 / 994	1356 / 1126
E	–	–	–	–	–	1062 / 880	1062 / 880
ESE	–	–	–	–	–	509 / 419	509 / 419
SE	–	–	–	–	–	45 / 38	45 / 38
SSE	–	–	–	–	–	191 / 150	191 / 150
S	–	–	–	–	23 / 19	369 / 298	392 / 317
SSW	–	–	–	15 / 9	–	229 / 180	244 / 189
SW	–	–	–	–	30 / 22	691 / 542	721 / 564
WSW	–	–	–	–	15 / 9	1151 / 903	1166 / 912
W	–	–	–	15 / 9	38 / 28	4065 / 3189	4118 / 3226
WNW	–	–	–	129 / 104	30 / 25	534 / 419	693 / 548
NW	–	–	–	99 / 76	220 / 176	915 / 718	1234 / 970
NNW	–	–	–	5 / 3	296 / 236	2424 / 1902	2724 / 2141
TOTAL	–	–	–	331 / 261	1134 / 929	25915 / 20972	27380 / 22162

2010 POPULATION PROJECTED
1980 POPULATION EXISTING

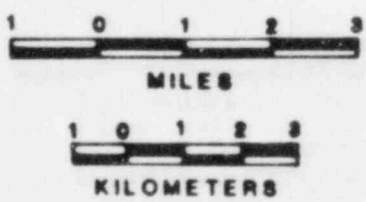
RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	2010	–	–	–	331	1465	27380
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.



REFERENCE
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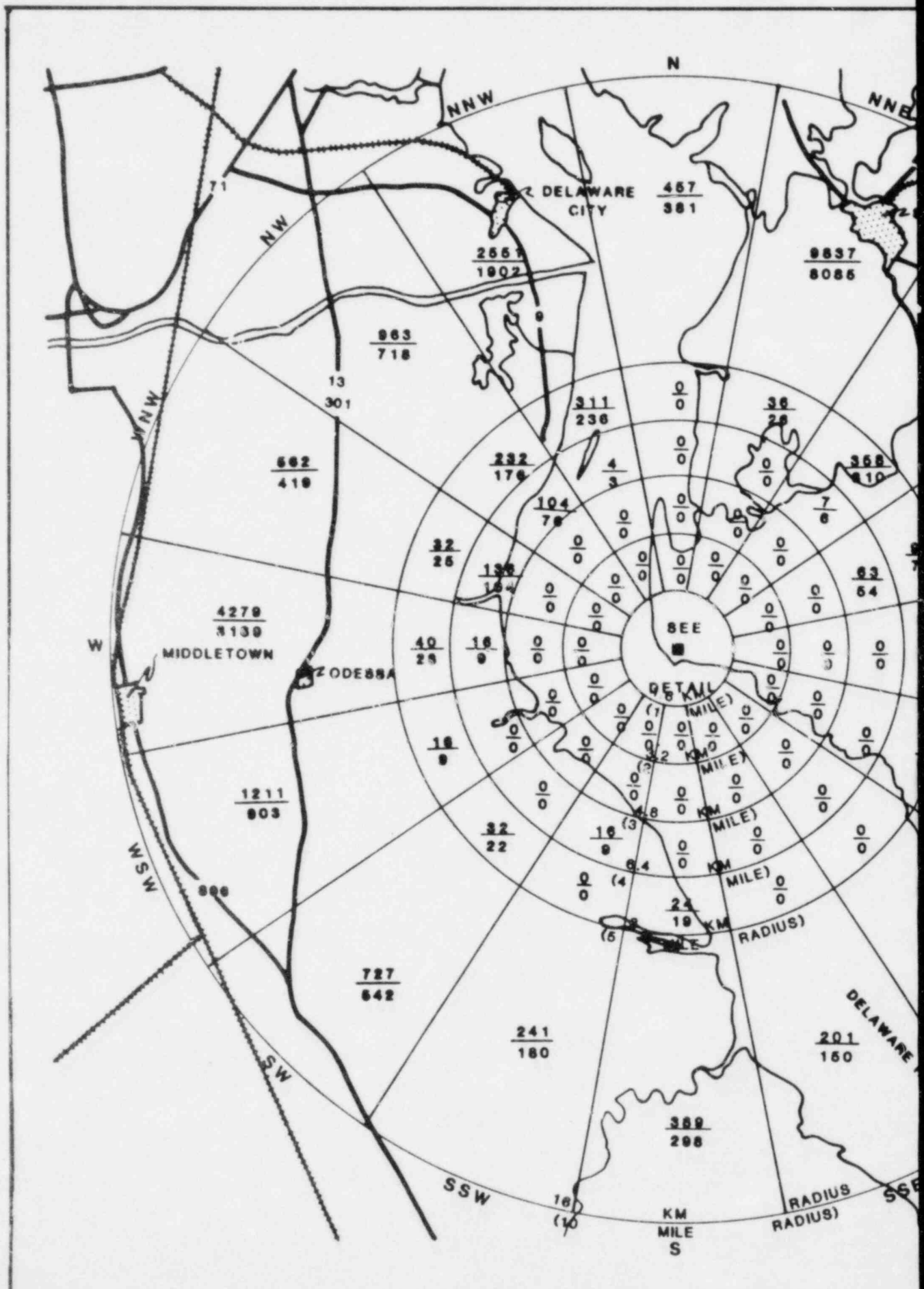
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

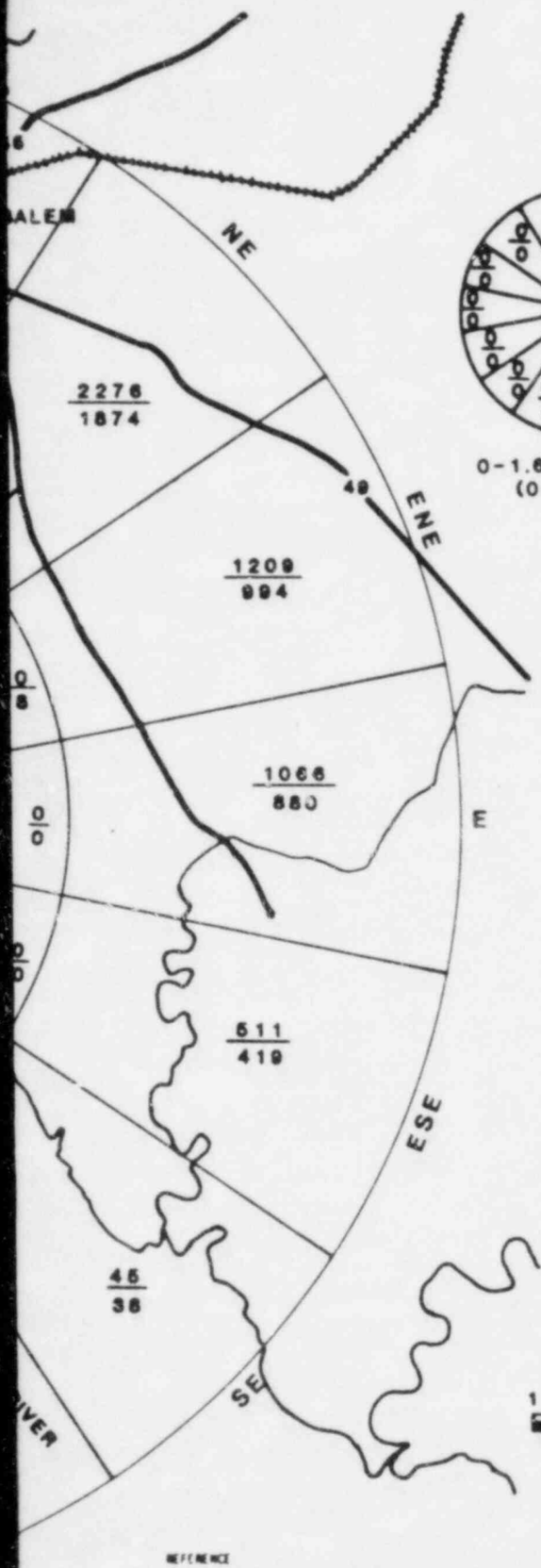
OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 2010 WITHIN 0 - 16 KILOMETERS (0 - 10 MILES)

FIGURE 2.1 - 9

8306280435 -09


N
NNW
NNE
NW
WNW
W
WSW
SW
SSW
S
SSE
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
DELAWARE
457
381
2551
1902
9837
8085
963
718
13
301
71
311
236
36
28
562
419
232
176
4
3
358
810
104
76
7
6
32
25
63
54
4279
3139
40
28
16
9
16
9
1211
903
32
22
16
9
24
19
727
542
241
180
201
150
389
298
KM
MILE
RADIUS
RADIUS)



KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	457/381	457/381
NNE	–	–	–	–	16/12	9817/8085	9871/8111
NE	–	–	–	7/6	358/310	2276/1874	2641/2190
ENE	–	–	–	63/55	53/48	1209/995	1362/1176
E	–	–	–	–	–	1066/880	1066/880
ESE	–	–	–	–	–	511/419	511/419
SE	–	–	–	–	–	45/38	45/38
SSE	–	–	–	–	–	201/150	201/150
S	–	–	–	–	24/19	389/298	413/317
SSW	–	–	–	16/9	–	241/180	257/189
SW	–	–	–	–	32/27	727/537	759/564
WSW	–	–	–	–	16/9	1211/903	1227/912
W	–	–	–	16/9	40/28	4279/3189	4335/3226
WNW	–	–	–	136/104	32/25	562/419	730/548
NW	–	–	–	104/74	232/196	853/700	1189/970
NNW	–	–	–	4/3	311/236	2551/1902	2866/2141
TOTAL	–	–	–	346/261	1171/929	26525/20972	28042/22162

2020 POPULATION PROJECTED
1980 POPULATION EXISTING

RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	2020	–	–	–	346	1517	28042
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

REFERENCE
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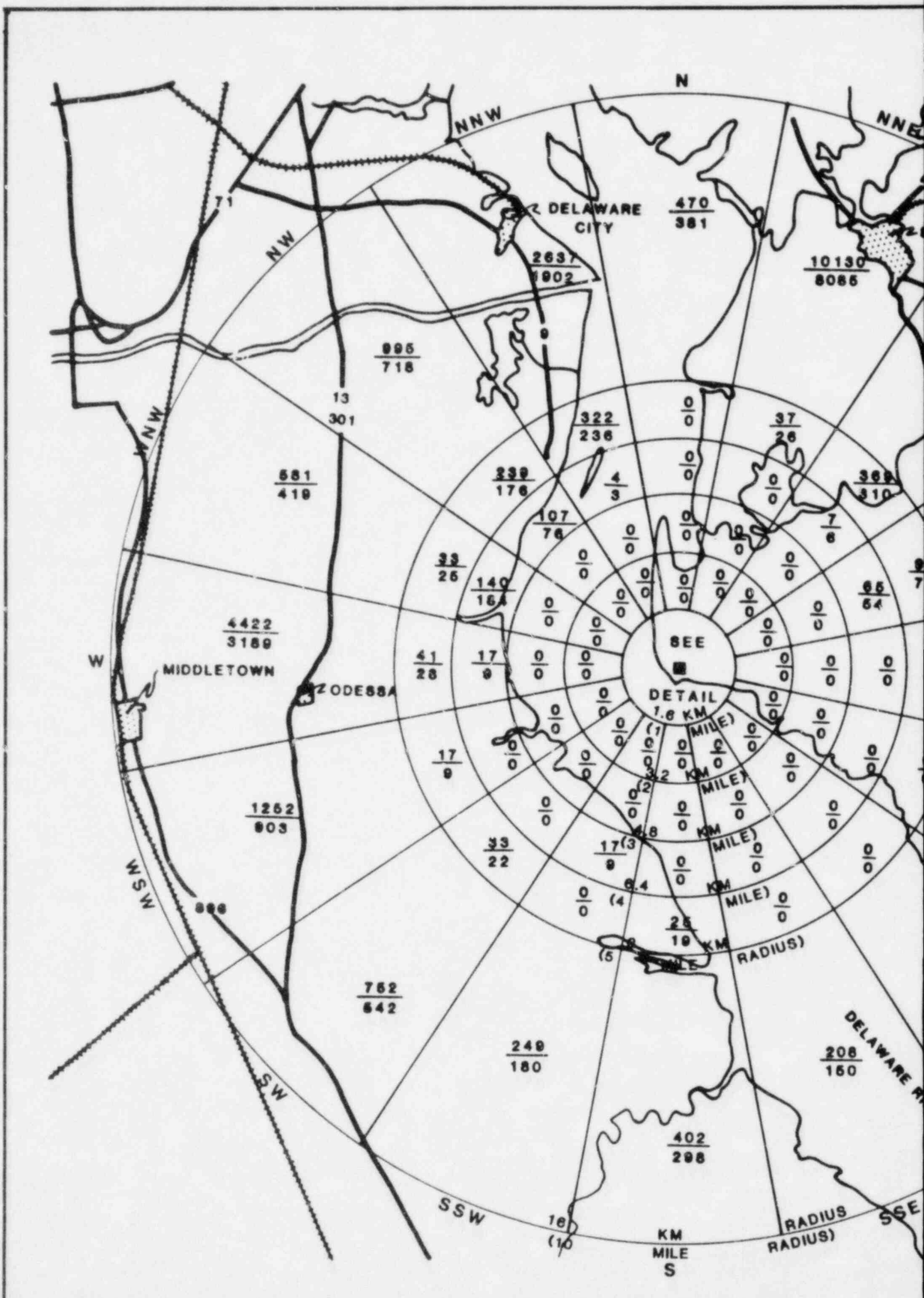
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

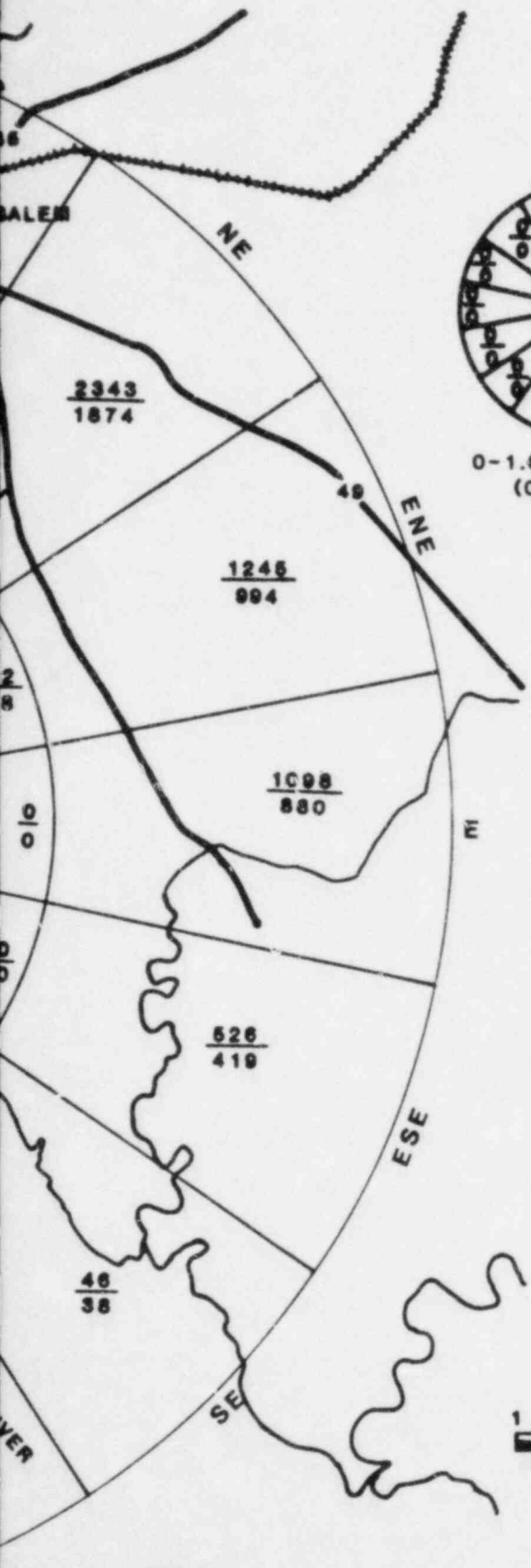
POPULATION PROJECTIONS AND DISTRIBUTION 2020
WITHIN 0 - 16 KILOMETERS (0 - 10 MILES)

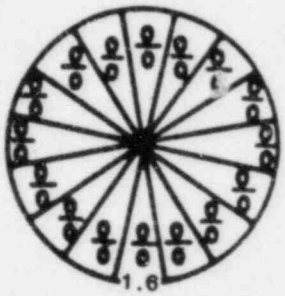
FIGURE 2.1 - 10

8306290435 -10


N
NNW
NNE
NW
WNW
W
WSW
SW
SSW
S
SSE
DELAWARE CITY
MIDDLETOWN
ODESSA
SEE DETAIL
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
25 19 KM (5 MILE RADIUS)
16 (10 KM MILE RADIUS)
DELAWARE R
470 381
2637 1902
10130 8085
995 718
13 301
322 236
37 26
581 419
239 176
4 3
369 310
107 76
7 6
33 25
140 164
65 54
4422 3189
41 28
17 9
17 9
1252 903
33 22
17 9
752 542
249 180
208 150
402 298
71
9
0 0

PRC
APERTURE
CARD





0-1.6 KM DETAIL
(0-1 MILE)

KMS	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	TOTAL
N	–	–	–	–	–	476 / 381	476 / 381
NNE	–	–	–	–	37 / 26	10130 / 8085	10167 / 8111
NE	–	–	–	7 / 6	369 / 318	2343 / 1874	2719 / 2198
ENE	–	–	–	65 / 54	92 / 78	1245 / 994	1402 / 1126
E	–	–	–	–	–	1098 / 880	1098 / 880
ESE	–	–	–	–	–	526 / 419	526 / 419
SE	–	–	–	–	–	46 / 38	46 / 38
SSE	–	–	–	–	–	208 / 150	208 / 150
S	–	–	–	–	25 / 19	402 / 298	427 / 317
SSW	–	–	–	17 / 9	–	249 / 180	266 / 189
SW	–	–	–	–	33 / 22	752 / 542	785 / 564
WSW	–	–	–	–	17 / 9	1252 / 903	1269 / 912
W	–	–	–	17 / 9	41 / 28	4422 / 3189	4480 / 3226
WNW	–	–	–	140 / 104	33 / 25	581 / 419	754 / 548
NW	–	–	–	107 / 76	239 / 176	995 / 718	1341 / 970
NNW	–	–	–	4 / 3	322 / 236	2637 / 1902	2963 / 2141
TOTAL	–	–	–	357 / 261	1208 / 929	27356 / 20972	28921 / 22162

2030 POPULATION PROJECTED
1980 POPULATION EXISTING

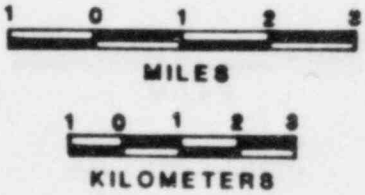
RADIUS IN KMS	YEAR	0-1.6	0-3.2	0-4.8	0-6.4	0-8	0-16
ACCUMULATED POPULATION	2030	–	–	–	357	1565	28921
	1980	–	–	–	261	1190	22162

SOURCES: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY AND DELAWARE

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.



REFERENCE:
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

Also Available On Aperture Card

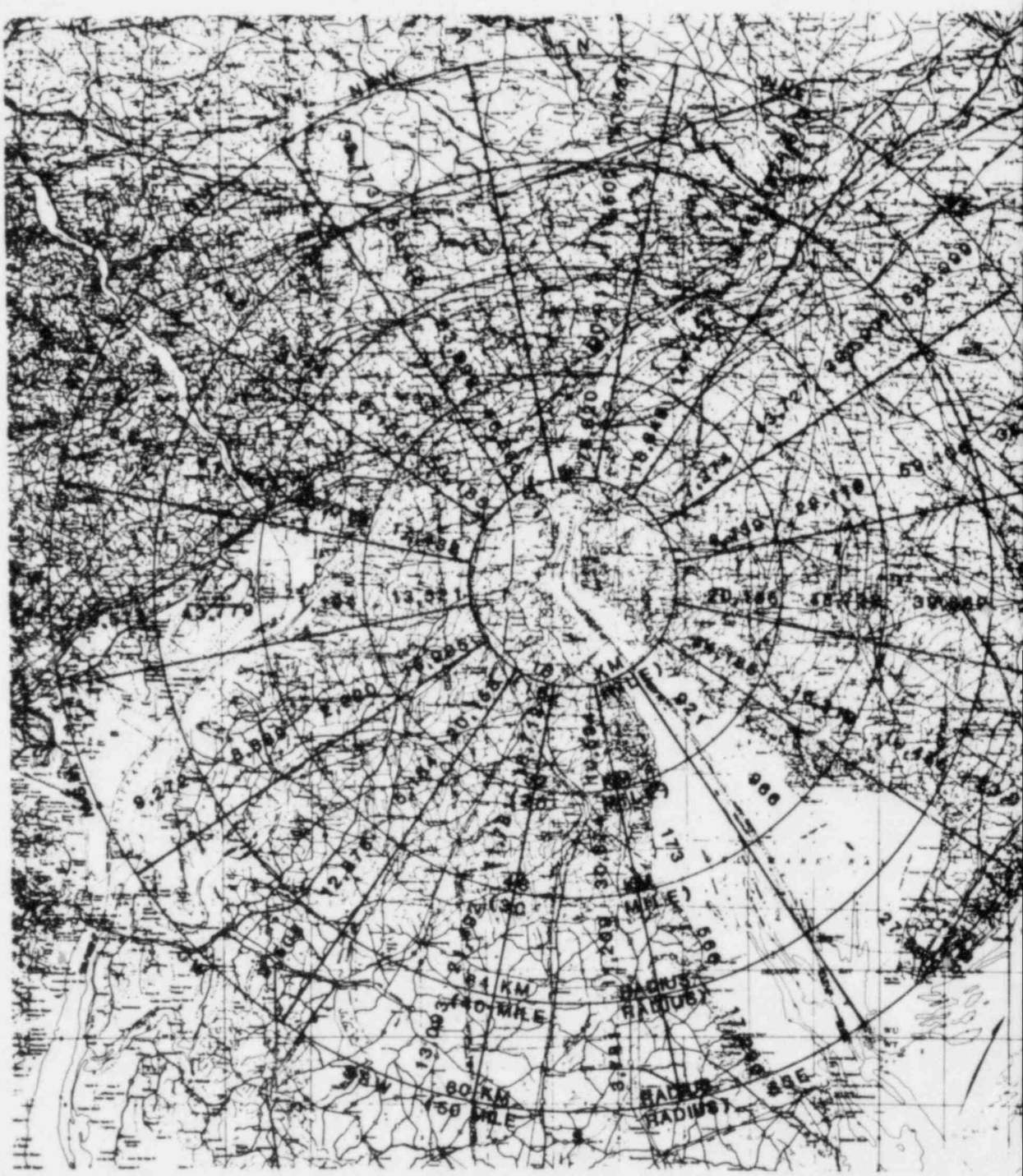
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS
AND DISTRIBUTION 2030
WITHIN 0 - 16 KILOMETERS
(0 - 10 MILES)

FIGURE 2.1 - 11

8306290435 -11



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5
KILOMETE

KMS	16-32	32-48	48-64	64-80	TOTAL
N	76.8	90.9	110.5	141.6	419.8
NNE	18.6	147.7	1134.2	928.8	2229.3
NE	7.3	43.7	391.9	528.1	971.0
ENE	6.1	29.1	59.1	39.2	133.5
E	20.2	48.7	39.9	23.2	132.0
ESE	14.2	16.3	10.5	23.0	64.0
SE	.9	1.0	—	27.9	29.8
SSE	—	.2	.6	17.2	18.0
S	10.6	30.7	11.2	3.8	56.3
SSW	18.7	11.8	21.5	13.1	65.1
SW	20.2	5.2	12.9	7.5	45.7
WSW	16.0	2.9	8.9	9.3	37.1
W	13.5	1.2	43.8	229.6	288.1
WNW	17.4	22.0	41.3	16.5	97.3
NW	53.2	26.2	15.1	29.4	124.2
NNW	46.9	63.6	50.4	38.8	199.7
TOTAL	340.6	541.2	1952.0	2077.1	4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	1980	22.2	362.8	904.0	2855.9	4933.0

POPULATION IN 000'S

PRC APERTURE CARD

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

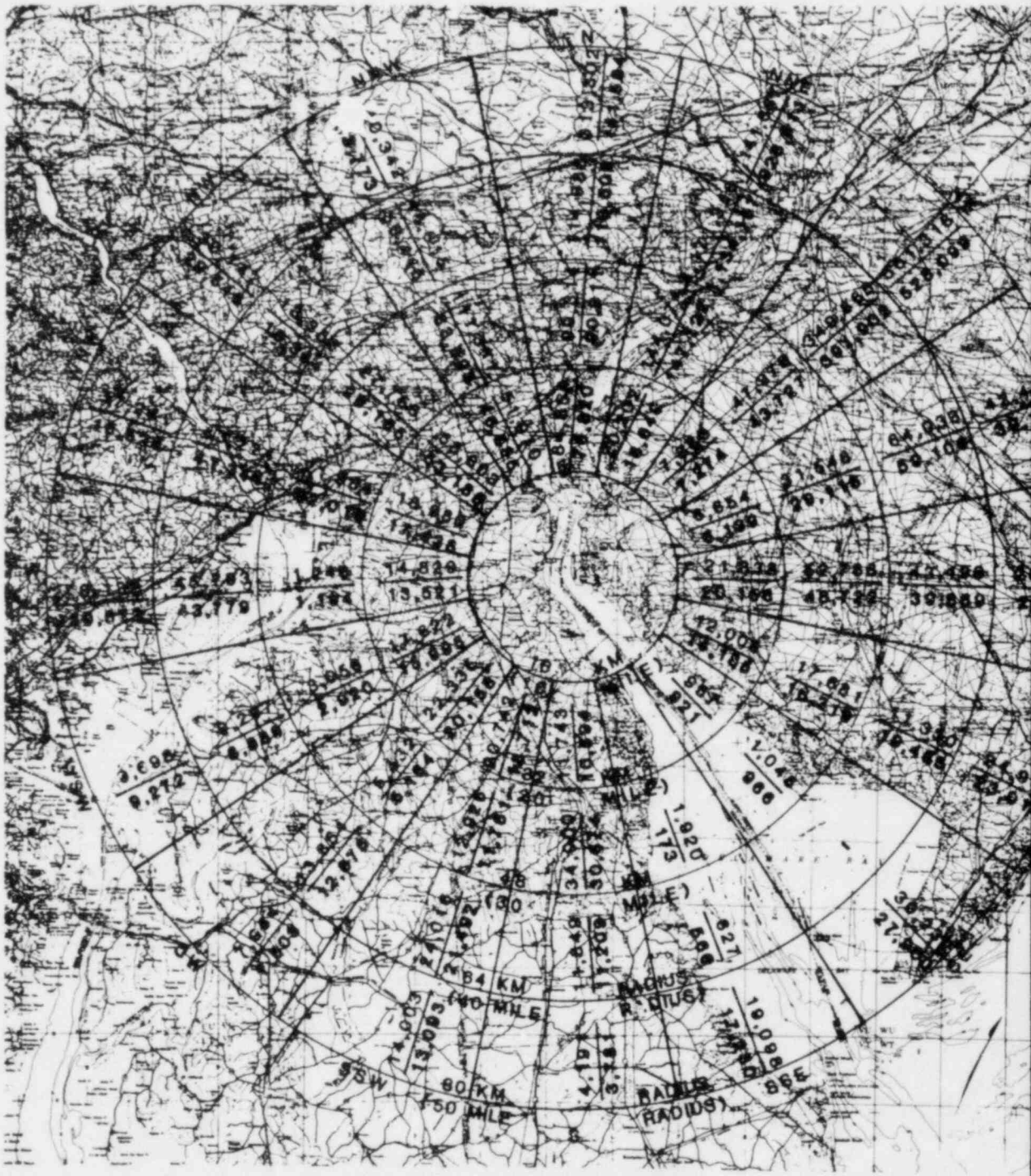
OPERATING LICENSE STAGE

POPULATION DISTRIBUTION 1980

WITHIN 16 - 80 KILOMETERS
(10 - 50 MILES)

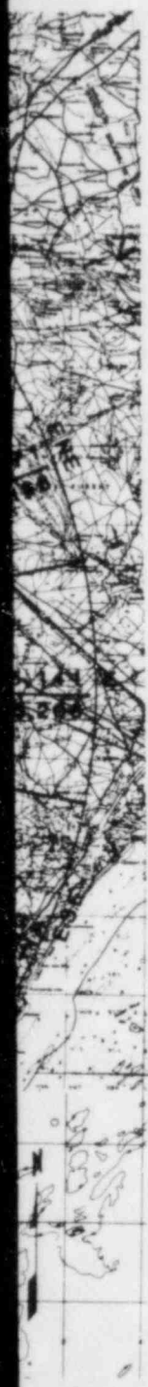
FIGURE 2.1 - 12

8306290435 -12



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5
KILOMETER



KMS	16-32	32-48	48-64	64-80	TOTAL
N	84.9 76.8	99.3 90.5	115.0 110.5	313.3 141.6	612.5 419.8
NNE	20.2 18.6	144.1 147.7	1171.3 1134.2	1141.7 928.8	2477.3 2229.3
NE	7.9 7.3	47.4 43.7	349.4 391.9	561.3 528.1	965.9 971.0
ENE	6.7 6.1	31.5 29.1	64.0 59.1	42.5 39.2	144.7 133.6
E	21.8 20.2	52.8 48.7	43.2 39.9	25.1 23.2	143.0 132.0
ESE	12.0 14.3	17.7 16.3	11.3 10.5	24.9 23.6	66.0 64.8
SE	1.0 .9	1.0 1.0	—	30.2 27.9	32.2 29.8
SSE	—	1.9 .2	.6 .6	19.1 17.3	21.5 18.0
S	11.7 10.6	34.0 30.7	11.8 11.2	4.2 3.8	61.8 56.3
SSW	20.7 18.7	12.9 11.8	24.0 21.5	14.0 13.1	71.7 65.1
SW	22.3 20.2	5.4 5.2	13.9 12.5	8.0 7.5	49.6 45.7
WSW	17.6 16.0	3.1 2.9	9.3 8.9	9.7 9.3	39.7 37.1
W	14.8 13.5	1.2 1.2	45.8 43.8	240.1 229.6	302.0 288.1
WNW	19.0 17.4	22.0 22.0	43.3 41.3	17.2 16.9	101.4 97.3
NW	58.8 53.2	27.8 26.2	18.5 15.1	30.2 29.4	135.7 124.2
NNW	52.0 46.9	111.4 63.6	48.8 30.4	40.3 38.8	252.3 199.7
TOTAL	371.4 340.6	613.5 541.2	1969.3 1952.0	2522.5 2077.1	5477.3 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	1987	24.2	395.6	1009.1	2979.0	5501.4
	1980	22.2	362.8	904.0	2855.9	4933.0

1987 POPULATION PROJECTED
1980 POPULATION EXISTING

POPULATION IN 000'S

PRC APERTURE CARD

Also Available On Aperture Card

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

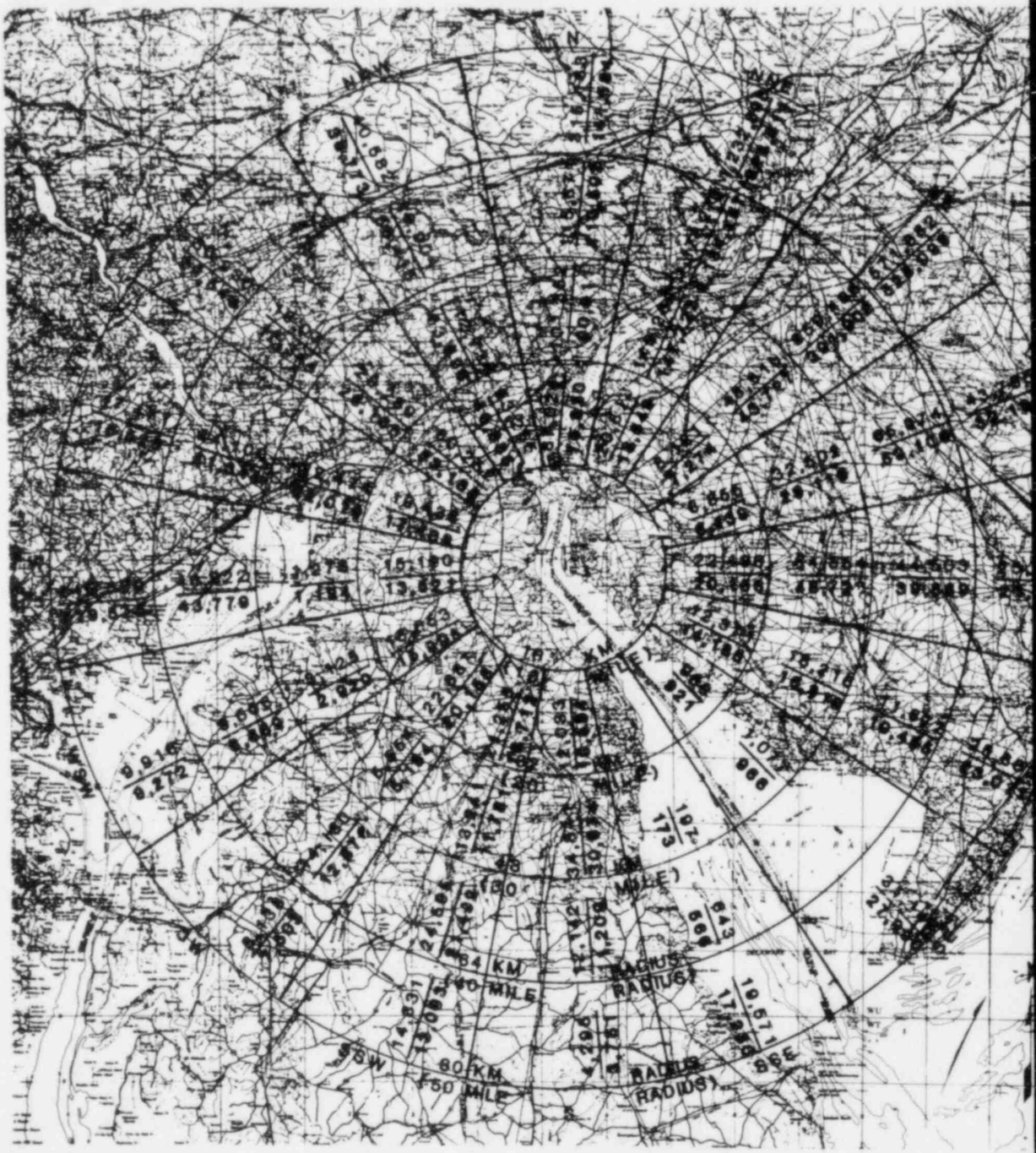
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 1987 WITHIN 16 - 80 KILOMETERS (10 - 50 MILES)

FIGURE 2.1 - 13

8306290435 -13



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5 2
KILOMETERS

KMS	16-32	32-48	48-64	64-80	TOTAL
N	87.0 76.8	101.4 90.9	115.7 110.5	315.2 141.6	619.2 419.8
NNE	20.8 18.6	145.3 147.7	1178.3 1134.2	1232.9 928.8	2577.3 2229.3
NE	8.1 7.3	48.8 43.7	359.5 391.9	571.9 528.1	988.3 971.0
ENE	6.9 6.1	32.5 29.1	66.0 59.1	43.8 39.2	149.1 133.6
E	22.5 20.2	54.4 48.7	44.5 39.9	25.9 23.2	147.3 132.0
ESE	12.4 14.2	18.2 16.3	11.7 10.5	25.7 23.0	67.9 64.0
SE	1.0 .9	1.0 1.0	—	31.1 27.9	33.2 29.8
SSE	—	.2 .2	.6 .6	19.6 17.2	20.4 18.0
S	12.0 10.6	34.8 30.7	12.1 11.8	4.3 3.8	63.3 56.3
SSW	21.3 18.7	13.2 11.8	24.6 21.5	14.3 13.1	73.4 65.1
SW	22.9 20.2	5.6 5.2	14.3 12.5	8.1 7.5	50.8 45.7
WSW	18.1 16.0	3.1 2.9	9.5 8.9	9.9 9.3	40.6 37.1
W	15.2 13.5	1.3 1.2	46.8 43.8	245.5 229.6	308.8 288.1
WNW	15.4 17.4	22.5 22.0	44.3 41.5	17.9 16.9	103.5 97.3
NW	60.3 53.2	28.3 25.2	16.1 15.3	30.9 29.4	135.5 124.2
NNW	53.3 46.9	112.7 63.6	48.9 50.4	40.6 38.8	255.5 199.7
TOTAL	381.0 340.6	623.3 541.2	1992.6 1952.0	2357.2 2077.1	5634.1 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	1990	24.9	405.9	1029.2	3021.8	5659.0
	1980	22.2	362.8	904.0	2855.9	4933.0

1990 POPULATION PROJECTED
1980 POPULATION EXISTING

POPULATION IN 000'S

PRC APERTURE CARD

Also Available On Aperture Card

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

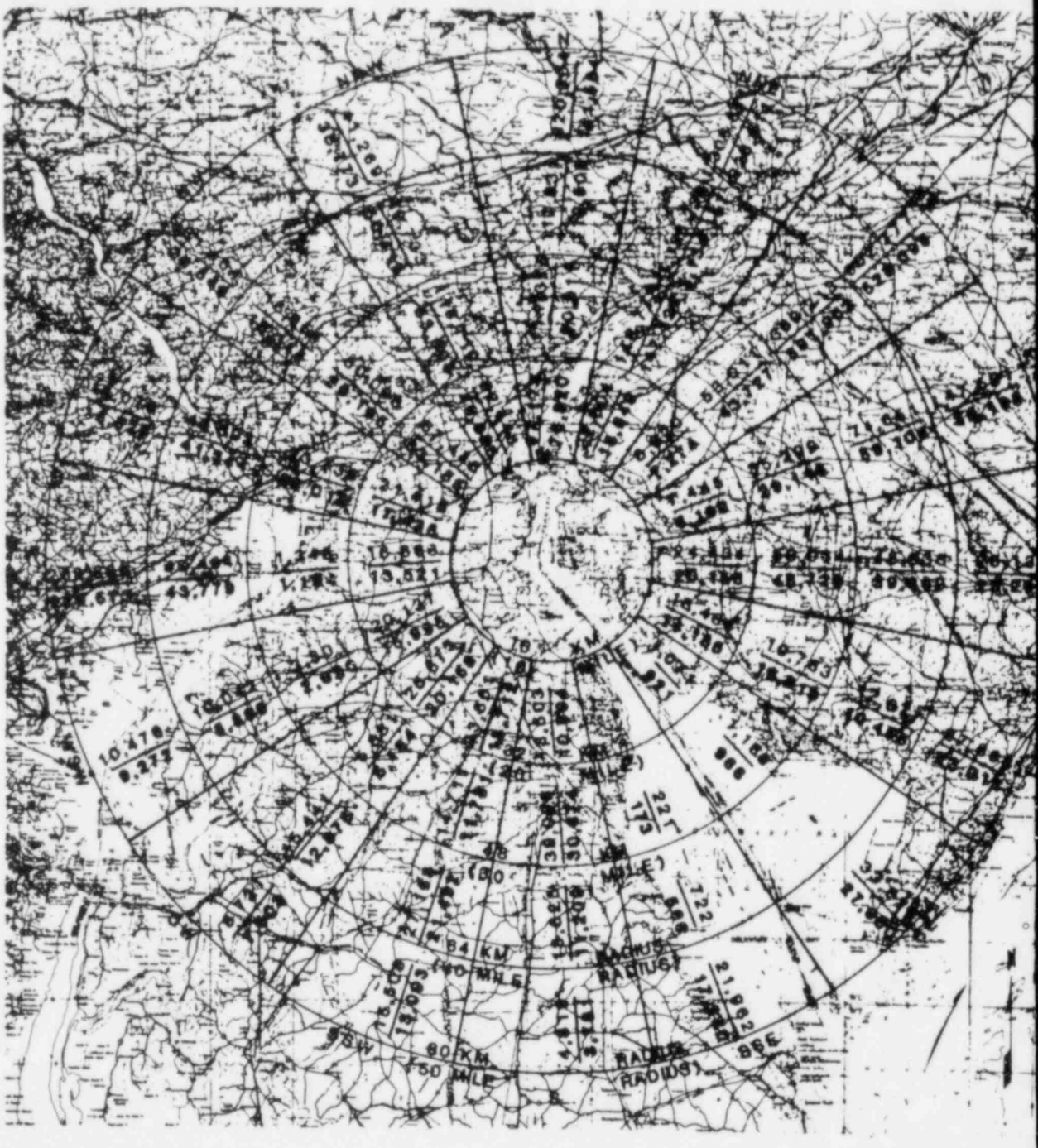
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 1990 WITHIN 16 - 80 KILOMETERS (10 - 50 MILES)

FIGURE 2.1 - 14

8306290435 -14



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5 20
KILOMETERS

KMS	16-32	32-48	48-64	64-80	TOTAL
N	97.2 76.8	111.4 90.9	117.6 110.3	320.5 141.6	646.7 419.8
NNE	27.6 18.6	140.8 147.7	1198.2 1134.2	1305.9 928.8	2676.5 2229.3
NE	8.8 7.3	53.0 43.7	389.2 391.9	602.8 528.1	1053.8 971.8
ENE	7.4 6.1	35.3 29.1	71.7 59.1	47.5 39.2	161.9 133.6
E	24.4 20.2	59.1 48.7	48.3 39.9	28.1 23.2	160.0 132.0
ESE	13.4 14.3	19.8 16.9	12.7 10.9	27.9 23.8	73.8 64.0
SE	1.1 .9	1.2 1.0	—	33.8 27.9	36.1 29.8
SSE	—	.2 .2	.4 .4	23.0 19.2	22.4 18.0
S	13.5 10.6	29.1 30.7	13.6 11.7	5.8 3.8	71.2 56.3
SSW	23.8 18.7	14.7 11.8	27.2 21.9	15.5 13.1	81.2 65.1
SW	25.7 20.2	5.9 5.2	15.4 12.9	8.7 7.5	55.7 45.7
WSW	20.4 16.0	3.1 2.9	14.8 6.9	15.5 9.3	54.0 37.1
W	16.9 11.5	1.3 1.2	49.5 41.8	255.4 229.6	237.1 288.1
WNW	21.4 17.4	23.7 22.0	45.5 41.3	18.1 16.5	105.6 97.3
NW	67.4 53.3	30.1 25.3	16.4 15.1	31.5 29.5	145.4 124.2
NNW	62.4 46.9	118.7 63.6	49.8 30.4	41.3 38.8	272.2 199.7
TOTAL	426.3 340.6	665.6 541.3	2066.4 1952.0	2276.2 2077.1	5537.8 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	2000	27.4	453.7	1119.3	3186.0	5965.2
	1980	22.2	362.8	904.0	2855.9	4933.0

2000 POPULATION PROJECTED
1980 POPULATION EXISTING

POPULATION IN 000'S

PRC APERTURE CARD

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

Also Available On Aperture Card

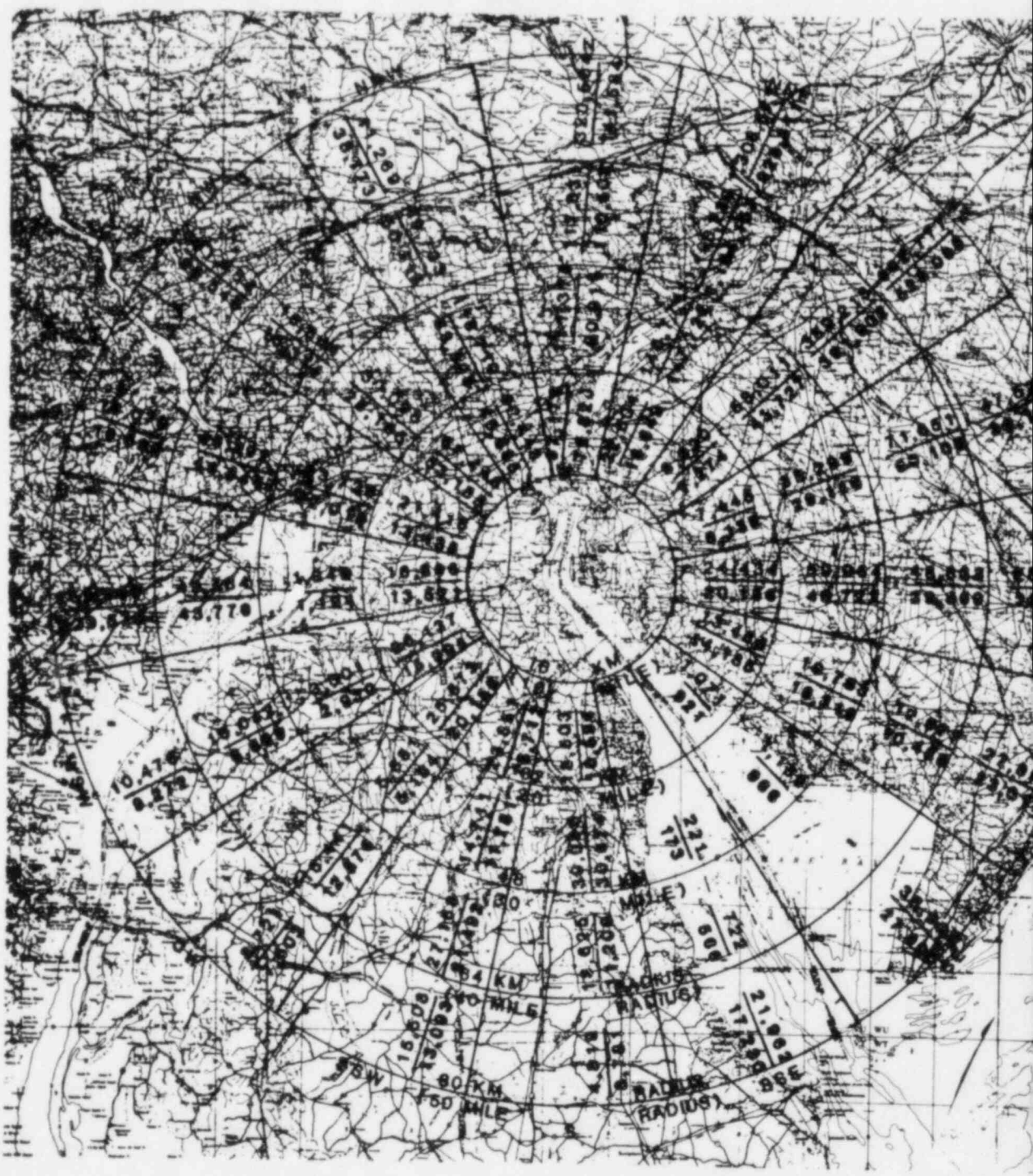
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 2000 WITHIN 16 - 80 KILOMETERS (10 - 50 MILES)

FIGURE 2.1 - 15

8306290435 -15



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5
KILOMETERS

KMS	16-32	32-48	48-64	64-80	TOTAL
N	97.2 76.8	111.4 90.9	117.6 110.5	320.5 141.6	646.7 419.8
NNE	22.6 18.5	148.8 147.7	1198.2 1134.2	1306.9 928.8	2676.5 2229.3
NE	8.8 7.3	33.0 43.7	389.2 391.9	602.8 528.1	1053.8 971.0
ENE	7.4 6.1	35.3 29.1	71.7 59.1	47.5 39.2	161.9 133.6
E	24.4 20.2	59.1 48.7	48.3 39.5	28.1 23.2	160.0 132.0
ESE	13.4 15.2	19.8 16.3	12.7 10.5	27.9 23.0	73.8 64.8
SE	1.1 .9	1.2 1.0	—	33.8 27.9	36.1 29.8
SSE	—	.2 .2	.7 .6	23.0 19.2	22.9 18.0
S	13.5 10.6	39.1 30.7	13.5 11.2	4.8 3.8	71.0 56.3
SSW	23.8 18.7	14.7 11.8	27.2 21.5	15.5 13.1	81.2 65.1
SW	25.7 20.2	5.9 5.2	15.4 12.8	8.7 7.5	55.7 45.7
WSW	29.1 16.0	3.2 2.9	10.3 8.9	10.2 9.3	52.8 37.1
W	16.9 13.5	1.3 1.2	49.5 43.6	259.4 229.4	237.1 288.1
WNW	21.4 17.4	23.7 22.0	56.0 41.5	18.1 16.5	169.5 97.3
NW	67.4 53.2	30.1 26.2	16.4 15.1	31.5 29.4	145.4 124.2
NNW	62.4 46.9	118.7 63.6	59.2 50.4	41.3 38.8	272.2 199.7
TOTAL	426.3 340.6	665.6 541.3	2066.7 1552.8	2279.2 2077.1	5937.8 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	2010	27.4	53.7	1119.3	3186.0	5965.2
	1980	22.2	362.8	904.0	2855.9	4933.0

2010 POPULATION PROJECTED
1980 POPULATION EXISTING

POPULATION IN 000'S

PRC APERTURE CARD

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

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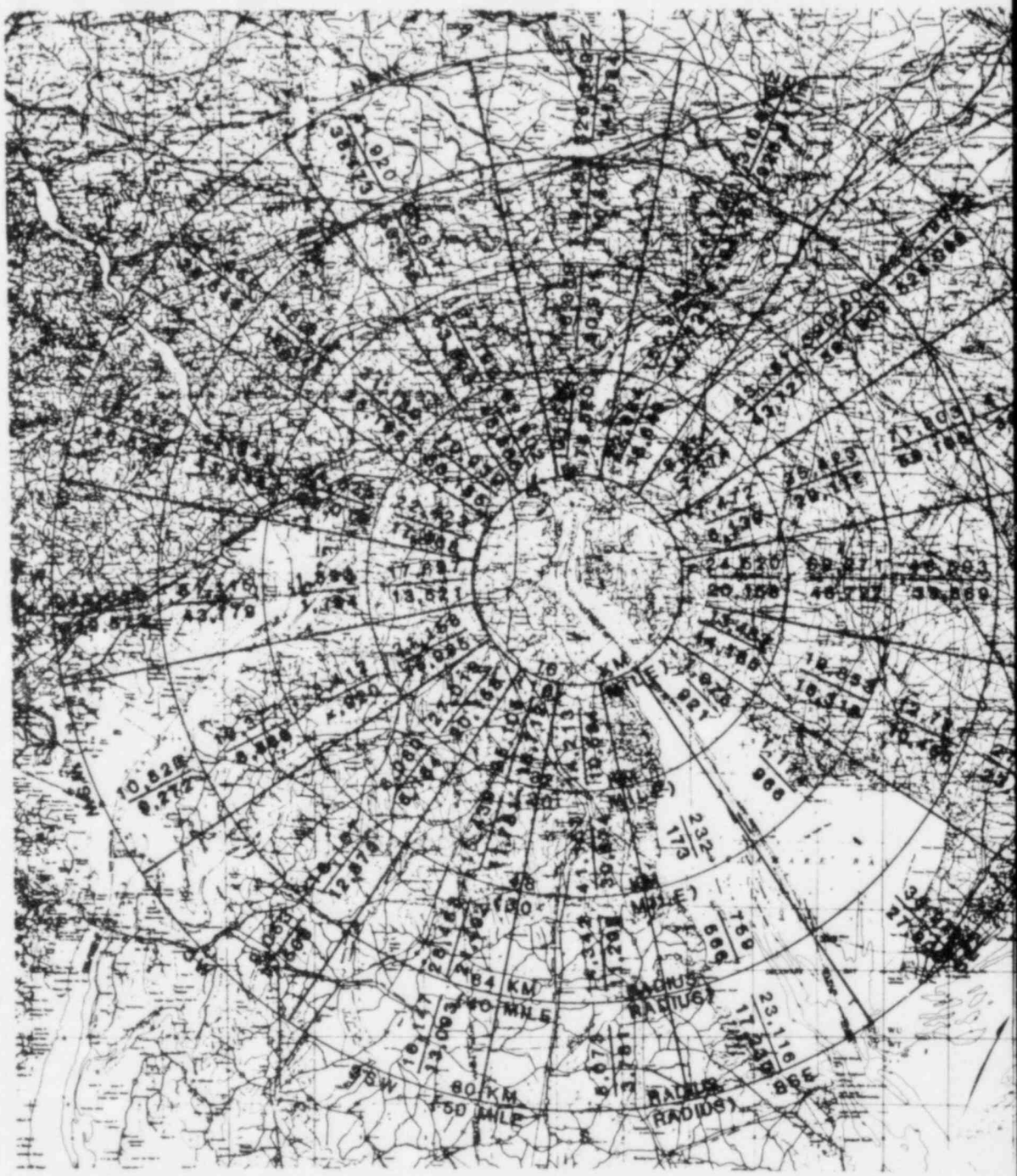
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 2010 WITHIN 16 - 80 KILOMETERS (10 - 50 MILES)

FIGURE 2.1 - 16

8306290435 -16



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

KMS	16-32	32-48	48-64	64-80	TOTAL
N	101.6 76.8	116.4 90.9	119.5 110.5	325.6 141.6	663.0 419.8
NNE	22.7 18.6	150.5 147.7	1217.1 1134.2	1310.9 928.8	2701.7 2229.3
NE	8.9 7.3	53.2 43.7	390.8 391.9	608.2 528.1	1061.0 971.0
ENE	7.5 6.1	35.4 29.1	71.9 59.1	47.7 39.2	162.5 133.6
E	24.5 20.2	59.3 48.7	48.5 39.9	28.2 23.2	160.5 132.0
ESE	13.5 14.2	19.9 16.3	12.7 10.5	28.0 23.0	74.1 64.0
SE	1.1 .9	1.2 1.0	—	33.9 27.9	36.2 29.8
SSE	—	.2 .2	.8 .6	23.1 19.2	24.1 18.0
S	14.2 10.6	41.2 30.7	14.3 11.2	5.1 3.8	74.8 56.3
SSW	25.1 18.7	15.4 11.8	28.5 21.5	16.1 13.1	85.2 65.1
SW	27.0 20.2	6.1 5.2	16.1 12.9	9.1 7.5	58.3 45.7
WSW	21.2 16.0	3.4 2.9	10.4 8.9	10.8 9.3	45.8 37.1
W	17.7 13.5	1.4 1.2	51.1 43.8	268.0 229.6	338.2 288.1
WNW	22.4 17.4	24.5 22.0	47.8 41.3	18.5 16.5	113.3 97.3
NW	70.9 53.2	31.1 26.2	16.6 15.1	32.0 29.4	150.6 124.2
NNW	62.3 46.9	122.2 63.6	50.5 50.4	41.9 38.8	277.5 199.7
TOTAL	441.1 340.6	681.8 541.2	2096.4 1952.0	2807.4 2077.4	6026.8 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	2020	28.0	469.2	1151.0	3247.7	6054.8
	1980	22.2	362.8	904.0	2855.9	4933.0

2020 POPULATION PROJECTED
1980 POPULATION EXISTING

POPULATION IN 000'S

PRC APERTURE CARD

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

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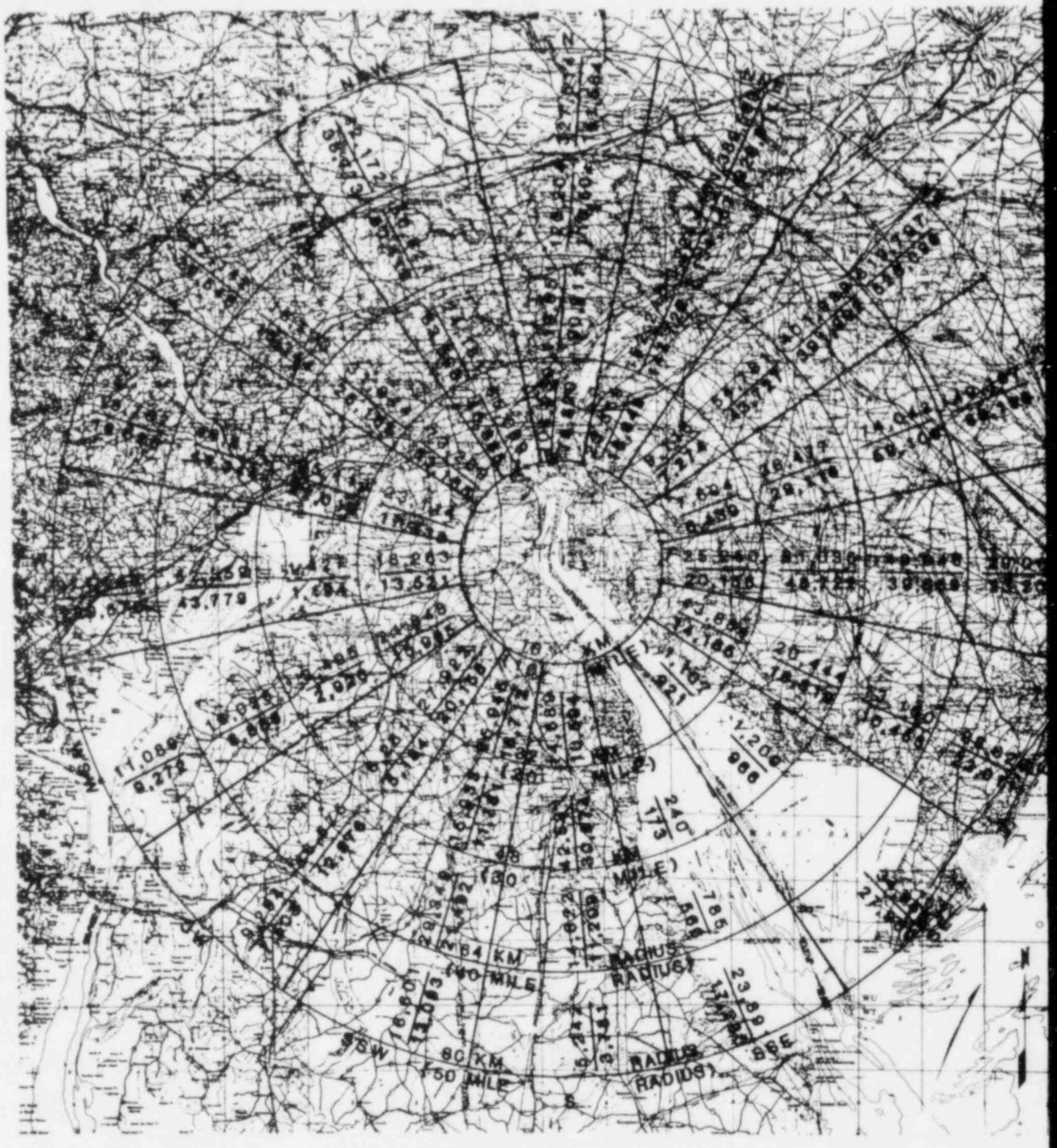
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 2020 WITHIN 16 - 80 KILOMETERS (10 - 50 MILES)

FIGURE 2.1 - 17



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5 20
KILOMETERS

KMS	16-32	32-48	48-64	64-80	TOTAL
N	104.9 76.8	119.7 90.9	120.2 110.5	327.5 141.6	672.3 419.8
NNE	23.4 18.6	152.2 147.7	1224.4 1134.2	1389.6 928.8	2789.6 2229.3
NE	9.1 7.3	54.8 43.7	402.0 391.9	619.8 528.1	1085.7 971.0
ENE	7.7 6.1	36.5 29.1	74.0 59.1	49.1 39.2	167.3 133.6
E	25.3 20.2	61.0 48.7	49.9 35.9	29.1 23.2	165.3 132.0
ESE	13.9 14.2	20.4 16.3	13.1 10.5	28.8 23.0	76.3 64.0
SE	1.4 .9	1.2 1.0	—	35.0 27.9	37.3 29.8
SSE	--	.2 .2	.8 .6	23.9 17.2	24.9 18.0
S	14.7 10.6	42.5 30.7	14.8 11.2	5.2 3.8	77.1 56.3
SSW	25.8 18.7	15.9 11.8	29.3 21.5	16.8 13.1	87.8 65.1
SW	27.9 20.2	6.2 5.2	16.4 13.9	9.3 7.5	60.4 45.7
WSW	21.8 16.0	3.5 2.9	16.0 8.9	11.1 9.3	52.4 37.1
W	18.3 13.5	1.4 1.2	57.4 43.8	274.6 229.6	346.6 288.1
WNW	23.1 17.4	25.1 22.0	48.9 41.5	18.8 16.9	115.9 97.3
NW	73.3 55.2	31.8 25.7	16.7 15.2	32.1 29.4	115.9 125.2
NNW	65.0 46.9	124.2 63.6	50.8 50.4	42.2 38.8	282.2 199.7
TOTAL	455.4 340.6	691.8 541.2	2130.1 1952.0	2912.6 2077.1	6195.0 4910.8

RADIUS IN KILOMETERS	YEAR	0-16	0-32	0-48	0-64	0-80
ACCUMULATED POPULATION	2030	28.9	484.3	1181.2	3311.3	6223.9
	1980	22.2	362.8	904.0	2855.9	4933.0

2030 POPULATION PROJECTED POPULATION IN 000'S
1980 POPULATION EXISTING

PRC APERTURE CARD

SOURCE: 1980 CENSUS OF POPULATION & HOUSING FOR NEW JERSEY, DELAWARE, PENNSYLVANIA AND MARYLAND.

NEW JERSEY DEPT. OF LABOR, NEW JERSEY POPULATION PROJECTIONS 1980-2000, FEBRUARY 1982.

U.S. DEPT. OF COMMERCE, 1980 OBERS BEA REGIONAL PROJECTIONS, JULY 1981.

NEW CASTLE COUNTY PLANNING BOARD, POPULATION PROJECTIONS 1980-2000, MARCH 1982.

Also Available On Aperture Card

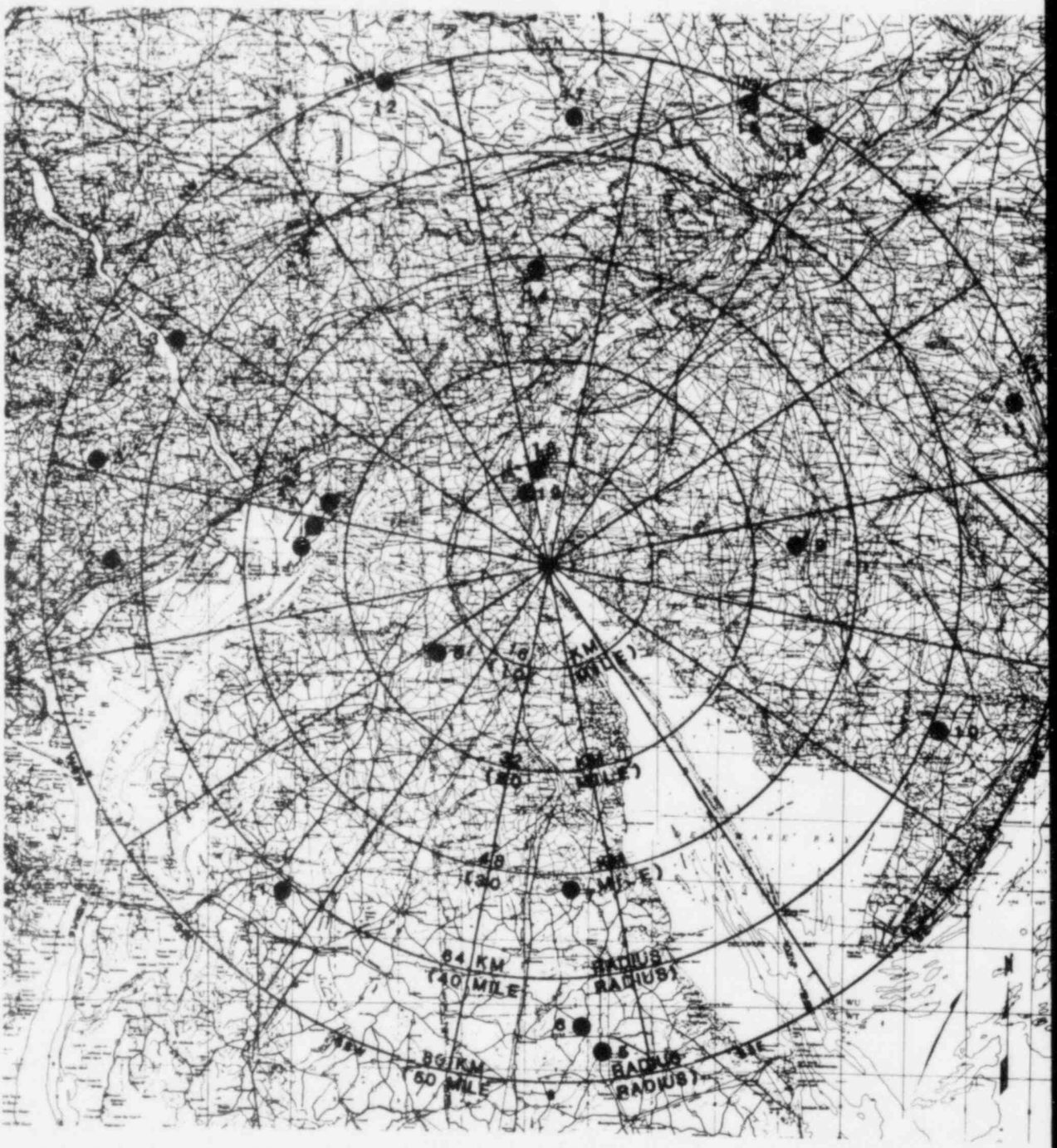
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

POPULATION PROJECTIONS AND DISTRIBUTION 2030
WITHIN 16 - 80 KILOMETERS
(10 - 50 MILES)

FIGURE 2.1 - 18

8306290435 -18



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5 20
KILOMETERS

		ANNUAL VISITATIONS
1.	TUCKAHOE STATE PARK, MD	50,149
2.	GUNPOWDER FALLS STATE PARK, MD	405,922
3.	ROCK STATE PARK, MD	218,608
4.	ELK NECK STATE PARK, MD	218,602
5.	REDDEN STATE FOREST, DE	4,000
6.	ELKENDALE STATE FOREST, DE	2,000
7.	KILLEN POND STATE PARK, DE	130,152
8.	BLACKBIRD STATE FOREST, DE	7,000
9.	PARVIA STATE PARK, DE	3,000
10.	BELLEPLAIN STATE FOREST, NJ	110,105
11.	WHARTON STATE FOREST, NJ	374,085
12.	FRENCH CREEK STATE PARK, PENN	361,121
13.	SUSQUCHANNOCK, PENN	32,383
14.	BRANDYWINE BATTLEFIELD STATE PARK, PENN	117,837
15.	FORT WASHINGTON, PENN	335,494
16.	INDEPENDANCE PARK, PENN	3,828,497
17.	VALLEY FORGE, PENN	12,181,740
18.	FORT MOTT STATE PARK, NJ	45,700
19.	FORT DELAWARE PARK, DE	12,200

SOURCE: DELAWARE STATE PARKS SERVICE, JUNE 1982

SOUTH JERSEY RESOURCE CONSERVATION & DEVELOPMENT AREA PLAN, U.S. DEPT. OF AGRICULTURE, SOIL CONSERVATION SERVICE, SOMERSET, NJ APRIL 1979

MARYLAND STATE PARK & RECREATION SERVICE, JUNE 1982

PENNSYLVANIA BUREAU OF STATE PARKS, JUNE 1982

PRC APERTURE CARD

Also Available On Aperture Card

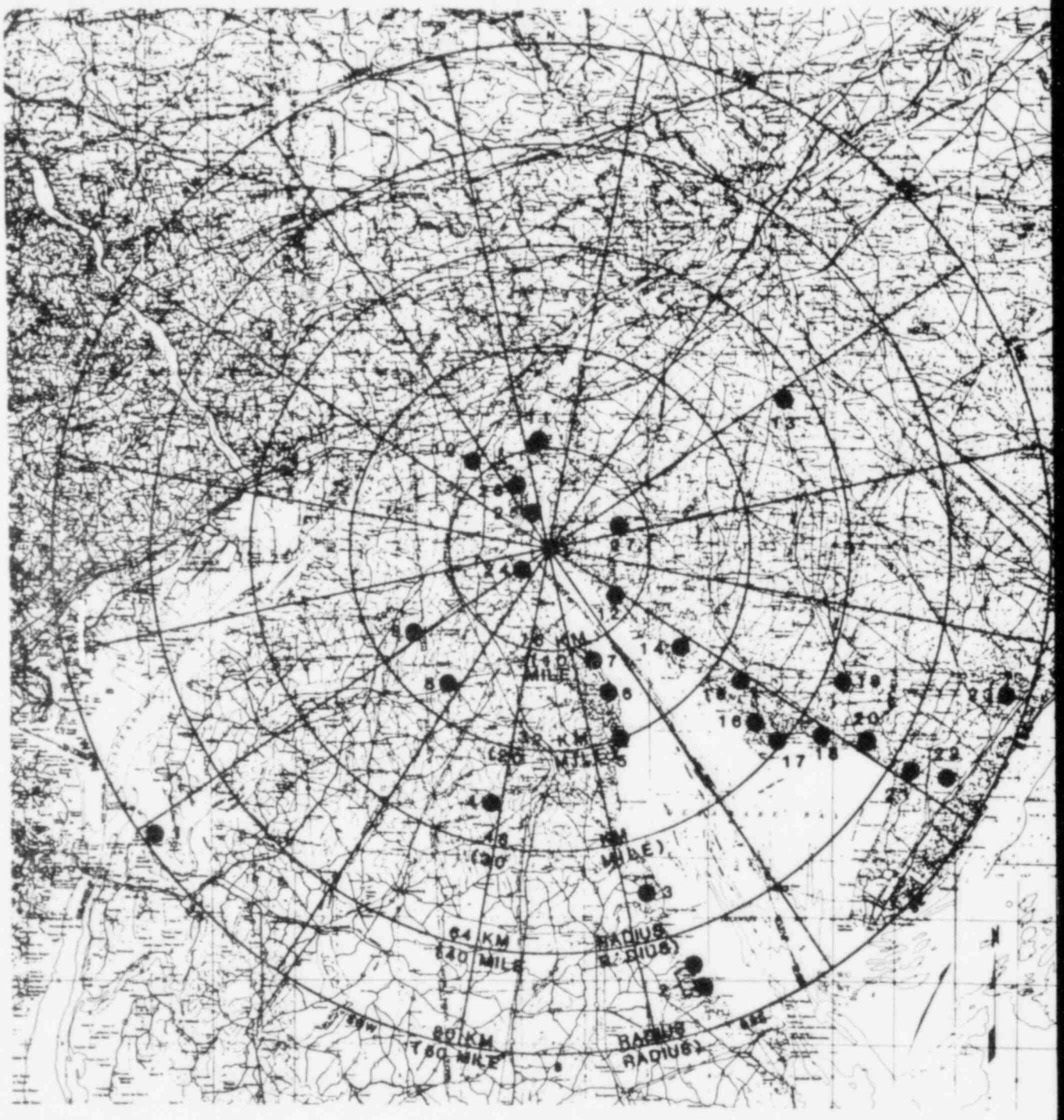
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

STATE PARKS & FORESTS 1981
WITHIN 0 - 80 KILOMETERS
(0 - 50 MILES)

FIGURE 2.1 - 19

8306290435 -19



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5 20
MILES
5 0 5 20
KILOMETERS

		ANNUAL VISITATION
1.	EASTERN NECK ISLAND NATIONAL WILDLIFE REFUGE, MD	45,400
2.	PRIME HOOK NATIONAL WILDLIFE REFUGE, DE	5,000
3.	MILFORD NECK WILDLIFE AREA, DE	2,000
4.	NORMAN G. WILDER WILDLIFE AREA, DE	1,500
5.	LITTLE CREEK WILDLIFE AREA, DE	2,500
6.	BOMBAY HOOK NATIONAL WILDLIFE REFUGE, DE	55,700
7.	WOODLAND BEACH WILDLIFE AREA, DE	8,000
8.	BLACKISTON WILDLIFE AREA, DE	2,500
9.	MILLINGTON WILDLIFE MANAGEMENT AREA, MD	4,000
10.	CANAL NATIONAL WILDLIFE REFUGE, DE	2,000
11.	KILLCOHOOK NATIONAL WILDLIFE REFUGE, DE	500
12.	MAD HORSE CREEK WILDLIFE MANAGEMENT AREA, NJ	1,000
13.	GLASSBORO FISH & WILDLIFE MANAGEMENT AREA, NJ	1,300
14.	DIX FISH & WILDLIFE MANAGEMENT AREA, NJ	700
15.	NANTUXENT FISH & WILDLIFE MANAGEMENT AREA, NJ	800
16.	FORTESCUE FISH & WILDLIFE MANAGEMENT AREA, NJ	300
17.	EGG ISLAND FISH & WILDLIFE MANAGEMENT AREA, NJ	1,200
18.	HEISLERVILLE FISH & WILDLIFE MANAGEMENT AREA, NJ	900
19.	EDWARD G. BEVON FISH & WILDLIFE MANAGEMENT AREA, NJ	500
20.	CORSON TRACT STATE WILDLIFE MANAGEMENT AREA, NJ	200
21.	DENNIS CREEK WILDLIFE MANAGEMENT AREA, NJ	700
22.	BEAVER SWAMP WILDLIFE MANAGEMENT AREA, NJ	500
23.	TUCKAHOE WILDLIFE MANAGEMENT AREA, NJ	1,200
24.	APPOQUINIMINK WILDLIFE AREA, DE	100
25.	REEDY ISLAND WILDLIFE REFUGE, DE	500
26.	AUGUSTINE CREEK WILDLIFE AREA, DE	500
27.	MASKELLS MILL POND WILDLIFE MANAGEMENT AREA, NJ	800

SOURCE: DELAWARE DIVISION OF PARKS & RECREATION, JUNE 1982
NEW JERSEY DIVISION OF PARKS & FORESTRY, JUNE 1982
DELAWARE DEPT. OF FISH & WILDLIFE, JUNE 1982
MARYLAND WILDLIFE ADMINISTRATION, JUNE 1982

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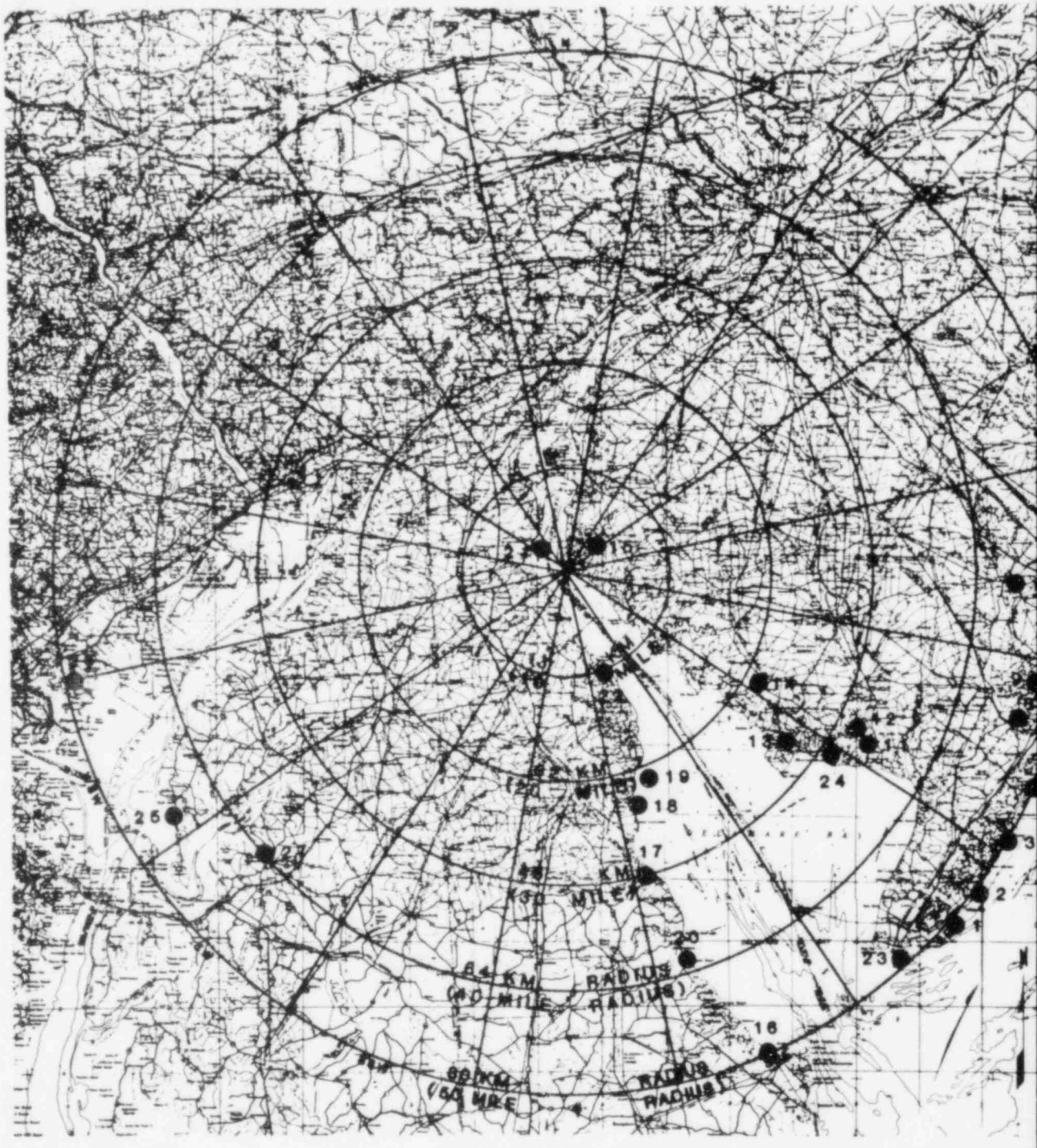
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

WILDLIFE MANAGEMENT AREA
1982
WITHIN 0 - 80 KILOMETERS
(0 - 50 MILES)

FIGURE 2.1 - 20

8306290435 - 20



REFERENCE:
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART:
NEW YORK

5 0 5
MILES
5 0 5 20
KILOMETERS

1. WILDWOOD, NJ
2. STONE HARBOR, NJ
3. AVALON, NJ
4. SEA ISLE CITY, NJ
5. MARMORA, NJ
6. OCEAN CITY, NJ
7. TUCKAHOE, NJ
8. SOMERS POINT, NJ
9. SCULLVILLE, NJ
10. MAYS LANDING, NJ
11. HEISLERVILLE, NJ
12. MATTS LANDING, NJ
13. FORTESCUE, NJ
14. NEWPORT, NJ
15. HANCOCK BRIDGE, NJ
16. LEWES, DE
17. BAUERS BEACH, DE
18. LITTLE CREEK, DE
19. PORT MAHON, DE
20. MISPILLION, DE
21. PORT PENN, DE
22. WOODLAND BEACH, DE
23. CAPE MAY, NJ
24. PORT NORRIS, NJ
25. ROCK HALL, MD
26. ESSEX, MD
27. CENTERVILLE, MD

SOURCES: TOWNSEND, R. GUIDE TO NEW JERSEY'S SALTWATER FISHING, DED, DIVISION OF FISH, GAME & SHELLFISHERIES, 1974

DAREL CHRISTIAN, CHIEF FISHERIES STATISTIC INVESTIGATION NE REGION, NATIONAL MARINE FISHERIES SERVICE, JUNE 1982

MARYANN CARSON, BUDGET TECHNICIAN, ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT, JUNE 1982

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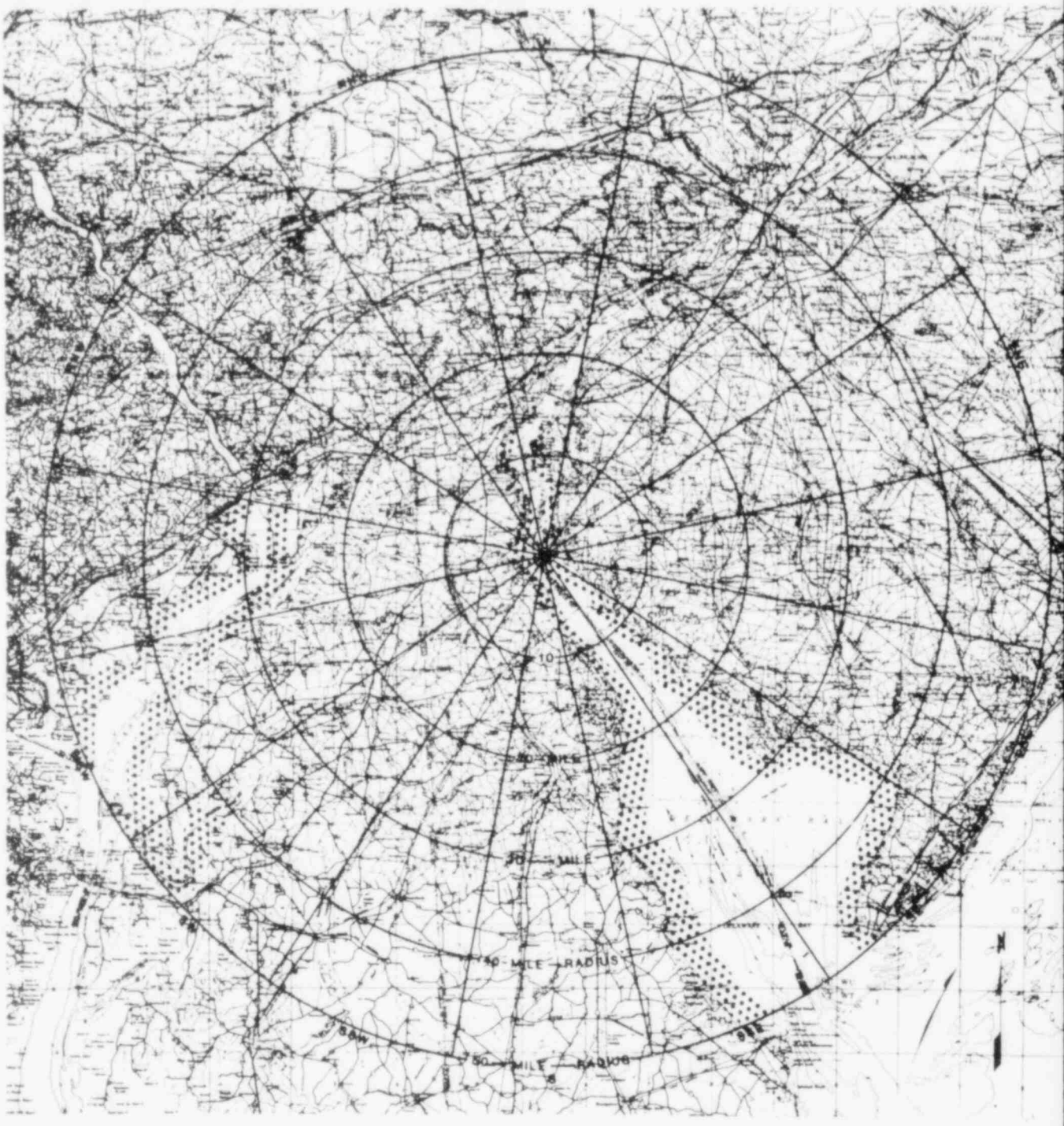
PORTS OF LANDING FOR
COMMERCIAL & RECREATIONAL
SALTWATER FISHING AREAS
1982
WITHIN 0 - 80 KILOMETERS (0 - 50 MILES)
FIGURE 2.1 - 21

8306290435 -21



REFERENCE
THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SECTIONAL AERONAUTICAL CHART
NEW YORK

5 0 5 20
MILES
5 0 5 20
KILOMETERS

RECREATIONAL AND COMMERCIAL FISHING AND SHELLFISHING AREAS

SOURCES: TOWNSEND, R, GUIDE TO NEW JERSEY'S SALTWATER FISHING, DED, DIVISION OF FISH, GAME & SHELLFISHERIES, 1974

DAREL CHRISTIAN, CHIEF FISHERIES STATISTIC INVESTIGATION NE REGION, NATIONAL MARINE FISHERIES SERVICE, JUNE 1982

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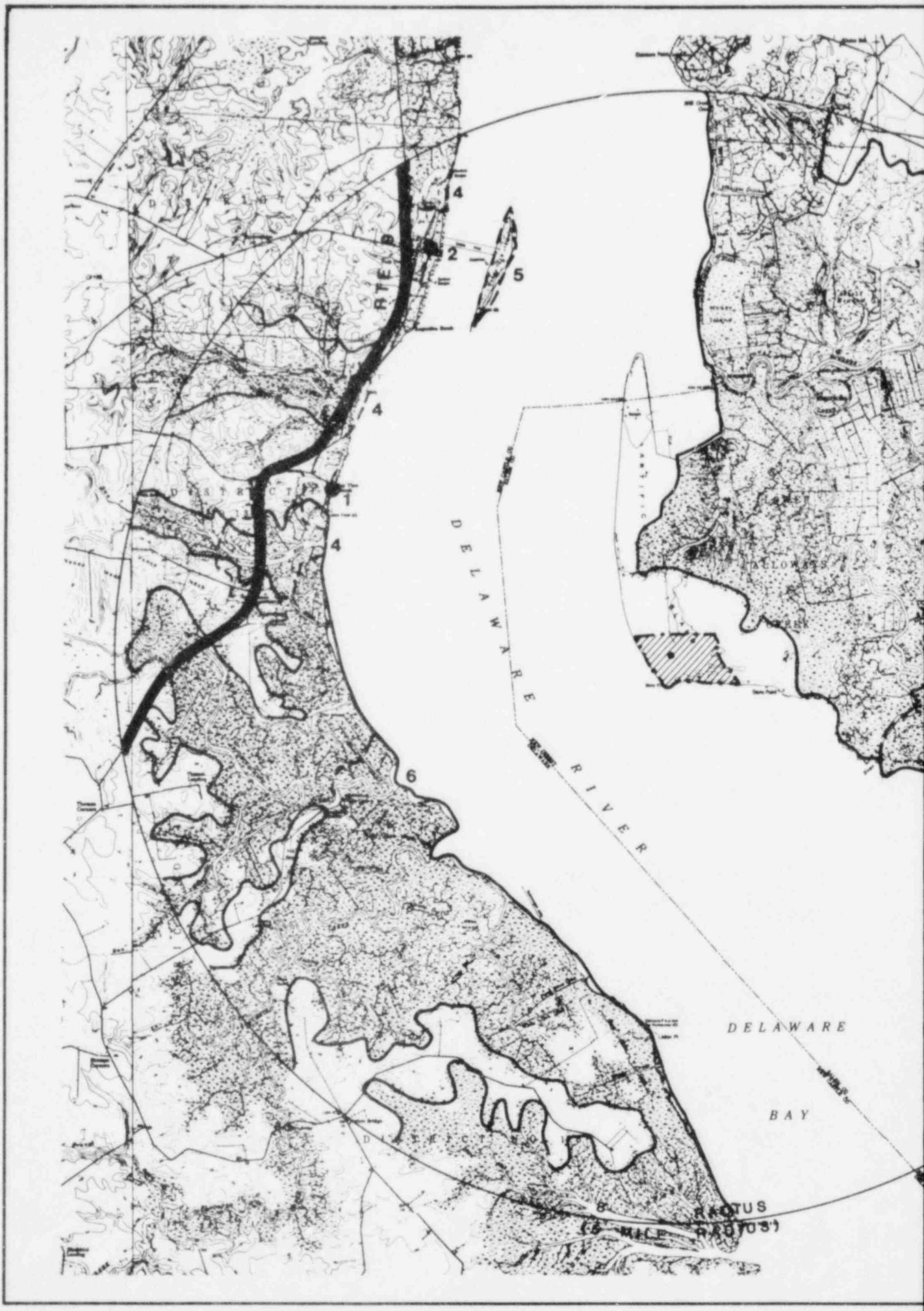
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

COMMERCIAL & RECREATIONAL FISHING & SHELLFISHING AREAS 1982
WITHIN 0 - 80 KILOMETERS (0 - 50 MILES)
FIGURE 2.1 - 22

8306290435 -22



DELAWARE RIVER
DELAWARE BAY
RAOTUS
(5 MILE RAOTUS)
1
2
4
5
6

PRC
APERTURE
CARD

UTILITY PROPERTY LINE/EXCLUSION AREA

UTILITY PROPERTY

MAJOR HIGHWAY

NEARBY SETTLEMENTS

		POPULATION (1980)
1.	BAY VIEW BEACH, DE	104
2.	PORT PENN, DE	236
3.	HANCOCK'S BRIDGE, NJ	327

RESIDENTIAL

AGRICULTURAL AND VACANT

WILDLIFE AREAS

4. AUGUSTINE CREEK WILDLIFE AREA
5. REEDY ISLAND WILDLIFE REFUGE
6. APPOQUINIMINK WILDLIFE AREA
7. MAD HORSE CREEK WILDLIFE MANAGEMENT AREA

WETLAND

SOURCE: PUBLIC SERVICE ELECTRIC & GAS, CO., JUNE 1982.
1980 CENSUS OF POPULATION & HOUSING, MARCH 1981.
NEW CASTLE COUNTY PLANNING BOARD, THE RED LION PLANNING DISTRICT PLAN, 1985, SEPTEMBER 1973.
NEW CASTLE COUNTY PLANNING BOARD, THE MIDDLETOWN-ODESSA-TOWNSEND PLANNING DISTRICT PLAN, SEPTEMBER 1973.
U.S. DEPT. OF AGRICULTURE, SOUTH JERSEY RESOURCE CONSERVATION & DEVELOPMENT AREA PLAN, APRIL 1979.
SALEM COUNTY COMPREHENSIVE PLAN MIDDLETOWN-ODESSA-TOWNSEND PLANNING DISTRICT PLAN, 1973.

N

1 0 1
MILES

1 0 1
KILOMETERS

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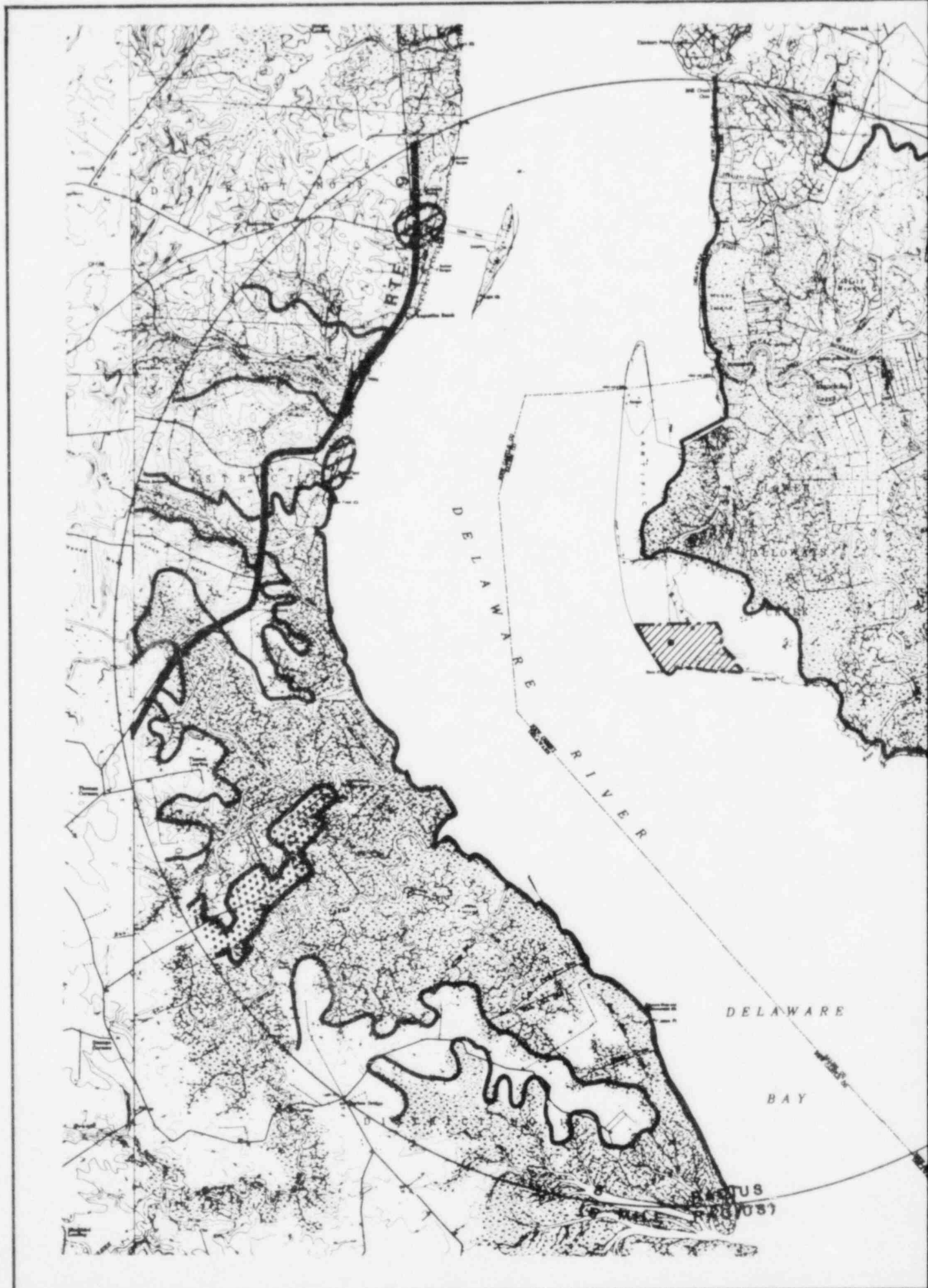
ENVIRONMENTAL REPORT

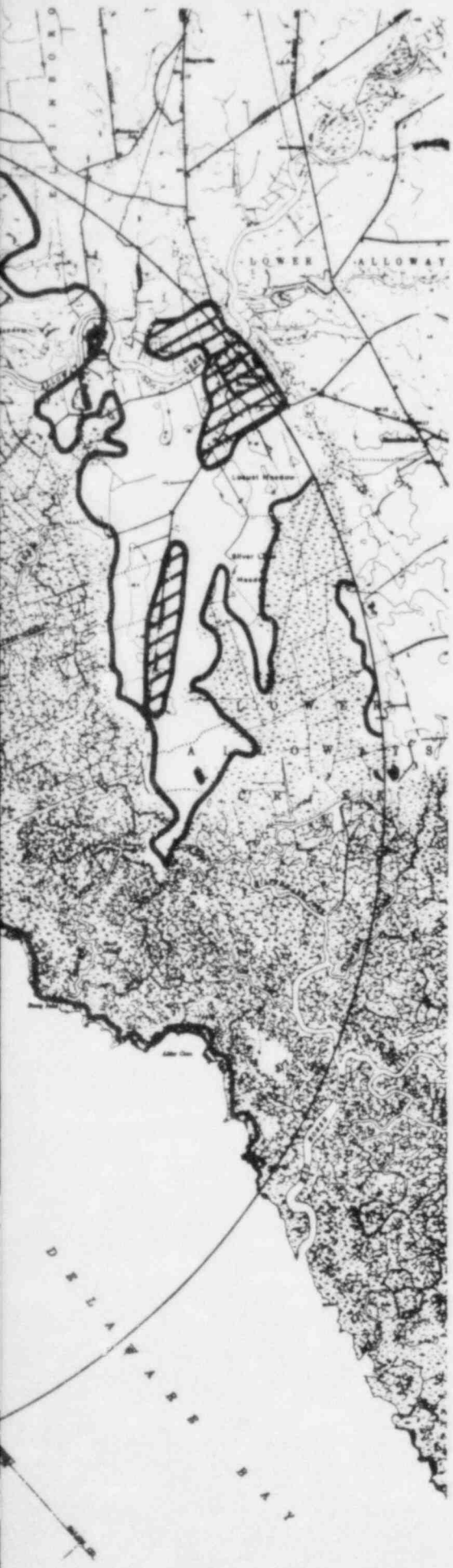
OPERATING LICENSE STAGE

EXISTING LAND USE
1982
WITHIN 0 - 8 KILOMETERS
(0 - 5 MILES)

FIGURE 2.1 - 23

8306290435 -23


RTE
DELAWARE RIVER
DELAWARE
BAY



AGRICULTURE

WOODLAND AND MARSH

RESIDENTIAL

INDUSTRIAL

UTILITY PROPERTY

SOURCES: SALEM COUNTY COMPREHENSIVE PLAN 1985
MIDDLETOWN - ODESSA - TOWNSEND
PLANNING DISTRICT PLAN, 1973

PRC APERTURE CARD

N

1 0 1
MILES

1 0 1
KILOMETERS

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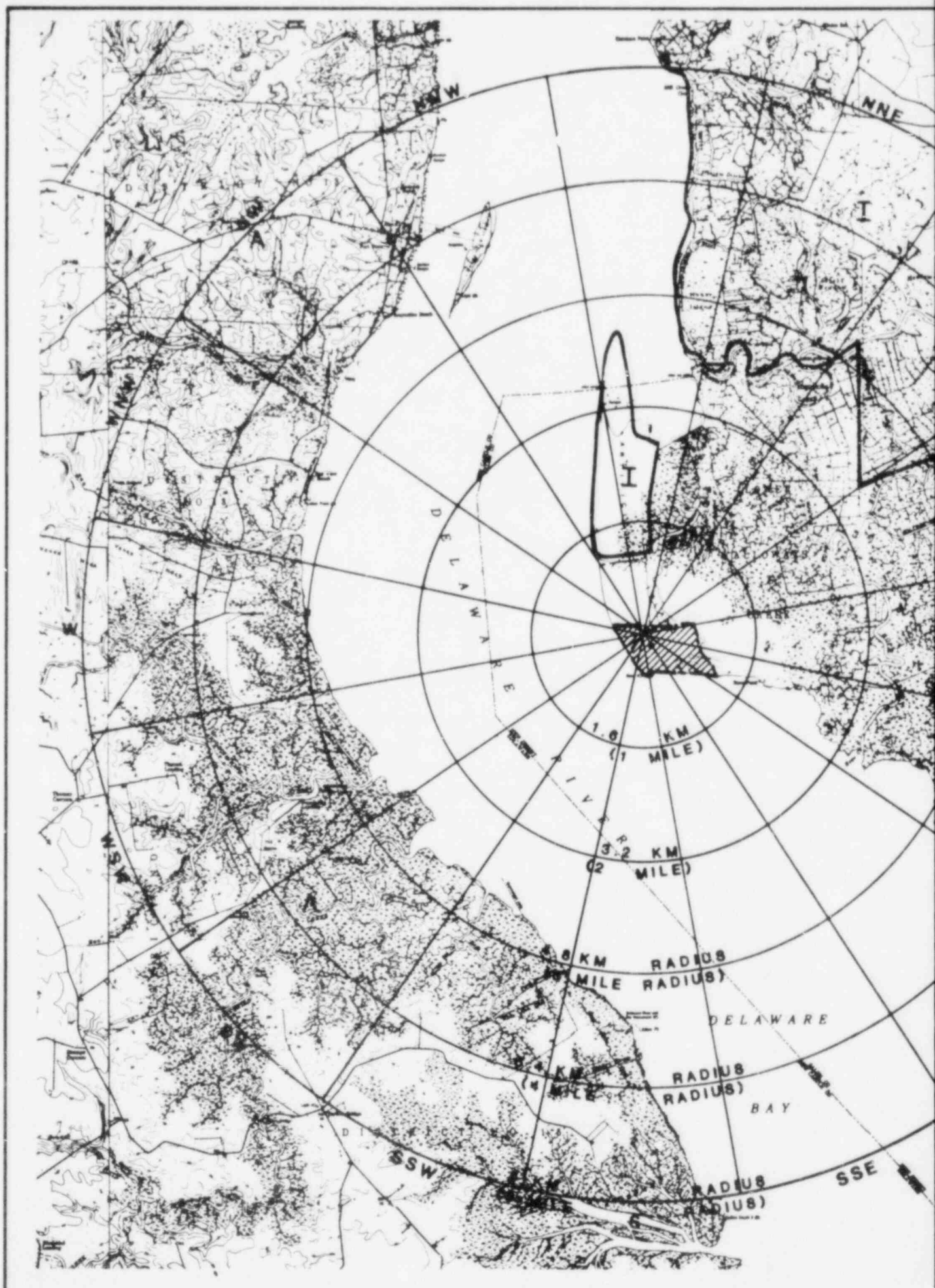
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

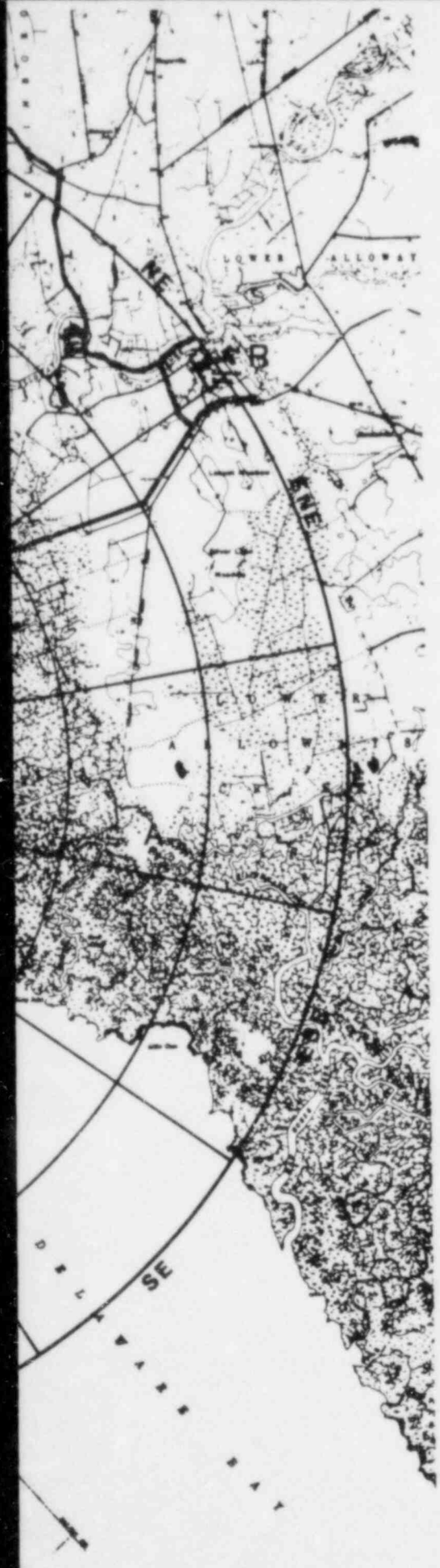
OPERATING LICENSE STAGE

PROJECTED LAND USE
WITHIN 0 - 8 KILOMETERS
(0 - 5 MILES)

FIGURE 2.1 - 24

8306290435 - 24


NNW
NNE
WNW
WSW
SSW
SSE
DELAWARE RIVER
DELAWARE BAY
1.6 KM (1 MILE)
3.2 KM (2 MILE)
RADIUS
RADIUS)
RADIUS
RADIUS)
RADIUS
RADIUS)



A AGRICULTURE AND RURAL RESIDENTIAL

R RESIDENTIAL

I INDUSTRIAL

UTILITY PROPERTY

SOURCES: SALEM COUNTY COMPREHENSIVE PLAN 1985
MIDDLETOWN - ODESSA - TOWNSEND
PLANNING DISTRICT PLAN, 1973

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N

1 0 1
MILES

1 0 1
KILOMETERS

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HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

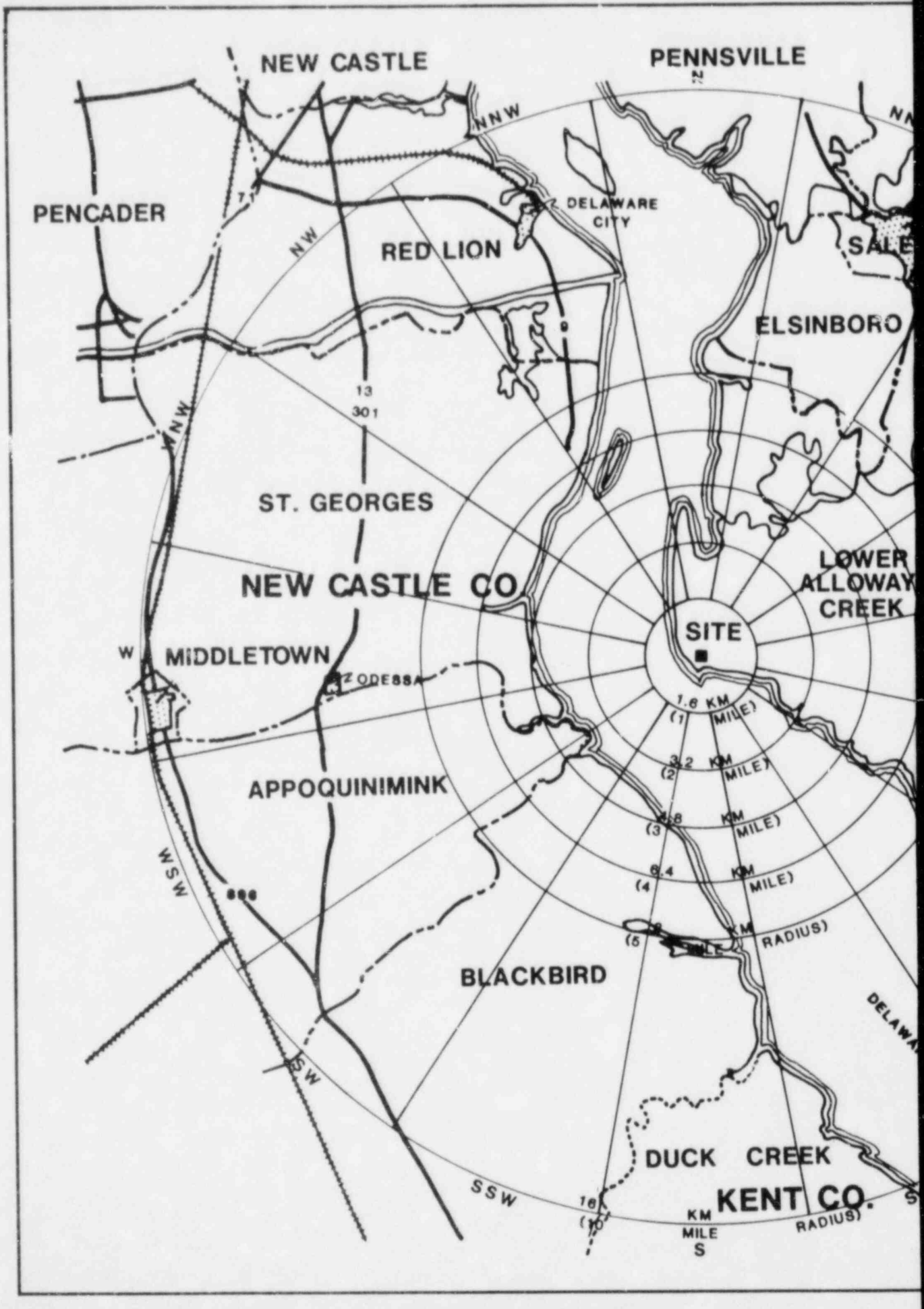
OPERATING LICENSE STAGE

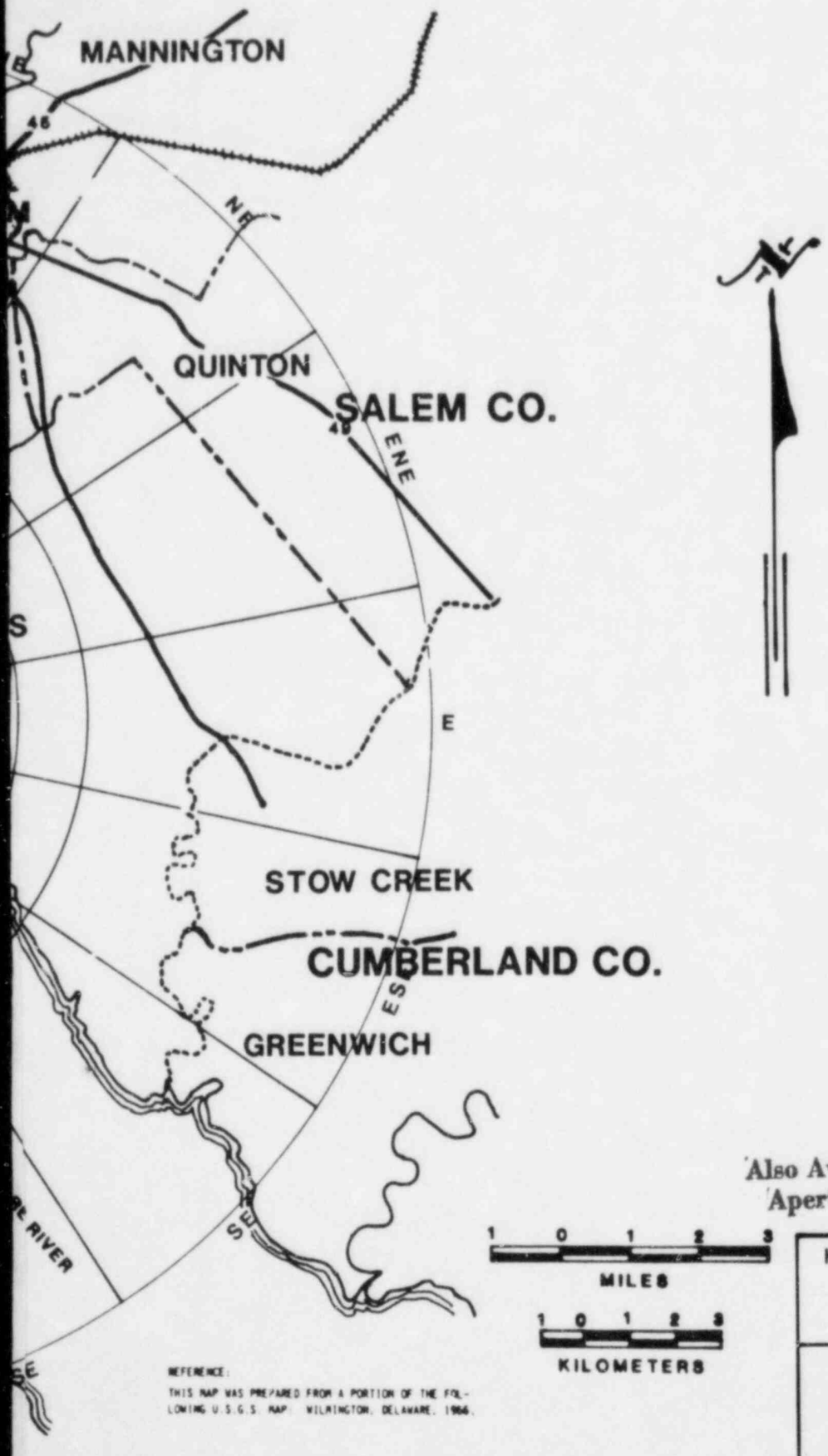
EXISTING ZONING

WITHIN 0 - 8 KILOMETERS
(0 - 5 MILES)

FIGURE 2.1 - 25

8306290435 - 25


NEW CASTLE
PENNSVILLE
N
NNW
PENCADER
DELAWARE CITY
NW
RED LION
SALE
ELSINBORO
13
301
NNW
ST. GEORGES
NEW CASTLE CO
LOWER ALLOWAY CREEK
SITE
W
MIDDLETOWN
ODESSA
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
KM RADIUS)
APPOQUINIMINK
WSW
BLACKBIRD
DELAWA
SW
DUCK CREEK
SSW
KENT CO.
KM
MILE
S
RADIUS)



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LEGEND

COUNTY BOUNDARY

SUBCOUNTY BOUNDARY

Also Available On Aperture Card

1 0 1 2 3
MILES

1 0 1 2 3
KILOMETERS

REFERENCE:
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

COUNTY AND SUBCOUNTY JURISDICTIONAL BOUNDARIES WITHIN 1.6 KILOMETERS (10 MILES)

FIGURE 2.1 - 26

8306290435 -26

2.2 ECOLOGY

2.2.1 TERRESTRIAL ECOLOGY

2.2.1.1 Study Area

All studies were done within a 16 kilometers (10 mile) radius of HCGS. Elevation of the area ranges from 0 to 75 feet above mean sea level, although most of the area is generally less than 30 feet above sea level.

The dominant features of the study area are the Delaware River and Bay (Figure 2.2-1). A continuum of open water, through a fringe of brackish tidal marsh of varying width, to upland fields, is the normal pattern along both shores. A thin sandy strand line separates the river and marsh in many places, most frequently in the southern half of the study area. The marsh area is more extensive in New Jersey, usually reaching several miles inland. The marshes feature numerous anastomosing tidal creeks, which in some cases extend well into the uplands. Salt marsh plants grow at the mouths of these creeks; these are gradually replaced upstream by less salt-tolerant species, until 13 to 14 kilometers inland, where freshwater vegetation composes the shoreline marshes.

Vegetation composition of the marsh in the northern part of the study area and in the upper creeks depends to some degree on the amount of spring rain. Wet springs result in lower salinity in the marsh during germination and seedling development, allowing more typically freshwater species to invade.

Tidal stage and vegetative cover strongly influence the physiography of the marsh. The normal tidal amplitude is 1.8 meters (5.8 feet). Sand bars, mud flats and the intertidal zone are visible at low tide. High tides cover these areas, expanding the creeks and flooding the vegetation.

2.2.1.2 Vegetation

Fifty-six families and 199 species of vegetation have been observed within eight kilometers (13 miles) of the site. Sixty-three of these plants are characteristic of disturbed areas and early successional stages. The common families are Compositae, Polygonaceae, Fabaceae, Gramineae and Cyperaceae. Of the 199 species, 134 occur in only approximately 20 percent of the study area, in ecotones such as beaches, creek banks, dikes and roadsides.

Vegetation within 16 kilometers (10 miles) of the site consists of three major habitat types: tidal marsh, upland fields and woodlands.

The tidal marshes are in a brackish portion of the estuary where the salinity ranges between 0 and 15 parts per thousand. Four basic tidal marsh associations occur: freshwater, brackish low marsh, brackish high marsh and reed grass.

Freshwater marsh occurs in the upper portions of the larger creeks and tributaries. The common species are arrow arum, Peltandra virginica; spatterdock, Nuphar adrena; wild rice, Zizania aquatica; cattail, Typha spp.; pickerel weed, Pontederia cordata; and smartweeds, Polygonum spp. The largest area of the freshwater marsh is located within the Salem River system, especially in Mannington Meadow.

Brackish low marsh occurs throughout the normal intertidal zone; it is usually flooded twice daily. Saltmarsh cordgrass, Spartina alterniflora, is the dominant species, normally comprising over 50 percent of the area. Associated species include saltmeadow cordgrass, Spartina patens; salt grass, Distichlis spicata; big cordgrass, Spartina cynosuroides; bulrushes, Scirpus spp., including S. acutus, balidus, robustus, and americanus; reed grass, Phragmites communis; and tidemarsh waterhemp, Amaranthus cannabinus.

Brackish high marsh, or salt meadow, occurs from about mean high tide to the limit of spring tide. Vegetation is generally shorter than in low marsh, and has a matted, swirled appearance. High marsh is characterized by two codominant species: saltmeadow cordgrass and salt grass. Productivity here is lower than in low marsh. The codominant species are less robust since they do not receive the twice daily tidal flushing, with its fresh supply of nutrients.

More species are associated with high marsh than with low marsh. Common associates include dwarf spikerush, Eleocharis parvula; Olney's threesquare, Scirpus olneyi; and orach, Atriplex patula. Herbaceous species such as seablite, Suaeda linearis; marsh fleabane, Pluchea purpurascens; saltmarsh aster, Aster tenuiflolius; and goldenrod, Solidago spp., occur scattered throughout the marsh. Saltmarsh cordgrass grows along drainage ditches and depressions. Big cordgrass grows in wetter areas, and marsh elder in the higher areas.

The northernmost instance of high marsh in the Delaware Estuary is adjacent to Hope Creek. High marsh is well developed south of the site, especially in the area of Liston Point, Delaware.

Reed grass is a relatively recent but successful invader in the Delaware Estuary. Generally considered a pest species, it is of little value to wildlife for either food or cover. Reed

grass is common on disturbed areas, such as dredge spoil. It grows best in fresh water or slightly brackish water near the site. Reed grass, which is well adapted to invading and holding new areas of marsh, has replaced many stands of more desirable species, such as saltmarsh cordgrass, throughout the study area.

Submerged aquatic macrophytes have not been found in the Delaware River near the site, but they are likely to occur in lakes, ponds and impoundments of the area. Coontail, Ceratophyllum demersum, was found in some of the freshwater potholes on Artificial Island, but these pools dry up during drought periods. The high turbidity and tidal amplitude probably prevent macrophytes from growing in the Delaware River near the site.

Sandy beaches line the river near the site. Low elevation beaches have reed grass interspersed with occasional marsh elder, beginning at the spring tide line. Species include saltmeadow cordgrass; Americana beachgrass, Ammophila breriligulata; reed-canary grass, Phalaris arundinacea; cocklebur, Xanthium strumarium; sea rocket, Cakile endentula; and wild radish, Raphanus raphanistrum.

Upland fields near the site are used for cultivation. Crops, predominantly corn and soybean, are usually rotated. Uncultivated fields contain many plant species, with panic grass, Panicum spp.; soft rush, Juncus effusus; velvet grass, Holcus lanatus; marsh fleabane; foxtail grass, Setaria faberii; thoroughwort, Eupatorium serotinum; and Kentucky bluegrass, Poa pratensis, dominant. Some areas become flooded by winter and spring rains, and become temporary wet meadows and potholes. Soft rush; marsh purslane, Ludwigia palustris; and spike-rush, Eleocharis sp., are common in these wet areas.

Four forest habitat types based on elevation and drainage have been identified within a 16 kilometer (10 mile) radius of southern Artificial Island (Reference 2.2-1).

Wet lowlands feature shrubs and small trees along stream banks. The type is characterized by red maple, Acer rubrum; sweet gum, Liquidambar styraciflua; and black willow, Salix nigra. These three species typically occupy about 75 percent of the type. This comprises approximately 27 percent of the forested lands within the 16 kilometer (10 mile) radius, but only about four percent of the total area.

Wet mid-elevation areas, the most common woodland type, comprise about 44 percent of the forested land and six percent of the total area. Fifty percent of the overstory is pin

oak, Quercus palustris, and sweet gum. This is the most common type in Delaware, occurring on the higher elevations of wooded streambeds and in upland depressions of poor drainage.

Well-drained, mid-elevation forests comprise the same percent area as wet lowlands (27 percent). White oak, Quercus alba; red oak, Q. rubra; and red hickory, Carya ovalis, are the dominant species; these occupy about 50 percent of the type. Well-drained, mid-elevation forests occur in relatively small scattered woodlots; this is the most common type in New Jersey.

Dry forests of high elevation comprise only three percent of the forecasted area and less than one percent of the total study area. White oak is dominant, occupying 50 percent of the type. Within the 16 kilometer (10 mile) radius, this type is only found in New Jersey.

2.2.1.3 Fauna

Amphibians

Nine species of salamanders and 11 frogs and toads have been recorded within a 16 kilometer (10 mile) radius of the site. All except the southern leopard frog, Rana pipiens, are restricted to freshwater areas or moist woodland inland of the marshes. Common species include red-backed salamander, Plethoden cinereus; northern two-lined salamander, Eurycea bislineata; Fowler's toad, Bufo woodhousei; northern cricket frog, Acris crepitaus; northern spring peeper, Hyla crucifer; eastern gray treefrog, Hyla versicolor; chorus frog, Pseudacris triseriata; bullfrog, Rana catesbeiana; green frog, Rana clamitans; and pickerel frog, Rana palustris.

Most amphibians are common in suitable habitats. Each species observed has a large range that covers an extensive portion of the United States. The eastern tiger salamander, Ambystoma tigrinum, was found in southern New Castle County, Delaware, just outside the study area; it may occur within the study area as well. This species is listed as endangered in New Jersey.

Reptiles

The studies recorded 26 species of reptiles, 13 turtles, 1 lizard, and 12 snakes. Eight were recorded from tidal marsh; four of these, the snapping turtle, Chelydra serpentina; northern diamondback terrapin, Malaclemnys

terrapins; eastern mud turtle, Kinosternon subrubrum; and northern water snake, Natrix sipedon, inhabit the brackish portions.

Other common reptiles in the area include spotted turtle, Clemmys guttata; eastern box turtle, Terrapene carolina; eastern painted turtle, Chrysemys picta; red-bellied turtle, Chrysemys rubriventris; and easten garter snake, Thamnophis sirtalis.

Some commercial trapping of the snapping turtle occurs within the study area from May through July. Turtle trapping has increased in recent years, especially in Delaware. This is the only reptile in the region of any current commercial importance.

The rarely observed bog turtle, Clemmys muhlenbergi, was found in the study area in Delaware by Arndt (Reference 2.2-1). Throughout its range it occurs only in scattered areas, because of restrictive habitat requirements. It is currently considered endangered in New Jersey.

Sea turtles are found occasionally within the study area in the Delaware Bay. These include the Atlantic green turtle, Chelonia mydas mydas; Atlantic Ridley, Lepidochelys kempi; Atlantic loggerhead, Caretta caretta caretta; Atlantic leatherback, Dermochelys coriacea coriacea; and Atlantic hawksbill, Eretmochelys imbricata imbricata. These turtles are all classified as endangered or threatened throughout their ranges.

Birds

The studies recorded 178 water, shore, marsh and upland bird species. This list includes permanent resident (25 percent), summer resident (37 percent), visitant (25 percent) and transient (13 percent) birds. Of the total, 29 percent were recorded primarily from tidal marsh, 19 from open water of the river, 19 from upland fields, and 33 from woods and brushland.

Thirty-three species are considered game birds, including four upland birds, 25 waterfowl and four marsh birds. Upland game birds include the resident ring-necked pheasant, Phasianus colchicus; bobwhite, Colinus virginianus; the migratory mourning dove, Zenaidura macroura; and American woodcock, Philohela minor. However, it is the seasonal migratory waterfowl which dominate the local game bird scene. Especially pursued are the exceptionally abundant Canada goose, Branta canadensis, and the ducks, including the

mallard, Anas platyrhynchos; black duck, Anas rubripes; and green-winged teal, Anas carolinensis. Other ducks are taken infrequently, particulary the diving ducks, which are hunted primarily downbay. Marsh birds, including the rails, Rallus spp.; common snipe, Capella gallinago; and American coot, Fulica americana, are occasionally hunted.

Community composition and relative abundance vary greatly by season, and are largely a function of migration. Those species that occur throughout the region and utilize more than one habitat type are most abundant. Most of the common year-round species, such as the red-winged blackbird, Agelaius phoeniceus; common grackle, Quiscalus quiscula; starling, Sturnus vulgaris; and brown-headed cowbird, Molothrus ater, are more abundant during periods of migration. Species abundant only during migration include the mallard; black duck; green-winged teal; pintail, Anas acuta; and rusty blackbird, Euphagus carolinus. In summer, abundant species are the laughing gull, Larus atricilla; great black-backed gull, Larus marinus; cattle egret, Bubulcus ibis; barn swallow, Hirundo rustica; robin, Turdus migratorius; and tree swallow, Iridoprocne bicolor. The Canada goose is most abundant from fall through spring.

Osprey, classified as endangered by the NJDEP, nest in transmission towers near the site. Since 1974 these nests have been monitored by boat and helicopter. The results of these observations are presented in PSE&G, 1977 through 1981, Annual Non-Radiological Reports (References 2.2-2 through 2.2-6). Observations prior to 1977 appear in References 2.2-7 through 2.2-16. Nestings have increased from six nests in 1974 to 18 nests in 1981. The number of birds fledged has ranged from four, in 1974 and 1981, to 16, in 1979. The population near the site remains active and should continue to produce fledglings.

Mammals

A total of 45 mammals have been observed or could be expected to occur within 16 kilometers (10 miles) of the site. Eight species are primarily associated with tidal marsh and other wet areas, 19 with woods and brush, and four with fields and grassy areas. Five are marine mammals occasionally found in the Delaware Bay.

Small mammals near the site include house mouse, Mus musculus; meadow vole, Microtus pennsylvanicus; masked shrew, Sorex cinereus; and marsh rice rat, Oryzomys pulustris. Upland species further away from the site

include white-footed mouse, Peromyscus leucopus; short-tailed shrew, Blarina brevicauda; and meadow jumping mouse, Zapus hudsonius.

The white-tailed deer, Odocoileus virginianus; eastern cottontail, Sylvilagus floridanus; and eastern gray squirrel, Sciurus carolinensis, are the most commonly pursued game species. The opossum, Didelphia marsupialis; New England cottontail, Sylvilagus transitionalis; raccoon, Procyon lotor; red fox, Vulpes fulva; gray fox, Urocyon cinereo-argenteus; and woodchuck, Marmota monax, are also taken. The eastern cottontail, white-tailed deer and red fox occur on Artificial Island, but due to restricted access, they are seldom hunted.

Furbearing species commercially trapped throughout the study area include muskrat, Ondatra zibethica; striped skunk, Mephitis mephitis; raccoon; opossum; gray fox; long-tailed weasel, Mustela frenata; and mink, Mustela vison. The river otter, Lutra canadensis, is legally trapped only in Delaware, and the red fox only in New Jersey. The beaver, Castor canadensis, is present in Delaware in the northwest part of the study area, and is protected.

Ten bat species have been recorded near the site. All are found infrequently in wooded areas or in buildings. The hoary bat, Lasiurus cinereus, and the evening bat, Nycticeius humeralis, have been reported only in the Delaware part of the study area (Reference 2.2-1). Five species, the little brown myotis, Myotis lucifugus; eastern pipistrel, Pipistrellis subflavus; big brown bat, Eptesicus fuscus; red bat, Lasiurus borealis; and seminole bat, Lasiurus seminolus, probably occur only during the warmer months, and migrate to other areas for the winter.

Marine mammals, all of which are federally protected, were occasionally observed near the site. The hooded seal, Crystophora cristata; harbor seal, Phoca vituline; harp seal, Pagophilus; and gray seal, Halichoerus grypus, reach the southern limits of their range in the Delaware Bay region; they are found infrequently along the ocean coast of New Jersey. Two specimens identified as hooded seals were repeatedly sighted over several days in Mad Horse Creek during January, 1973. One observation of a harbor seal off the southern end of Artificial Island was made on March 8, 1977.

Porpoises and whales have been recorded in the Atlantic Ocean and the Delaware Bay. These animals have been reported in the study area by local crabbers, but attempts

at identification are impractical. Two pilot whales, or common blackfish, Globicephala melaena, beached at Delaware City in 1976.

2.2.2 AQUATIC RESOURCES

Early 1968 marked the beginning of ecological studies in the vicinity of Artificial Island. These early studies were descriptive in nature. With time they evolved to identify important aspects of the local aquatic ecosystem. This information is now available to permit assessment of the impact of the construction and operation of generating stations built and operated on the island. The start and end dates of each program (Table 2.2-1) reflect the evolution of the overall effort to create a base from which to assess plant impact.

Annual progress reports and annual operating reports contain much of the data collected during these studies, as well as the procedures used (References 2.2-2 through 2.2-15). A summary report is also available for the period 1968 through 1976 (Reference 2.2-16).

2.2.2.1 Phytoplankton and Detritus

Phytoplankton are microscopic plants with little or no mobility that live in the water. Their distribution is determined largely by local water movements. They are primary producers; together with waterborn detritus, they form the basis of the estuarine food web.

Ichthylogical Associates initiated studies of phytoplankton in March, 1973; the studies continued through December, 1978. Seasonal and spatial trends were determined for size, photosynthetic rate, composition of the standing crop and relative abundance of detritus. During 1973 and 1974 samples were collected at six locations in the vicinity of Artificial Island. Two additional locations were added in 1975, and one was added in 1977 (Figure 2.2-2). PSE&G describes the data collected and the methods employed during the program in Reference 2.2-17.

While some 100 phytoplankton genera have been identified near Artificial Island, only a few taxa, particularly Skeletonema costatum, consistently dominated the annual local community. The nannoplankton (i.e., measuring less than 10 microns) also contribute to the productivity of the system, especially in the warmer months, but these were not studied because of their small size. The net plankton, such as S. costatum, Melosira spp. and Chaetoceros spp. appear to be among the most important producers near Artificial Island; the smaller plankton

are probably at least as important. Since chlorophyll a was extracted from the entire population sampled regardless of cell size, the amount of chlorophyll extracted is probably a better indicator of standing crop (and production) than cell density.

Seasonal trends in annual phytoplankton standing crop, relative composition and productivity near Artificial Island (Figure 2.2-3) were generally similar from year to year. The most productive periods were the warmer months when standing crop was maximum; production was less or negligible in the colder months when standing crop levels were minimum. Additionally, the greatest rate of production always occurred at the surface; production decreased with depth to near zero at a depth of two meters (seven feet). These data suggest that local phytoplankton production, being seasonal and restricted to a relatively shallow euphotic zone, supplies only part of the total local primary food base.

Even though natural conditions are often unfavorable for rapid growth, the phytoplankton community is not solely dependent on local populations, but is largely augmented by input from up- and downriver regions of the estuary. Freshwater species (such as Ankistrodesmus falcatus, Melosira spp. and Cyclotella spp.) and marine species (such as S. costatum and Chaetoceros spp.) were common in the study area.

Plant detritus, with its associated micro-flora, may be a large contributor to the local food base. Detritus consists of particulate organic matter in various stages of decay. Aquatic sources include vascular plant and phytoplankton remains and zooplankton fecal pellets. The phaeo-pigments are decomposition products of chlorophyll a; they are representative of the micro-sized fraction of detrital load.

Terrestrial-derived plant detritus consists mostly of fragments of grass (family Gramineae) including roots, stems and rhizomes. Larger stems and green leaves of Phragmites communis and Spartina spp. and smaller fragments (length less than 5 centimeters) of these and other grasses (Ichthyological Associates, 1976; unpublished observations) have as their most immediate source the extensive local low marsh stands that are regularly flooded and drained by the tides.

2.2.2.2 Aquatic Invertebrates

Invertebrates are a diverse assemblage, which occupies a variety of habitat types, depending on species and life stage, including the water column, bottom sediments and intertidal zone.

The study of aquatic invertebrate fauna covered a period from 1971 through 1978 near Artificial Island. Investigations included studying the macroinvertebrate plankton, microzooplankton, benthos and blue crab. Annual reports present the species composition as well as the procedures and methods used. Sampling for invertebrates covered the area in the immediate vicinity of Artificial Island (Figure 2.2-4).

The invertebrates were divided on the basis of habitat into two primary components. The zooplankton are those organisms with limited mobility that spend all or part of their life cycle in the water column. The benthos are those that spend all or part of their life cycle in or on the bottom sediments. Although most taxa primarily occupy only one of the two basic habitats, several taxa exist and function in both habitats (e.g., mysids, amphipods and larval stages of benthic invertebrates).

Zooplankton

The zooplankton near Artificial Island consists of larval stages of benthic invertebrates and a large variety of smaller organisms (e.g., protozoa), which were not taken frequently in the samples because of size or behavior.

Zooplankton performs an essential part of an aquatic food web by converting energy bound up in phytoplankton and plant detritus and making it available to higher-level consumers.

The zooplankton near Artificial Island reflects the physicochemical characteristics of the Delaware River in this region; it is typical of the type found in mid-Atlantic estuaries. The wide range of seasonal and daily changes in salinity has shaped the species composition, which is numerically dominated by a few taxa, including Acartia tonsa, Eurytemora affinis, Rhithropanopeus harrisii (larvae), Uca minax (larvae), copepod nauplii, "rotifer" spp., Neomysis americana, and Gammarus spp.

Changes in the species composition (Figures 2.2-5 and 2.2-6) reflect seasonal variation in factors such as freshwater flow, salinity and temperature. During periods of high freshwater runoff, the freshwater rotifers, "rotifer" spp., Brachionus angularis, Notholca sp.; the cyclopoid copepod, Halicyclops fosteri, and the amphipod, Gammarus spp., dominate. During

late summer and fall, more saline forms, such as ctenophores, and the copepods, Acartia tonsa and Pseudodiaptomus coronatus, dominate.

Numerical abundance of zooplankton varies seasonally, related to water temperature (Figure 2.2-7). During spring and summer, abundance increases; this increase reflects reproductive activity.

The horizontal distribution of the local zooplankton is primarily determined by flow direction and velocity. Many species are passively transported into the area from the upper and lower regions of the estuary, and in a minor way through the Chesapeake and Delaware Canal. Others have evolved behavioral mechanisms that allow them to selectively control their position within the water column. By varying position in the water column, these zooplankton are able to utilize the two-layer circulation system that sometimes exists within the estuary to remain within or move to a preferred water mass. This behavior was demonstrated by the macroplankters, Neomysis americana, Gammarus spp., Corophium lacustre, Crangon septemspinosa, Edotea triloba and Rhithropanopeus harrisii (megalops). Microzooplankton also demonstrated vertical movement, but to a lesser degree.

The distributions of larval stages of species whose adults live in or on specific substrates reflect their origin in these localized areas. Examples include grass shrimp, Palaemoetes pugio; fiddler crab, Uca minax; and mud crab, Rhithropanopeus harrisii. Larvae and juveniles of grass shrimp were collected in greatest density in inshore areas, fiddler crab larvae and juveniles near intertidal mud banks and at the mouth of tidal creeks, and mud crab megalops near oystershell beds.

Benthos

The invertebrates that make up the benthos near Artificial Island are primarily resident euryhaline forms. Most are primary consumers that feed on phytoplankton and detritus. Both pelagic larvae and adults of benthic organisms are components of the estuarine food web, functioning as prey for higher level consumers such as fishes. The attached benthos (e.g., hydroids, oysters and barnacles) are also important as habitat formers (e.g., shelter and attachment surfaces) for other invertebrates.

This discussion considers only those organisms that were retained on a 0.5-millimeter (0.02 inch) mesh sieve. These macrofauna are the major constituents of the local community.

The principal factors regulating benthic species composition, distribution and abundance are salinity, temperature and substrate type. The availability of suitable substrate is the factor most limiting distribution and abundance of many taxa in this reach of the estuary. The combined effect of these factors is reflected in a benthos characterized by a relatively low diversity, with dominant taxa including Scolecolepides viridis, Polydora sp., Paranais litoralis, Balanus improvisus and Cyathura polita.

As a result of species-specific habitat preference and/or dependence, each substrate type has its characteristic assemblage of organisms. Some species are limited to one type, while others may occur in all. Water velocity and the way it affects disposition of sediments is the primary determinant of substrate type. Near Artificial Island the basic types are sand, clay, mud, and to a lesser extent, gravel-shell. This discussion considers all data from each substrate type to provide a general overview.

Sand substrate has a low organic content, is subject to scouring by strong currents, and lacks attachment surfaces. Species richness (from 7 to 10 annually), density and biomass were least in this substrate. The limited ability of sand to support infauna or epifauna is reflected by Scolecolepides viridis, which, although dominant in sand, was much more abundant in other substrate types. However, some organisms seem especially adapted to utilize a sand substrate; Chiridotea almyra, also dominant in sand, was less abundant elsewhere, and Parahaustorius sp. was taken only in sand. Other common occupants of the sand substrate were Gammarus spp., Neomysis americana, Turbellaria and Paranais litoralis.

Clay substrate is also characterized by low organic content, high susceptibility to scouring and little attachment surface. It consists mostly of clay, silt and some detritus. Species richness (9 to 12), density and biomass were moderate. Polydora sp. was the dominant taxon in clay, and was less common elsewhere. Other members of the clay community were Gammarus spp., Scolecolepides viridis, Cyathura polita, Corophium lacustre and Nereis succinea.

Mud is characterized by high organic content and little attachment surface, and is typical of depositional areas with a slow current velocity. Species richness (12 to 13), density and biomass were moderate. Paranais litoralis was the dominant taxon in mud; it was less common in other types. Other members of the mud community were Scolecolepides viridis, Oligochaeta #1, Rhynchocoela, and Cyathura polita.

Gravel-shell substrate is characterized by a high organic content and a wide range of attachment surfaces, including small rocks, gravel and shell. It provides food and habitat for many benthic organisms. Species richness (16 to 19), density and biomass were greatest in these areas. Balanus improvisus, which requires firm substrate for attachment, was the dominant taxon. Other members of the gravel-shell community were Paranais litoralis, Scolecolepides viridis, Nereis succinea and Corophium lacustre. Taxa utilizing the surface attachment aspect of this substrate include the mussel, Modiolus demissus; the oyster, Crassostrea virginica; the anenome, Diadumene leucolena; and some ectoprocts (bryozoans). The nudibranch, Doridella obscura, which feeds on ectoprocts, was taken only on gravel-shell.

The local benthic composition reflects seasonal changes in salinity and temperature. The effects of these changes are reflected in the greater diversity of benthos when salinity is high; this increase in diversity is also caused by the movement of species such as the isopod, Edotea triloba, and the cumacean shrimp, Leucon americanus, into the study area from downbay. Larval stages of several species immigrate into the study area in summer and fall, and become temporarily established in low density in the benthos; these species include the polychaetes, Glycera dibranchiata, Glycinde solitaria, and Sabellaria vulgaris; the pelecypods, Mulinia lateralis and Mya arenaria; and the tunicate Molgula manhattensis.

Water temperature determines the timing of reproductive activity for many species; temperature is therefore closely associated with seasonal increases in benthic populations. This effect is most evident in the occurrence of recently set larvae of Balanus improvisus shortly after the optimum temperature for reproduction is reached.

2.2.2.3 Aquatic Vertebrates

Since 1968, the fishes in the river and tidal tributaries have been sampled with a variety of gear. The initial objective was to inventory the fishes that occur in the Artificial Island area. After a period of extensive sampling, the seasonality of community structure was defined, and study goals were expanded to include seasonal and spatial distribution and annual variation by life stage. Studies of life history aspects (e.g., age, growth and food habitats) of selected species were conducted. Results and procedures were presented in annual progress reports. Table 2.2-2 summarizes the sampling gear used in various locations within the study area.

The ichthyofaunal community of the Delaware River near Artificial Island is a diverse assemblage of species which, on the basis of life strategy, can be divided into two distinct groups: resident and migratory forms. The dominant resident species have been bay anchovy, hogchoker, Atlantic and tidewater silversides, naked goby, mummichog and silvery minnow. Dominant migratory species have been the river herrings, Atlantic menhaden, white perch, weakfish, spot and Atlantic croaker.

Changes in composition, abundance and distribution of the region's ichthyofauna parallel a large seasonal variation in physical and chemical conditions, most notably in water temperature and salinity. This association is manifested through differences in timing and location of spawning and the subsequent recruitment to this area of early life stages, and through habitat and feeding behavior of all stages.

In spring, species richness increases with water temperature as estuarine residents move from downbay overwintering areas and anadromous species migrate upstream from offshore waters. Progeny of several marine fish migrate or are transported to low salinity nursery areas. Adult bay anchovy, Atlantic silverside, hogchoker and white perch typically arrive in the study area from downbay in March and April to feed in preparation for later spawning. The anadromous striped bass, American shad, blueback herring and alewife pass through the study area. Larvae and young of the ocean-spawning Atlantic menhaden and spot appear locally as early as March, as temperature rises.

During May, as bay anchovy and hogchoker reach spawning condition, they begin to move back downbay to higher salinity spawning grounds. This movement continues through summer as younger specimens mature in local waters. Adult weakfish enter the bay from offshore, and resident naked goby begin spawning downbay. By mid-June, progeny of all these species typically have moved into the low salinity nursery grounds near Artificial Island. Their local abundance increases, and remains high through summer. Young spot and Atlantic menhaden, however, prefer less saline water, and their local abundance decreases as they move upstream.

By early to mid-July, eggs and larvae, recently spawned near Artificial Island or transported from downbay, peak in number. Together with older cohorts produced earlier and downbay, they comprise most of the local ichthyofauna. During July through September, activity slows, and young of the dominant species reach their peak in annual abundance.

Abundance declines during late September, October and November, as the decreasing water temperature initiates emigration to overwintering areas downbay and/or offshore. Perhaps more in response to lowering salinity than to temperature, white perch move into the area from upriver in the fall. Conversely, progeny of Atlantic croaker migrate into the area during the fall, and utilize it as a nursery until minimum water temperatures (January or February) prompt their return downbay, to warmer water. During winter, variety within the local ichthyofaunal community is low; only white perch, hogchoker and silvery minnow are common. Low water temperature limits activity as metabolism slows, and restricts the distribution of these fish to the deeper waters.

2.2.3 ENDANGERED AND THREATENED SPECIES

The shortnosed sturgeon, Acipenser brevirostrum, has been found in the Delaware River; it is listed as endangered by both the Fish and Wildlife Service (50 CFR 17) and the state of New Jersey (NJR 7:25-11.1). From 1950 through June 1982 a total of 49 incidental captures have occurred in the Delaware River drainage area. Five specimens were captured in the vicinity of Artificial Island. Of these, two were found in either a gill net or 4.5-meter trawl, and the remaining three were found at a cooling water intake, having died prior to arrival there. Brundage (Reference 2.2-17) provides a discussion of all captures. Masnik (Reference 2.2-18) discusses the impact of the operation of HCGS.

Sea turtles have also been observed within the Delaware Bay, including the Atlantic loggerhead, Caretta caretta; Kemp's Atlantic Ridley, Lepidochelys kempii; and green sea, Chelonia mydas. The loggerhead and green sea turtles are threatened and the Ridley is endangered (50 CFR 17). The state of Delaware maintains a list of incidental sea turtle captures. Between 1978 and 1980 a total of eight loggerheads and three Ridley's were listed. In addition, during the current study, eleven turtles were captured in bottom trawls or on an intake structure's trash bars. Seven of these turtles were loggerheads; four of the seven were dead, and three were alive, and were released. Two Ridley's were found: one live and one dead. One live green sea turtle and one unidentified live turtle were also found. All live turtles were released. During the current study, most dead turtles were confirmed as having been dead prior to reaching the intake structure; these were disposed of in accordance with National Marine Fisheries Service (NMFS) directions.

Terrestrial endangered and threatened species within the vicinity of the site included the peregrine falcon (federally listed as endangered) and the bald eagle and osprey (listed by the State as endangered).

Peregrine falcons have not bred east of the Mississippi since the 1950's. The peregrine was last known to nest in New Jersey along the Hudson River. New Jersey is along the migratory path of the peregrine, and several have been observed in the vicinity of the site during recent years. Suitable nesting areas, cliffs and ledges, are not near the site so no breeding is expected. The NJDEP has attempted to reintroduce the peregrine to New Jersey by installing nesting platforms along the ocean. These individuals will not be affected by the station.

The bald eagle, classified as endangered by New Jersey, has been observed near the site during most years. Between 1971 and 1981, 20 sightings were recorded during studies near Artificial Island (References 2.2-1 through 2.2-12). No nesting occurs in New Jersey except at one location in Cumberland County about 40 kilometers (25 miles) southeast of the site. The sightings along the Delaware River may be multiple sightings of a few eagles.

Osprey, classified as endangered by New Jersey, has been a successful breeder on the transmission towers next to the site. Nesting studies between 1974 and 1981 show an increase in nests from 6 to 18, with the number of active nests also increasing from 3 to 12 (References 2.2-1 through 2.2-9). The nesting osprey appear as early as mid-March, with nest construction beginning soon after, and remain through mid-October. Clutches are laid by mid-April, with incubation taking 28 days. Fledging occurs by late July, and the birds leave the nest by mid-August. This area represents the highest concentration of ospreys in the state and continues to be a suitable nesting site.

Marine mammals, all of which are federally protected, were occasionally observed in the present study. The hooded seal, Crystophora cristata; harbor seal, Phoca vitulina; harp seal, Phoca groenlandica; and gray seal, Halichoerus grypugs, reach the southern limits of their range in the Delaware Bay region; they occur infrequently along the ocean coast of New Jersey. Two specimens identified as hooded seals were repeatedly sighted by crabbers over several days in Mad Horse Creek during January, 1973. One observation of a harbor seal off the southern end of Artificial Island was made on March 8, 1977.

Porpoises and whales have been observed in the Atlantic Ocean and in Delaware Bay. These animals have been reported from the study area by local crabbers, but attempts at identification are impractical. Two pilot whales, or common blackfish, Globicephala melaena, beached at Delaware City in 1976.

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TABLE 2.2-1

ARTIFICIAL ISLAND ECOLOGICAL STUDIES
COMPONENTS SAMPLED

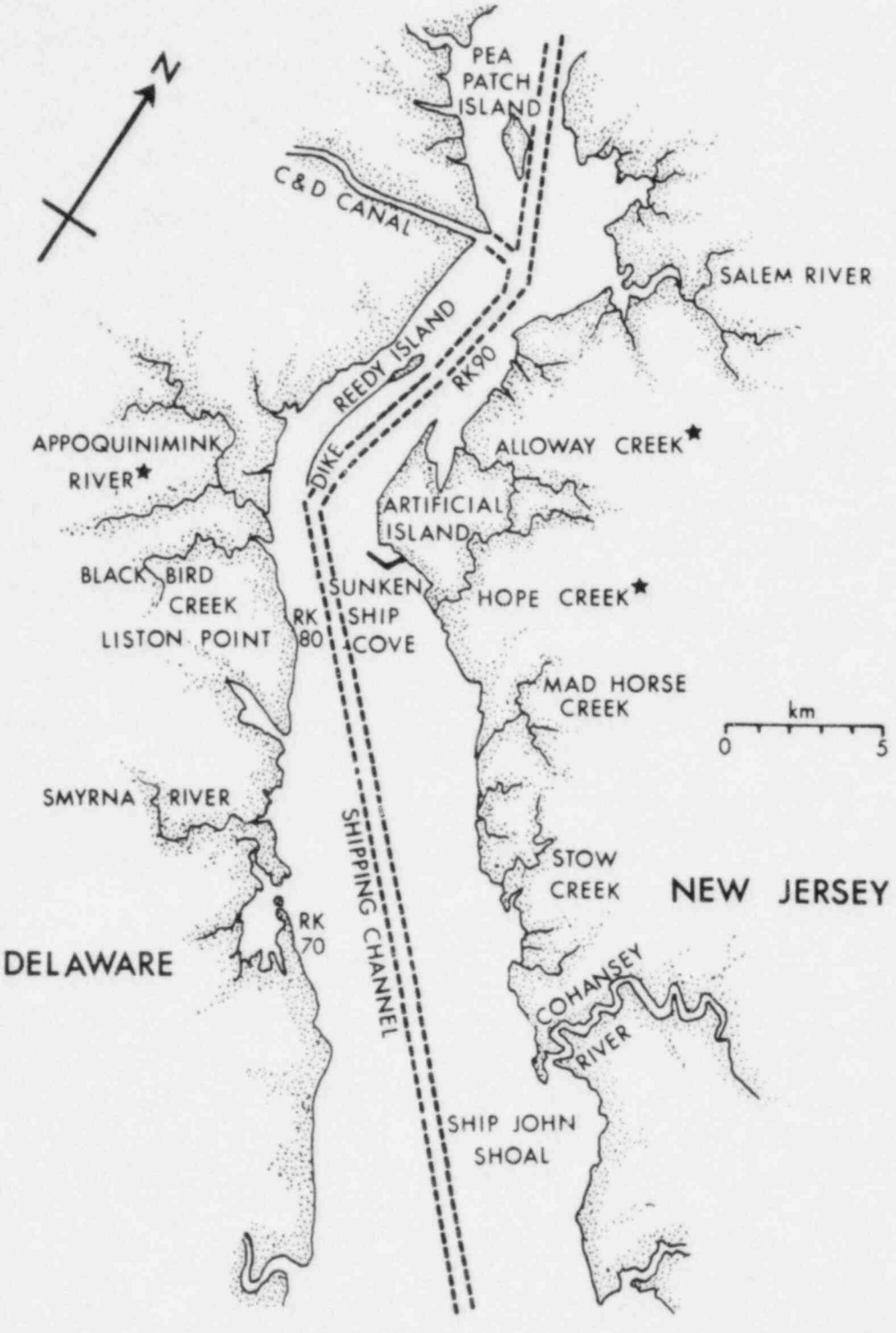
COMPONENT	YEAR INITIATED	YEAR COMPLETED
Fishes		
Ichthyoplankton	1971	Continuing
Trawls		
Day	1968	Continuing
Night	1969	1978
Simultaneous seine & trawl	1971	1978
Creek	1969	1978
Seines		
River	1968	1978
Creek	1969	1978
Gill nets	1969	1978
Invertebrates		
Benthos	1971	1978
Zooplankton	1968	1978
Blue crab	1968	Continuing
Larval crab	1971	1973
Phytoplankton	1973	1978

TABLE 2.2-2

CHRONOLOGY OF PRIMARY SAMPLING GEAR DEPLOYMENT IN THE DELAWARE RIVER AND TIDAL TRIBUTARIES NEAR ARTIFICIAL ISLAND, 1968-1970
(* - INVENTORY; X - MONITORING, SCHEDULED; + - SPECIAL STUDY)

GEAR	TRAWL							SEINE								SIMULTANEOUS		GILL NET						PLANKTON NET		
SPEC.	2.7 m	4.9 m		7.6 m				3.0 x 1.2 m				7.6 x 1.2 m		68.6 x 3.0 m		4.9-m Trawl 3.0-m Seine 7.6-m Seine 68.6-m Seine		7.9-cm	str		14-cm	str		0.5 - m		
																		2 x 183 m	2 x 183 m		3 x 183 m 6 x 183 m	3 x 91 m 6 x 91 m				
AREA SAMPLED	Trib. (bottom)	River (bottom)		River (bottom)		River (surface)		River		Trib.		River		River		River (entire water column)		River (surface drifted)	River (bottom staked)		River (surface drifted)	River (bottom staked)		River (surface/ midwater/ bottom)		Trib.
DAY/ NIGHT	D	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	D	N	D	D	N	D	N	D
YEAR																										
1968												*	*													
1969	*	*	*	*	*	*	*					*	*					*			*					
1970	X	*	*	*	*	*	*	*	*	*	*	X	*	*	*			X			X	+	+			
1971	X	X	+	+	+			X	+	X	+	X	+			+	+	X			X			*	*	
1972	X	X	+					X	+	X	+	X	+			+	+	X	+	+	X	+	+	*	*	
1973	X	X	+					X	+	X	+	X	+			+	+	X			X			X	+	
1974	X	X	+					X	+	X	+	X	+			+	+	X			X			X	+	*
1975	X	X	+					X	+	X	+	X	+			+	+	X			X			X	+	X
1976	X	X	+					X	+	X	+	X	+			+	+	X			X			X	+	

M PB2 125/11 17-18/gs

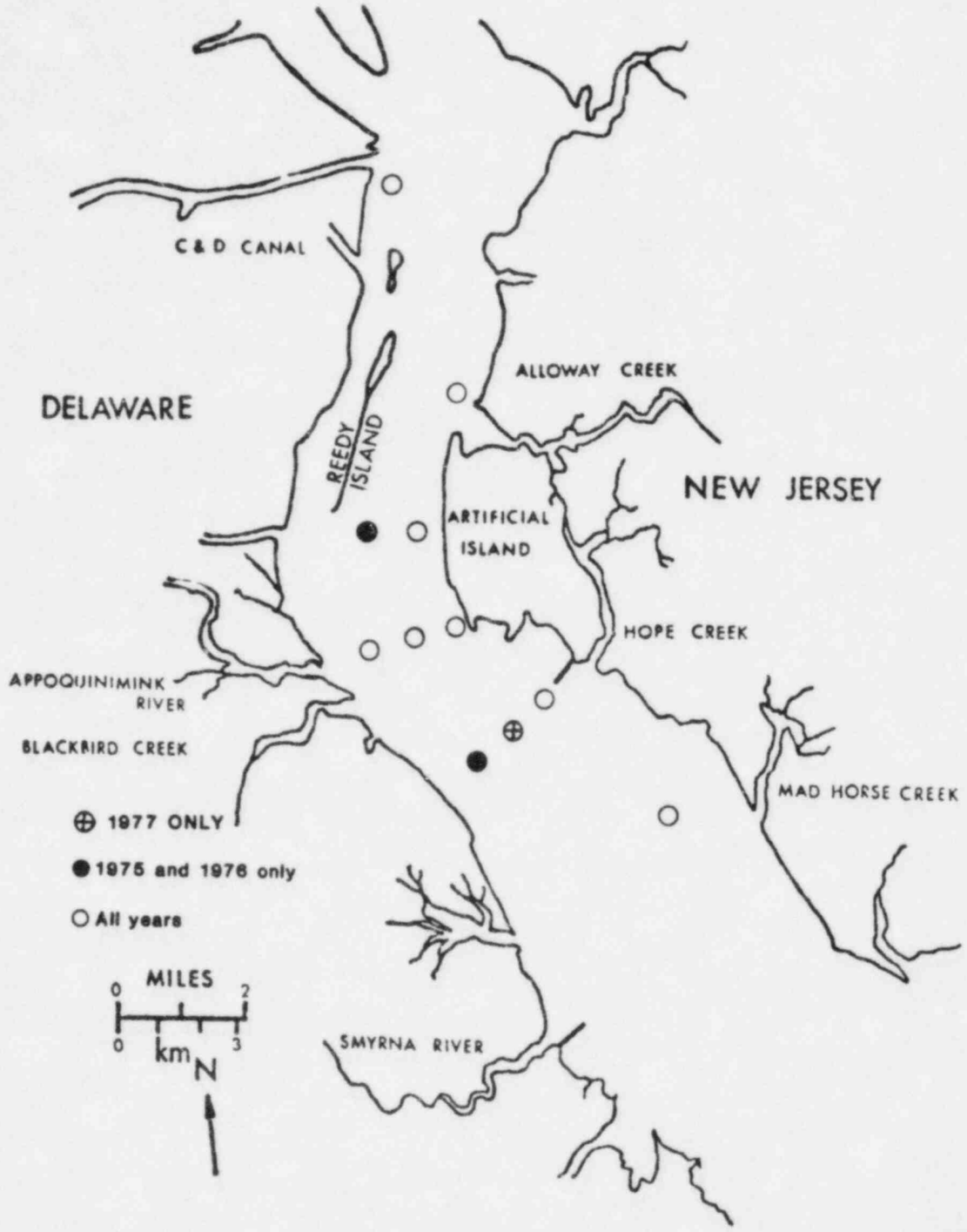


HOPE CREEK GENERATING STATION
ENV'RONMENTAL REPORT

OPERATING LICENSE STAGE

DELAWARE RIVER REACH AND LOCAL TIDAL TRIBUTARIES (★) NEAR ARTIFICIAL ISLAND IN WHICH SAMPLES WERE COLLECTED.

FIGURE 2.2 - 1

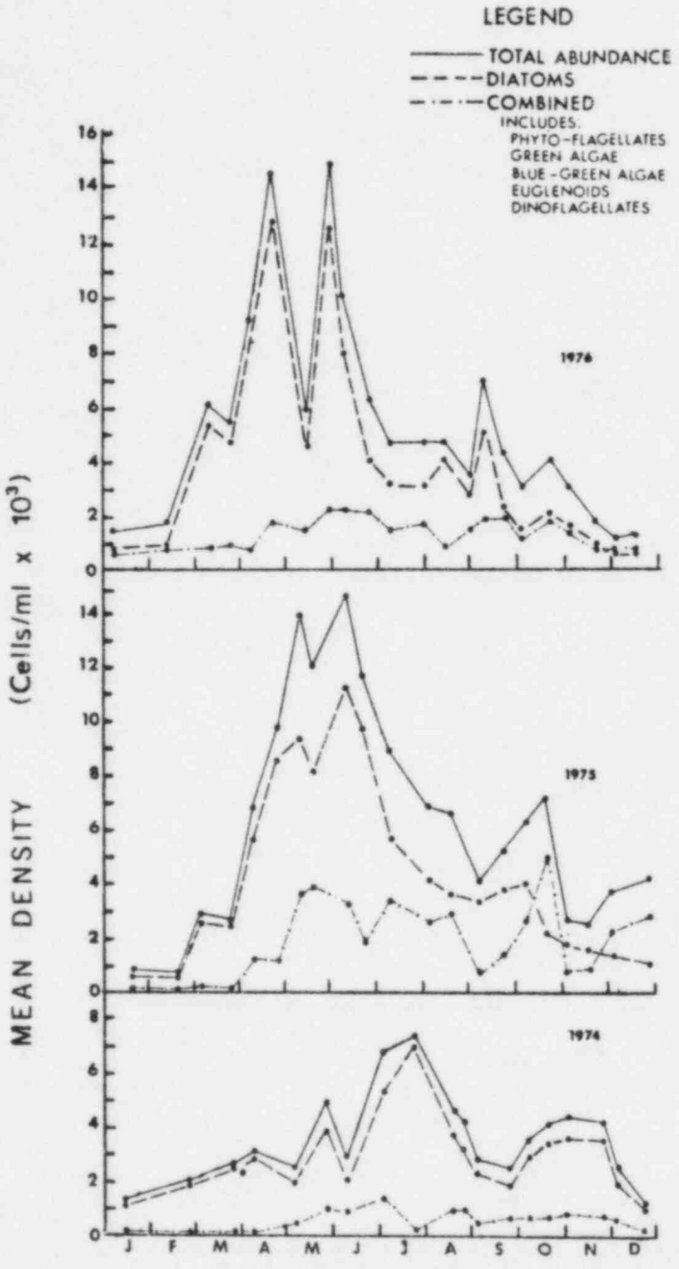


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

PHYTOPLANKTON
SAMPLING STATIONS,
1973 - 76

FIGURE 2.2 - 2

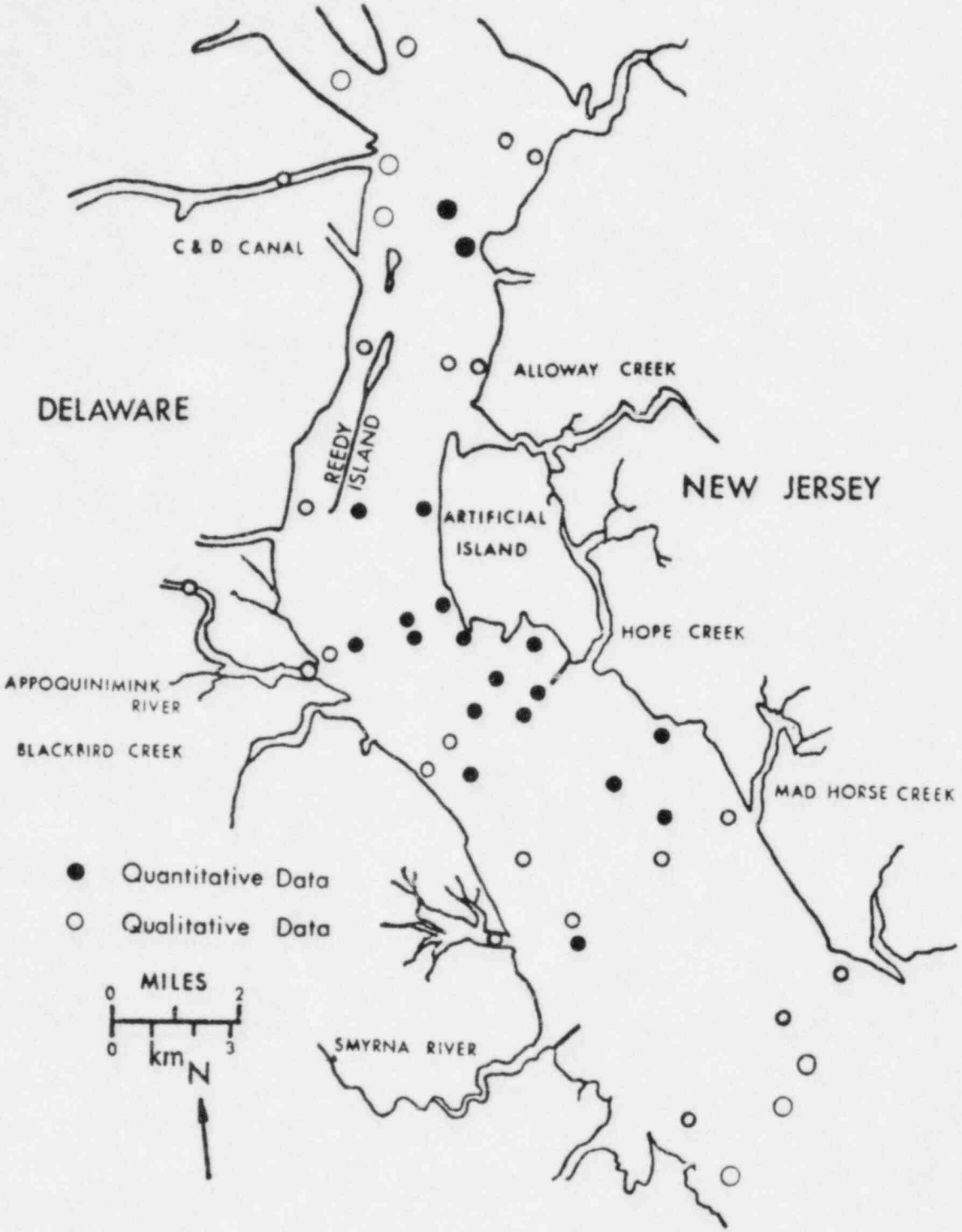


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SEMIMONTHLY MEAN DENSITYOF TOTAL PHYTOPLANKTON, DIATOMS, AND COMBINED TAXA.

FIGURE 2.2 - 3

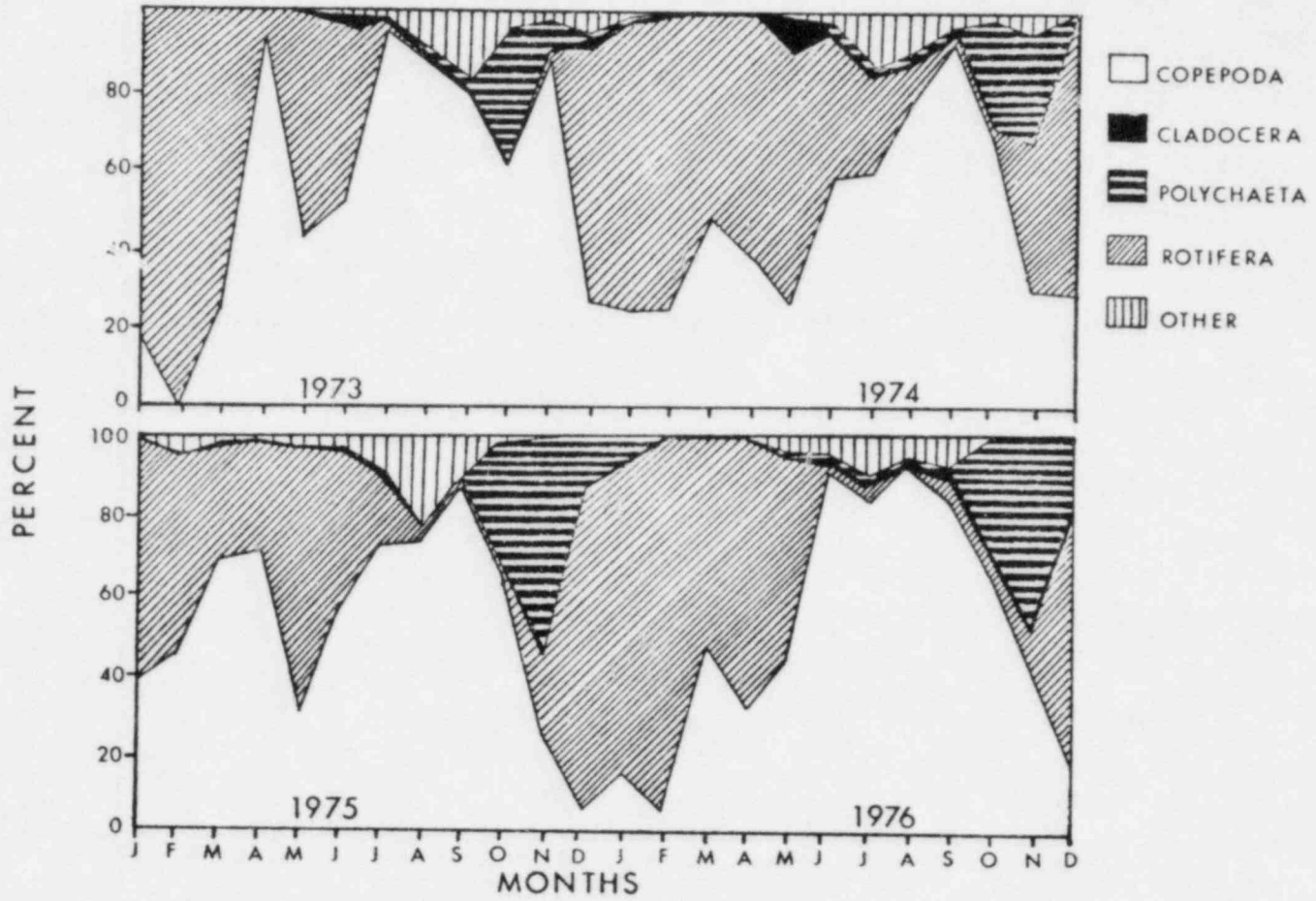


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

STATIONS AT WHICH BENTHOS WAS SAMPLED, 1971-1976
(not all stations sampled each year).

FIGURE 2.2 - 4

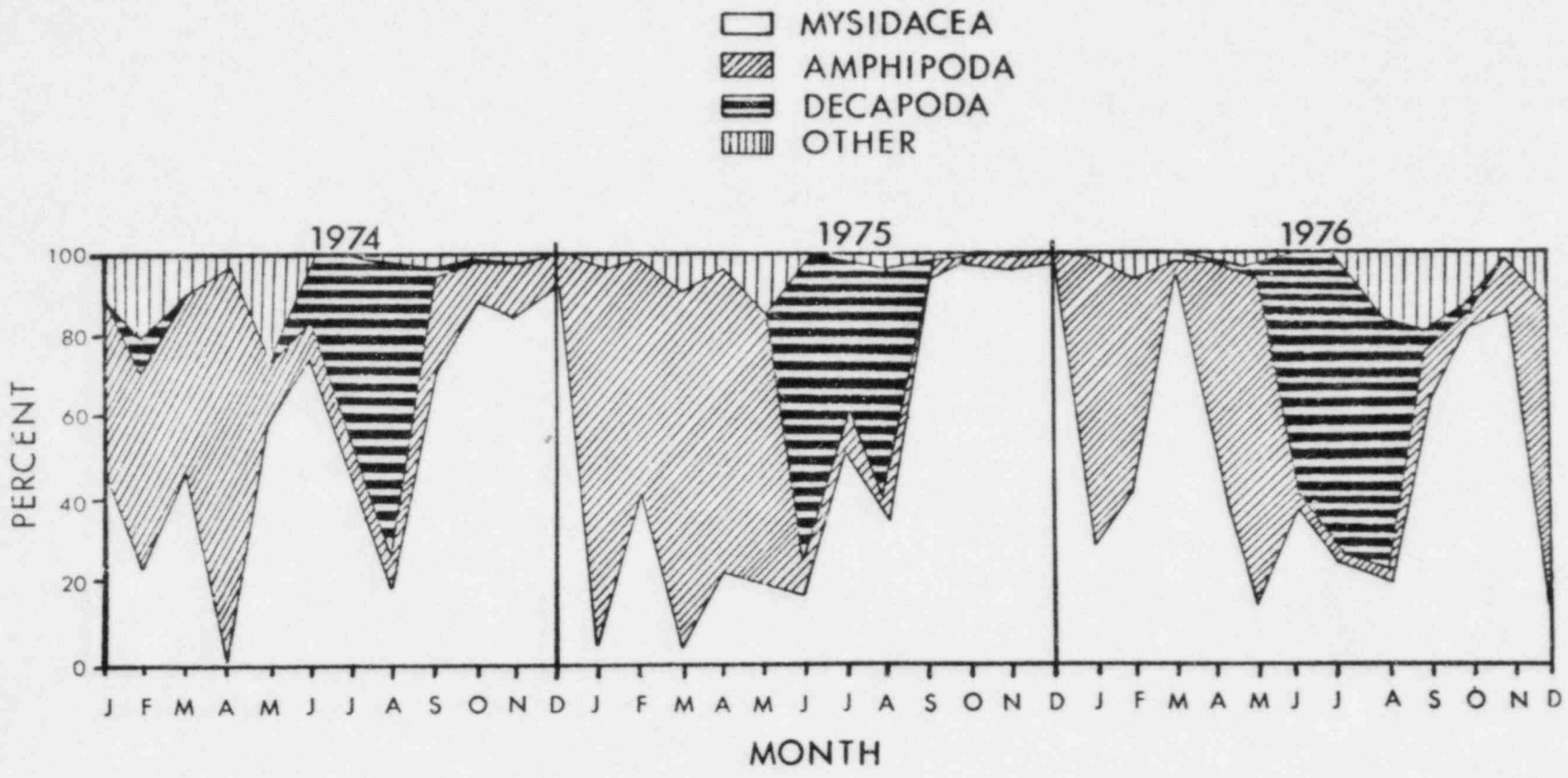


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

RELATIVE TEMPORAL ABUNDANCE OF DOMINANT MICROZOOPLANKTON GROUPS

FIGURE 2.2 - 5

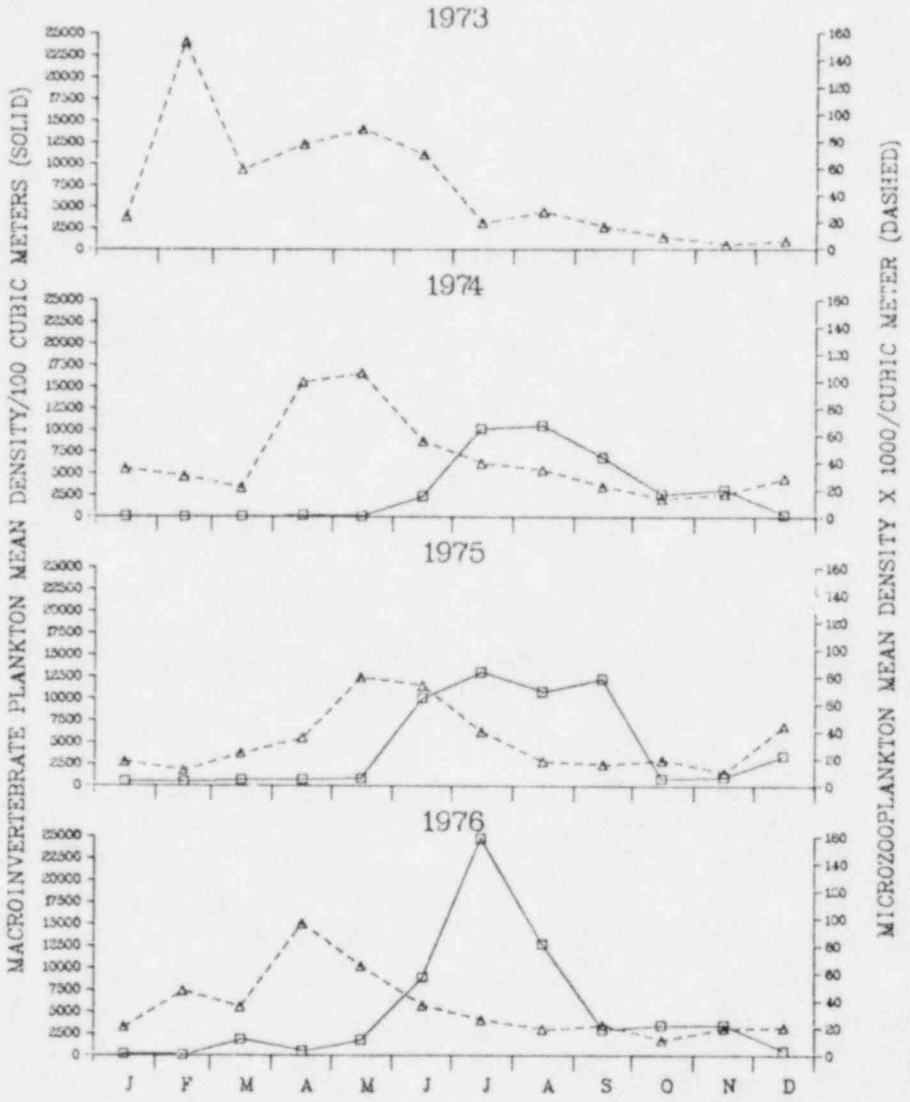


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

RELATIVE TEMPORAL ABUNDANCE OF DOMINANT MACROINVERTEBRATE PLANKTON GROUPS.

FIGURE 2.2 - 6



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY MEAN DENSITY OF MICRO-ZOOPLANKTON (1973-1976) AND MACROINVERTEBRATE PLANKTON (1974-1976)

FIGURE 2.2 - 7

2.3 METEOROLOGY

2.3.1 GENERAL CLIMATE

Based on the Koeppen climatic classification system, the region intersects two climatic zones: humid continental and humid subtropical. Both zones have characteristics of warm summers and mild winters (Reference 2.3-1). Summer maximum average temperatures are near 27°C (80°F), and the coldest month is January, which has an average daily temperature of approximately 0°C (32°F). Examining a 30-year record of mean precipitation amounts for Wilmington, Delaware National Weather Service (NWS) station, shows that the most rainfall occurs in the summer months, followed by spring, fall and winter (Reference 2.3-2).

The area of southern New Jersey is frequented by Polar Canadian air masses in the fall and winter, and occasionally invaded by Arctic Canadian air late in winter. During the spring and summer, the dominant air mass is Maritime Tropical (Reference 2.3-1).

Precipitation

Table 2.3-1 gives the frequency of precipitation events such as rain, snow, ice storms, thunderstorms and hail. The data in Table 2.3-1 were obtained from the Revised Uniform Summary of Surface Weather Observations, Dover (Delaware) Air Force Base, 1942-1965. The data presented in Tables 2.3-2 and 2.3-3 show snowfall distributions that were obtained from Philadelphia International Airport and Trenton Airport, respectively.

Humidity, Winds

Humidity annually averages 70 percent (Reference 2.3-3). Prevailing winds on a monthly average during the winter (December to March) are from a northwest direction with a range of speeds from 14 to 21 kilometers per hour (9 to 13 miles per hour). Average monthly winds for the spring and summer months (April to August) are from a southerly to southwesterly direction at speeds ranging from 11 to 16 kilometers per hour (7 to 10 miles per hour). Winds during the fall are predominantly from the west-southwest, veering to a west-northwest direction by December. The average wind speeds are highest during the winter months (Reference 2.3-3).

Seasonal and Annual Frequencies of Severe Weather

Severe weather is any destructive storm, such as a tropical cyclone (hurricane), tornado, waterspouts, thunderstorm, hail or freezing rain storm. The frequency and severity of these storms in the HCGS region are assessed in this section.

Tropical Cyclones

Tropical cyclones originate over the tropical waters of the Atlantic Ocean, Caribbean Sea and the Gulf of Mexico, from early summer through fall. The most intense form is called a hurricane, which has wind speeds greater than 117 kilometers per hour (73 miles per hour); however, other less destructive stages can exist, which are known as tropical depressions and tropical storms. The remnants of those tropical cyclones that dissipate over land are referred to as extratropical cyclones. Reference 2.3-4 shows that, from 1899 through 1980, 12 extratropical cyclones, eight tropical storms and no hurricanes passed through the region. The average annual frequency of destructive tropical cyclones is less than 0.2 (less than 10 storms per 55 years) according to Dunlap (Reference 2.3-5).

The region is fairly well shielded from the most destructive forces of tropical cyclones, since it is not located directly on the Atlantic Coast. In fact, no hurricanes have been documented in the Climate of Delaware (Reference 2.3-6) as entering the state of Delaware directly from the Atlantic Coast.

Tornadoes

Tornadoes, although infrequent, do occur in the region, primarily during the spring and summer. Summaries prepared by Pearson (Reference 2.3-7) indicate that there were 108 tornadoes reported within a two-degree latitude by two-degree longitude area centered on the site during the period 1950 through 1981. This two-degree by two-degree area represents approximately 38,829 square kilometers (15,000 square miles). Of these 108 tornadoes, none had an estimated Fujita-Pearson force scale exceeding F3, 331 kilometers per hour (206 miles per hour).

The closest reported tornado came within 16 kilometers (10 miles) of the site on July 1, 1954, across the Delaware River in Delaware. This tornado had a path area of 0.08 square kilometer (0.03 square mile).

Using the statistical methods of Thom (Reference 2.3-8), the probability of a tornado striking any given point in the one-degree latitude-longitude square centered on the HCGS site is once in every 10,229 years. This probability estimate is based upon a frequency of 1.4 tornadoes per year in the one-degree square. The annual frequency of tornadoes was obtained from Pearson's summary, which showed that 44 tornadoes, of which three had multiple touchdowns, occurred in the one-degree latitude-longitude square encompassing the site. The average path area for these 44 tornadoes was 0.67 square kilometer (0.26 square mile).

Waterspouts

Golden states that a waterspout is an intense columnar vortex of limited horizontal extent, existing over a body of water, that does not necessarily contain a funnel cloud (Reference 2.3-9). The basic differences between tornadoes and waterspouts are that tornadoes are generally more intense, larger and longer-lived.

The data on waterspouts is limited, and concentrates on events occurring in the vicinity of the Florida Keys. Several studies on their size, duration, intensity, associated phenomena and effects have been made in the Keys area, yet little information is available to relate these storms to those occurring elsewhere (References 2.3-9 and 2.3-10).

Basically, the largest and most intense waterspouts can be of tornadic size. The upper limit to the rotational velocity is presently estimated as approaching 322 kilometers per hour (200 miles per hour), with typical translational velocities approaching 24 to 32 kilometers per hour (15 to 20 miles per hour).

Estimates of the frequency of waterspouts at the HCGS site are extremely difficult to project. Waterspouts rarely leave evidence of their occurrence. The frequency of waterspouts occuring in the HCGS region, over the Delaware River or Bay, probably approaches that of tornadoes in the region.

Thunderstorms and Lightning

Thunderstorms are a seasonal phenomenon in the region of the HCGS site. The Wilmington NWS records show an average of 31 thunderstorm days per year, with 26 of these days occurring during the warmer months of April through September (Reference 2.3-11).

Direct observation of lightning strokes is not a routine function at any of the standard observation stations; however, Uman has developed a statistic which indicates that the number of lightning flashes (cloud to ground) per square mile (2.6 square kilometers) per year is equal to between 0.05 and 0.8 times the number of thunderstorm days per year (Reference 2.3-12). A conservative estimate of the number of lightning strokes per year in the square mile containing the HCGS site is 25.

Hail

Severe hail storms are a relatively rare phenomenon in the region. Pautz (Reference 2.3-13) reports only eight occurrences of hail with diameters of 1.9 centimeters (0.75 inch) or greater in New Jersey, and none in Delaware, during the period 1955 through 1967. Of these eight occurrences in New Jersey, six storms had hail with diameters ranging from 1.9 to 3.8 centimeters (0.75 to 1.50 inches), and two had diameters greater than 3.8 centimeters (1.50 inches). Baldwin (Reference 2.3-14) and Changnon (Reference 2.3-15) both report an annual frequency of approximately one hail storm per year in the HCGS region. Hail is generally associated with severe thunderstorms, and is thus most likely to occur during the late spring and summer.

The Monthly Climatological Data for Wilmington, Delaware (Reference 2.3-16) shows six occurrences of hail during the period 1977 through 1981, which agrees well with frequencies reported by Baldwin and Changnon.

Ice Storms

A survey by Bennett for 1928 through 1937 indicates that ice or freezing rain may occur as often as one to three times per year in the site region (Reference 2.3-17). These occurrences are most frequent during the winter. Glaze accumulations greater than 0.63 centimeter (0.25 inch) are expected only once per year. A more recent summary of glaze statistics by Baldwin (Reference 2.3-14) indicates that during the 20 year period 1950 through 1969 approximately four days of freezing rain occurred annually throughout the region. Freezing rain has occurred on 25 days during 1977 through 1981 at the Wilmington NWS Station (Reference 2.3-16). The longest duration of freezing rain at the Wilmington NWS station during this period was 15 hours on February 15 and 16, 1979.

High Air Pollution Potential

Episodes of limited atmospheric dispersion in the U.S. have been studied by Holzworth (Reference 2.3-18) in terms of urban and area source problems. Holzworth has estimated approximately 20 forecast days of high potential for air pollution during a five-year period in the vicinity of the site. Using a pressure gradient technique to define stagnating conditions, Korshover (Reference 2.3-19) found between 150 and 175 stagnation days in the region during the 40 year period from 1936 through 1975; this converts to approximately four stagnation days per year, which is the same as Holzworth's estimate. The summer and fall experience the highest potential for stagnation days.

2.3.1.1 Local Meteorology

The analysis of the local meteorology in the vicinity of the HCGS site is based upon five years of data (January, 1977 to December, 1981) collected at the on-site meteorological tower. The 91 meter (300 foot) tower is located on Artificial Island, approximately 1.6 kilometers (one mile) southeast of HCGS. Section 2.3.2 gives a full description of the meteorological tower and its instrumentation.

The analysis of regional meteorology for the HCGS area is based upon data from the Wilmington, Delaware NWS first order station, 29 kilometers (18 miles) north of the site. This station provides both representative long-term data for the region as well as meteorological data concurrent with the on-site data period. The representativeness of the meteorological data from the site tower and from the Wilmington NWS station to the long-term meteorology at HCGS is assessed in this section by a comparison of the two data sets. This assessment contrasts the extremes and distributions of the key meteorological parameters crucial to the safety, operation and construction of the plant.

No two meteorological data sets collected at the same location during different time periods or at two different locations for the same time period can be identical; however, the differences between these two data sets must be assessed to assure, in this application, that the on-site and/or long-term data reasonably represent the conditions that would be expected over the approximately 40-year lifetime of the plant.

This assessment uses the on-site data set for the five-year period and either the concurrent Wilmington NWS data or the Wilmington long-term climatological records.

2.3.1.1.1 Temperature

Table 2.3-4 summarizes the on-site monthly and annual means and extremes of temperature. January has the lowest mean monthly temperature of -2.1°C (28.2°F), and July has the highest mean monthly temperature of 23.8°C (74.8°F). The overall maximum hourly temperature at the site is 34.5°C (94.1°F), recorded on July 19, 1977 and July 20, 1980. The lowest hourly temperature recorded during the period is -18.°C (-1.3°F), on February 18, 1979 and January 17, 1977.

Table 2.3-5 shows monthly and annual frequency distributions of the temperature data. These distributions demonstrate that larger temperature ranges exist during the winter months, compared to the relatively small temperature ranges of the summer months. Annually, temperatures below -5.0°C (23°F) occur less than 5.0 percent of the time, and temperatures greater than or equal to 25.0°C (77°F) occur less than 9.0 percent of the time.

Table 2.3-6 summarizes the diurnal range of hourly temperatures for the period. The average temperature for each hour of the day is listed on an annual and monthly basis.

Table 2.3-7 contrasts the monthly and annual mean temperatures at the site and at Wilmington for the five-year on-site data period. This table shows a tendency for summer maximum temperatures at the site to be slightly lower than at Wilmington, and winter minimums to be slightly higher. Specifically, the maximum temperature at the site was 2°C (4°F) cooler than at Wilmington, while the minimum temperature at the site was 3°C (5°F) warmer. During this concurrent period, the mean monthly and annual temperatures at the site compare very favorably with Wilmington.

Table 2.3-8 lists the Wilmington NWS long-term temperature means and extremes. These means are generally similar to the five-year period (concurrent with the HCGS data period) mean temperatures measured at Wilmington. The mean temperatures at Wilmington during the five-year period are considerably cooler than the long-term Wilmington mean temperature for January and February. Both of these months have average temperatures more than 2°C (4°F) lower than the long-term means. This difference reflects the extremely cold winters the Northeast has experienced during the last few years. The annual average temperature during the five-year concurrent period in Wilmington is only 0.3°C (0.6°F) lower than the long-term record. The long-term extreme temperatures are comparable to those measured during the five-year period.

2.3.1.1.2 Dew Point Temperature

The means and extremes of dew point temperature appear in Table 2.3-9. The highest dew point temperatures occur during the summer; the overall maximum hourly dew point of 28.4°C (83.1°F) was recorded in August. The overall minimum hourly dew point temperture of -24.7°C (-12.5°F) occurred in December.

Table 2.3-10 gives the monthly and annual frequency distributions of dew point temperature. On an annual basis, dew point temperatures greater than or equal to 20.0°C (68°F) occur 9.3 percent of the hours, and 9.6 percent of the hours have dew point temperatures less than -10°C (14°F).

Table 2.3-11 shows the monthly and annual diurnal range of dew point temperatures. There is little diurnal variation of the dew point temperature within each month.

2.3.1.2 Monthly and Annual Wind

Monthly and annual joint frequency wind distributions, which were derived from wind speed and direction at the 91 meter, 46 meter and 10 meter (300 foot, 150 foot and 33 foot) levels of the Artificial Island Meteorological Tower, appear in Tables A-1 through A-6 of Reference 2.3-20.

2.3.1.3 Monthly and Annual Wind by Stability Class

Monthly and annual joint frequencies of wind direction and speed by atmospheric stability class at heights that are relevant to atmospheric transport of effluents are presented in Tables A-1 through A-6 of Reference 2.3-20. Tables A-1 through A-3 are based on the entire five-year period, while Tables A-4 through A-6 are monthly wind distributions. Atmospheric stability was derived using the NRC's delta temperature classification system. The observed delta temperature interval at the site was from 91 to 10 meters (300 to 33 feet).

2.3.1.4 Monthly and Annual Summaries of Precipitation

Reference 2.3-20 presents monthly by calendar year precipitation distributions in its Table A-15. The combined monthly and the overall precipitation distributions for the five years also appear in Table A-16 of Reference 2.3-20. The hourly measurements are categorized by the amount of water equivalent precipitation that fell during each hour. In addition, maximum hourly, daily and monthly total precipitation amounts are highlighted in the summaries.

The maximum hourly precipitation recorded at the site was 4.06 centimeters (1.60 inches), on August 3, 1981. On October 25, 1980, the maximum daily amount of 7.87 centimeters (3.10 inches) was recorded. The maximum monthly precipitation of 20.07 centimeters (7.90 inches) fell in January, 1979. The following list shows the maximum water equivalent precipitation measured at the site over various time periods during the five years.

Time Period	Maximum Measured Water Equivalent Precipitation centimeters	(inches)
a. 1 hour	4.06	(1.60)
b. 2 hours	4.83	(1.90)
c. 3 hours	5.33	(2.10)
d. 6 hours	6.10	(2.40)
e. 12 hours	7.11	(2.80)
f. 24 hours	7.87	(3.10)
g. 1 month	20.07	(7.90)

During the five-year period, the precipitation was fairly evenly distributed throughout each year. The precipitation intensity was generally light. More than 70 percent of the recorded precipitation hours during the five years occurred at rates of less than or equal to 0.25 centimeter per hour (0.10 inch per hour). The monthly distributions show that the summer months exhibit higher hourly precipitation rates than the winter months.

Tables A-17 and A-18 of Reference 2.3-20 show the duration of precipitation and the accumulated amounts as frequency distributions for the entire five-year period and by month. The majority of precipitation events lasted less than six consecutive hours. There was only one case of precipitation lasting between 12 and 23 consecutive hours during the five years.

Those hours with recorded precipitation are distributed by wind direction and speed recorded at the three tower levels, and categorized by precipitation rates. In addition, all precipitation hours are grouped into frequency distributions by wind speed and direction. The eight hourly rate categories used range from the smallest, amount equal to 0.25 centimeter (0.10 inch), to the largest, amounts exceeding 3.81 centimeters (1.50 inches). In Reference 2.3-20, Tables A-19 through A-21 present the distributions for the entire period, and Tables A-22 to A-24 list the combined monthly distributions. These distributions indicate that precipitation

is most frequently associated with winds containing an easterly component at all levels. Furthermore, winds at the 33-foot level are most frequently southeast during precipitation, and northeast and east-northeast winds are the most common 150-foot and 300-foot wind directions during precipitation.

A comparison of the on-site and Wilmington precipitation extremes during January, 1977 through December, 1981 reveals that the on-site extremes are comparable to those at Wilmington. The one-hour, 24-hour and one-month maximum precipitation totals are shown in the following list:

	Time Period	Artificial Island centimeters (inches)		Wilmington NWS centimeters (inches)	
a.	1 hour	4.06	(1.60)	3.43	(1.35)
b.	24 hours	7.87	(3.10)	10.01	(3.94)
c.	1 month	20.07	(7.90)	21.36	(8.41)

The long-term maximum 24-hour and monthly precipitation totals measured at Wilmington NWS are 16.59 centimeters (6.53 inches) in August, 1945 and 37.87 centimeters (14.91 inches) in August, 1911, respectively. These maximums significantly exceed those measured at the site.

Table 2.3-12 gives the monthly and annual means along with the monthly extremes and 24-hour maximums of precipitation at the Wilmington NWS station. The mean monthly precipitation totals range from a minimum of 6.60 centimeters (2.60 inches) in October to a maximum of 10.95 centimeters (4.31 inches) in July. The mean annual total precipitation for the 1941 through 1970 period was 102.24 centimeters (40.25 inches).

These long-term climatological monthly precipitation means generally compare favorably with those measured at the site; the on-site monthly precipitation means are shown in Table A-16 of Reference 2.3-20.

Since snowfall is not measured at the site, monthly and annual means and the monthly and twenty-four hour maximum snowfall from the Wilmington NWS records are given in Table 2.3-13. February had the highest mean monthly snowfall of 16.26 centimeters (6.4 inches). The maximum monthly snowfall of 69.85 centimeters (27.5 inches) occurred in February, 1979. The maximum 24-hour snowfall of 55.88 centimeters (22.0 inches) was recorded in December, 1909.

2.3.1.5 Wind Speeds Greater than 50 Knots

There was only one occurrence during the five-year period (January, 1977 through December, 1981) where the wind speed at any of the wind-measuring heights of 10 meters, 46 meters and 91 meters (33 feet, 150 feet and 300 feet) was observed to be greater than 50 knots (92.6 kilometers per hour or 57.58 miles per hour). This one hour is equivalent to a 0.00228 percent occurrence during the five-year period of record. The date of this occurrence was January 26, 1978 (hour ending 4); this wind speed was only observed at the 91 meter (300 foot) level of the tower. The associated wind direction was 150 degrees (southeast); this was considered a synoptic situation.

2.3.2 ON-SITE METEOROLOGICAL DATA COLLECTION PROGRAM

In order to arrive at atmospheric dispersion factors for use in calculating radiological exposures from both low level routine releases and accidental releases, an extensive data collection program was undertaken at the site. The present meteorological monitoring program is in conformance with the recommendations of Regulatory Guide 1.23, Revision 0.

The official HCGS preoperational data collection program commenced in April, 1976. The tower, a 91 meter (300 foot) guy wire supported structure, is located at latitude 39 degrees, 27 minutes, 48.9 seconds north, and longitude 75 degrees, 31 minutes, 11.76 seconds west.

A detailed representation of the meteorological facility is not necessary because of the simplicity of the terrain. The tower data used is primarily that from the 10 and 91 meter (33 and 300 foot) levels, although data were obtained at the intermediate 46 meter (150 foot) elevation. The wind instrumentation consisted of Aerovanes, and the temperature-difference measurements were obtained from aspirated resistance thermometers. Precipitation, humidity and solar radiation measurements are on record, in case they are ever needed for general environmental applications.

Anemometers and wind vanes are located at the 91 meter, 46 meter and 10 meter (300 foot, 150 foot and 33 foot) elevations. Temperature measurement includes ambient temperature taken at the 10 meter (33 foot) elevation and temperature differences taken between the 91 and 10 meter (300 and 33 foot) levels and the 46 and 10 meter (150 and 33 foot) levels. All temperature sensors consist of thermistors in a motor

aspirated solar radiation shield. The dew point is measured at the 10 meter (33 foot) level, while rainfall and barometric pressure are measured at approximately 0.9 and 1.8 meters (3 and 6 feet), respectively. Solar radiation is measured at a height of 2.4 meters (8 feet) above ground level. Figure 2.3-1 depicts the heights of these instruments on the tower.

Table 2.3-14 lists the meteorological data parameters, elevations and instrument characteristics. A sigma computer was installed for experimental purposes, but is not considered part of the permanent system.

Additional sources of the meteorological data used to provide a description of airflow trajectories from the site out to a distance of 80 kilometers (50 miles) include Wilmington (ILG) and Philadelphia (PHL, PNE) NWS stations. Other sources of meteorological data are presented in Figure 2.3-2.

Hourly wind, temperature and cloud cover data are readily available from these NWS stations. Pasquil-Gifford stability can be derived from the wind speed and cloud cover data using an algorithm from the EPA's CRSTER air quality model.

2.3.3 REGIONAL METEOROLOGY

For an assessment of atmospheric transport to distances of 80 kilometers (50 miles) from the station, the following additional regional meteorological information from the NWS Station in Wilmington, Delaware is presented below:

2.3.3.1 Wind Speed and Direction Data

Figure 2.3-3 presents the annual wind rose for the 6 meter (20 foot) level at the Wilmington, Delaware NWS station. The wind rose was derived from wind direction and speed data for the period of record, January, 1972 to December, 1981.

2.3.3.2 Atmospheric Stability

Determinations of atmospheric stability are made from the temperature differences measured between the 91 and 10 meter (300 and 33 foot) levels and the 46 and 10 meter (150 and 33 foot) levels of the on-site tower. These temperature difference data are grouped into seven stability classes (A through G) according to the NRC lapse rate criteria of Regulatory Guide 1.23 Revision 0.

Monthly and annual summaries of atmospheric stability have been incorporated into the wind roses previously presented in Tables A-1 through A-6 of Reference 2.3-20. The distribution of on-site atmospheric stability for the five-year record is summarized in Table 2.3-15.

The temperature difference scheme classifies 43.9 percent of the hours as unstable to neutral (Pasquill Classes A through D) and 56.1 percent of the hours as stable (Pasquill Classes E through G).

Table 2.3-15 also shows the Wilmington stability distributions for the concurrent data period as well as the long-term 1972 through 1981 record. The Wilmington NWS stability is determined from the STAR program methodology consistent with Turner's scheme (Reference 2.3-21).

In light of differing techniques used to determine atmospheric stability (temperature difference method for on-site data and the STAR method for the Wilmington data), the stability distributions given in Table 2.3-15 are expectedly different. In fact, when the stability is grouped into three classes, unstable (Classes A, B and C), neutral (D) and stable (E, F and G), the distributions become:

		On-site (%)	Concurrent NWS (%)	Long-term NWS (%)
a.	Unstable	5.3	15.1	15.2
b.	Neutral	38.6	54.4	53.8
c.	Stable	56.1	30.5	31.1

2.3.3.3 Monthly Mixing Height Data

The table below was derived from isopleths of height data by season presented in U.S. EPA Publication 101 entitled Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States.

	Season	Mixing Height (meters) Morning	Afternoon
a.	Winter	850	1000
b.	Spring	750	1700
c.	Summer	600	1800
d.	Autumn	700	1300
e.	Annual	700	1300

2.3.3.4 Precipitation

See Section 2.3.1.4.

Wilmington, Delaware NWS Station is the only relevant station.

2.3.4 TOPOGRAPHY SURROUNDING THE SITE

Detailed 80 kilometer (50 mile) and eight kilometer (five mile) topographic maps are presented in Figures 2.1-1 and 2.1-2, respectively.

Plots of maximum elevation versus distance from the center of the plant in each of the sixteen 22.5-degree compass point sectors are presented in Figures 2.3-4 through 2.3-7.

2.3.5 50 PERCENT ACCIDENT X/Q ESTIMATES

Table 2.3-16 contains 50 percent accident X/Q estimates for the site boundary, 0.90 kilometer (0.56 mile), and the low population zone (LPZ), 8.0 kilometers (5.0 miles). Additional distances of 2 to 20 kilometers (1 to 10 miles), and multiples of 8 kilometers (5 miles) out to 80 kilometers (50 miles), are presented in Table A-25 of Reference 2.3-20. Long-term X/Q estimates are presented in Tables 2.3-17 through 2.3-22.

2.3.6 EXISTING ENVIRONMENTAL CONDITIONS

2.3.6.1 National and State Ambient Air Quality Standards Compliance

Table 2.3-23 summarizes the National Ambient Air Quality Standards for Total Suspended Particulates (TSP) as well as standards for states located within a 97 kilometer (60 mile) radius of HCGS.

2.3.6.2 Visibility

Table 2.3-24 shows that winter is the period when visibility at Wilmington NWS most often falls below 0.15 kilometer (0.25 mile). Visibility levels of less than 11 kilometers (7 miles) occur more often in the summer months; since summer is the time of year when smoke and haze are observed on the maximum number of days, the low visibility in winter months is most likely caused by snow and/or rain. There may be a relationship between TSP and visibility, but it has not been quantified.

2.3.6.3 Relative Humidity

The on-site data summarized in Tables 2.3-25, 2.3-26 and 2.3-27 show the expected diurnal and seasonal patterns of relative humidity of a site with the characteristics of a humid climate (Reference 2.3-1). Table 2.3-25 shows a rise in relative humidity during the late spring and summer months. Minimum relative humidities occur in the winter months, as expected. Table 2.3-26 shows the influx of humidity into the area during the summer months, and lower humidity in winter months. Table 2.3-27 shows the diurnal variation of relative humidity, along with the increase of humidity during the summer months.

2.3.6.4 Solar Radiation

Solar radiation is currently measured at Artificial Island as part of the ongoing meteorological program. The only significant structure that would have the potential for impact on solar radiation would be the cooling tower, with its associated plume.

2.3.6.5 Fog

Naturally-occurring ground fog may interfere with Delaware River ship traffic. Table 2.3-24 provides monthly and annual frequencies of fog observed at Wilmington, Delaware NWS Station for the period January 1977 through December 1981.

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TABLE 2.3-1

PERCENTAGE OF DAYS WITH VARIOUS HYGROMETERS
DOVER DELAWARE AIR FORCE BASE
1942-1965

Month	Fog	Snow and/or Sleet	Hail	Thunderstorms
Jan	43.7	4.1	0.4	0.6
Feb	45.0	3.4	0.2	0.9
Mar	48.4	2.7	-	3.7
Apr	44.4	0.3	0.2	8.9
May	49.0	-	0.9	16.6
Jun	55.3	-	0.4	17.1
Jul	54.3	-	0.2	19.6
Aug	66.3	-	-	17.4
Sept	59.0	-	-	6.8
Oct	53.8	-	0.2	3.0
Nov	47.6	0.6	0.2	1.2
Dec	44.5	2.5	0.2	0.5
Annual	51.2	1.2	0.3	8.2

TABLE 2.3-2

SNOWFALL[1]
centimeters/(inches)

PHILADELPHIA INTERNATIONAL AIRPORT

Month	Mean		Monthly Maximum	
Jan	14.4	(5.7)	50.0	(19.7)
Feb	15.5	(6.1)	46.7	(18.4)
Mar	10.4	(4.1)	34.0	(13.4)
Apr	0.8	(0.3)	10.9	(4.3)
May	-	T[2]	-	T
Jun	-	-	-	-
Jul	-	-	-	-
Aug	-	-	-	-
Sept	-	-	-	-
Oct	-	T	-	T
Nov	2.0	(0.8)	22.4	(8.8)
Dec	11.7	(4.6)	47.8	(18.8)
Annual	54.9	(21.6)		

[1]Length of record (years) = 28.

[2]T = Trace of precipitation.

TABLE 2.3-3

SNOWFALL[1]
centimeters/(inches)

TRENTON, NEW JERSEY AIRPORT

Month	Mean		Monthly Maximum		24-Hour Maximum	
Jan	14.7	(5.8)	40.9	(16.1)	25.7	(10.1)
Feb	17.0	(6.7)	58.7	(23.1)	33.0	(13.0)
Mar	11.2	(4.4)	54.6	(21.5)	36.3	(14.3)
Apr	1.0	(0.4)	10.7	(4.2)	10.7	(4.2)
May	T[2]	T	T	T	T	T
Jun	-	-	-	-	-	-
Jul	-	-	-	-	-	-
Aug	-	-	-	-	-	-
Sept	-	-	-	-	-	-
Oct	0.3	(0.1)	4.1	(1.6)	4.1	(1.6)
Nov	2.5	(1.0)	33.0	(13.0)	19.6	(7.7)
Dec	12.4	(4.9)	54.6	(21.5)	42.2	(16.6)
Annual	59.2	(23.3)		-		-

[1]Length of record (years) = 34.

[2]T = Trace of precipitation.

TABLE 2.3-4

ON-SITE TEMPERATURE MEANS AND EXTREMES[1]
JANUARY, 1977 - DECEMBER, 1981

Combined Months	TEMPERATURE (°C) Mean	Hourly Maximum	Hourly Minimum
Jan	-2.1	15.5	-18.5
Feb	-0.9	16.5	-18.5
Mar	5.4	24.5	-13.0
Apr	11.6	29.8	-2.6
May	16.6	29.0	4.0
Jun	20.8	32.0	9.5
Jul	23.8	34.5	12.5
Aug	23.6	32.5	12.0
Sep	19.7	31.5	7.0
Oct	12.4	24.5	0.5
Nov	7.9	21.5	-4.0
Dec	2.5	19.5	-15.5
Annual	11.7	34.5	-18.5

[1]Temperature is measured at the 10 meter (33 foot) level.

TABLE 2.3-5

ON-SITE HOURLY TEMPERATURE FREQUENCY DISTRIBUTIONS(1)
JANUARY 1977 - DECEMBER 1981

Temperature (°C)	MONTH											
	Jan		Feb		Mar		Apr		May		Jun	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
32.5 - 34.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
30.0 - 32.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	30	0.9
27.5 - 29.9	0	0.0	0	0.0	0	0.0	11	0.3	43	1.2	129	4.0
25.0 - 27.4	0	0.0	0	0.0	0	0.0	20	0.6	121	3.5	332	10.2
22.5 - 24.9	0	0.0	0	0.0	16	0.4	41	1.2	205	5.9	643	19.8
20.0 - 22.4	0	0.0	0	0.0	18	0.5	114	3.3	471	13.6	917	28.3
17.5 - 19.9	0	0.0	0	0.0	30	0.8	226	6.4	704	20.3	592	18.3
15.0 - 17.4	6	0.2	12	0.4	80	2.2	379	10.8	758	21.8	386	11.9
12.5 - 14.9	13	0.4	31	0.9	202	5.5	647	18.5	529	15.2	165	5.1
10.0 - 12.4	30	0.8	89	2.7	320	8.8	821	23.4	403	11.6	46	1.4
7.5 - 9.9	67	1.9	194	5.8	620	17.0	653	18.6	166	4.8	1	0.0
5.0 - 7.4	181	5.1	265	8.0	737	20.2	424	12.1	67	1.9	0	0.0
2.5 - 4.9	389	11.0	379	11.4	655	17.9	105	3.0	5	0.1	0	0.0
0.0 - 2.4	607	17.1	440	13.3	498	13.6	55	1.6	0	0.0	0	0.0
-2.5 - -0.1	638	18.0	562	16.9	248	6.8	7	0.2	0	0.0	0	0.0
-5.0 - -2.6	681	19.2	598	18.0	145	4.0	2	0.1	0	0.0	0	0.0
-7.5 - -5.1	520	14.7	388	11.7	33	0.9	0	0.0	0	0.0	0	0.0
-10.0 - -7.6	219	6.2	182	5.5	32	0.9	0	0.0	0	0.0	0	0.0
-12.5 - -10.1	129	3.6	117	3.5	15	0.4	0	0.0	0	0.0	0	0.0
-15.0 - -12.6	49	1.4	50	1.5	3	0.0	0	0.0	0	0.0	0	0.0
-17.5 - -15.1	11	0.3	7	0.2	0	0.0	0	0.0	0	0.0	0	0.0
-20.0 - -17.6	7	0.2	5	0.2	0	0.0	0	0.0	0	0.0	0	0.0
Total	3,547	100.0	3,319	100.0	3,652	100.0	3,505	100.0	3,472	100.0	3,241	100.0

(1) Temperature is measured at the 10 meter (33 foot) level.

TABLE 2.3-5 (Continued)

Temperature (°C)	MONTH													
	Jul		Aug		Sep		Oct		Nov		Dec		Annual	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
32.5 - 34.9	52	1.5	6	0.2	0	0.0	0	0.0	0	0.0	0	0.0	58	0.1
30.0 - 32.4	136	3.9	137	4.0	13	0.4	0	0.0	0	0.0	0	0.0	316	0.8
27.5 - 29.9	381	11.0	366	10.7	79	2.4	0	0.0	0	0.0	0	0.0	1,009	2.4
25.0 - 27.4	791	22.9	797	23.2	264	8.1	0	0.0	0	0.0	0	0.0	2,325	5.6
22.5 - 24.9	957	27.7	991	28.9	555	17.1	36	1.0	0	0.0	0	0.0	3,444	8.4
20.0 - 22.4	684	19.8	616	18.0	776	23.9	131	3.7	7	0.2	0	0.0	3,734	9.1
17.5 - 19.9	299	8.7	332	9.7	640	19.7	303	8.6	85	2.6	12	0.3	3,223	7.8
15.0 - 17.4	117	3.4	149	4.3	551	17.0	523	14.9	207	6.3	32	0.9	3,200	7.8
12.5 - 14.9	36	1.0	35	1.0	234	7.2	805	22.9	416	12.6	46	1.3	3,159	7.7
10.0 - 12.4	0	0.0	2	0.1	103	3.2	681	19.4	449	13.6	126	3.6	3,070	7.4
7.5 - 9.9	0	0.0	0	0.0	31	1.0	641	18.2	595	18.0	336	9.5	3,304	8.0
5.0 - 7.4	0	0.0	0	0.0	3	0.1	298	8.5	628	19.0	616	17.5	3,219	7.8
2.5 - 4.9	0	0.0	0	0.0	0	0.0	93	2.6	513	15.5	687	19.5	2,826	6.9
0.0 - 2.4	0	0.0	0	0.0	0	0.0	7	0.2	293	8.9	664	18.9	2,564	6.2
-2.5 - -0.1	0	0.0	0	0.0	0	0.0	0	0.0	94	2.8	495	14.1	2,044	5.0
-5.0 - -2.6	0	0.0	0	0.0	0	0.0	0	0.0	14	0.4	272	7.7	1,712	4.2
-7.5 - -5.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	160	4.5	1,101	2.7
-10.0 - -7.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	47	1.3	480	1.2
-12.5 - -10.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	0.6	281	0.7
-15.0 - -12.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	0.2	108	0.3
-17.5 - -15.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1	20	0.0
-20.0 - -17.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	12	0.0
Total	3,453	100.0	3,431	100.0	3,249	100.0	3,518	100.0	3,301	100.0	3,521	100.0	41,209	100.0

TABLE 2.3-6

ON-SITE DIURNAL TEMPERATURE VARIATIONS[1]
JANUARY, 1977 - DECEMBER, 1981

	TEMPERATURE (°C)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	-2.6	-1.9	4.2	10.0	14.9	19.2	22.1	22.1	18.4	11.3	7.0	1.8	10.4
2	-2.8	-2.2	3.8	9.6	14.5	18.8	21.8	21.8	18.1	11.0	6.8	1.7	10.1
3	-2.9	-2.4	3.6	9.3	14.1	18.5	21.5	21.5	17.8	10.7	6.6	1.5	9.9
4	-3.1	-2.6	3.4	9.0	13.8	18.2	21.2	21.3	17.6	10.5	6.5	1.3	9.7
5	-3.2	-2.8	3.2	8.8	13.6	18.0	21.0	21.0	17.4	10.3	6.3	1.2	9.5
6	-3.4	-3.0	2.9	8.6	13.5	17.9	20.9	20.9	17.2	9.9	6.3	1.0	9.3
7	-3.6	-3.1	2.7	8.9	13.8	18.2	21.1	20.9	17.1	9.8	6.2	0.9	9.3
8	-3.6	-3.0	3.2	9.9	14.6	18.9	21.8	21.4	17.4	9.8	6.2	0.8	9.7
9	-3.2	-2.4	4.2	11.0	15.5	19.8	22.8	22.4	18.2	10.5	6.9	1.1	10.5
10	-2.6	-1.5	5.2	12.0	16.6	20.8	23.9	23.5	19.4	11.8	7.9	1.9	11.4
11	-1.9	-0.6	6.1	12.8	17.6	21.8	24.9	24.4	20.5	13.0	8.8	2.8	12.4
12	-1.3	0.3	6.8	13.5	18.4	22.6	25.5	25.2	21.3	14.0	9.5	3.5	13.2
13	-1.0	1.0	7.5	14.1	19.2	23.1	26.1	25.8	21.9	14.7	10.0	4.1	13.8
14	-0.6	1.4	8.1	14.4	19.7	23.6	26.5	26.2	22.4	15.1	10.5	4.4	14.2
15	0.2	1.6	8.5	14.7	19.9	23.9	26.8	26.5	22.7	15.3	10.5	4.6	14.5
16	0.2	1.5	8.4	14.7	19.8	23.7	26.7	26.5	22.8	15.3	10.3	4.4	14.4
17	0.4	1.4	8.1	14.4	19.5	23.5	26.6	26.2	22.6	14.9	9.6	4.0	14.1
18	-1.0	0.8	7.4	13.9	19.1	23.3	26.3	25.8	22.1	14.4	9.0	3.5	13.6
19	-1.3	0.2	6.6	13.1	18.3	22.6	25.7	25.2	21.3	13.7	8.5	3.2	13.0
20	-1.6	-0.2	6.1	12.3	17.5	21.9	24.9	24.5	20.5	13.0	8.1	2.9	12.4
21	-1.9	-0.6	5.6	11.6	16.9	21.0	24.1	23.8	19.9	12.4	7.7	2.6	11.8
22	-2.2	-0.9	5.3	11.2	16.3	20.5	23.6	23.3	19.4	12.0	7.5	2.4	11.4
23	-2.4	-1.2	5.0	10.8	15.8	20.1	23.0	22.9	18.9	11.6	7.2	2.1	11.0
24	-2.5	-1.4	4.7	10.4	15.5	19.7	22.6	22.5	18.6	11.3	7.0	2.0	10.7

(1) Temperature is measured at the 10 meter (33 foot) level.

TABLE 2.3-7

TEMPERATURE MEANS AND EXTREMES
JANUARY, 1977 - DECEMBER, 1981

Combined Months	ARTIFICIAL ISLAND (°F)[1]			WILMINGTON NWS STATION (°F)		
	Mean	Hourly Maximum	Hourly Minimum	Mean	Hourly Maximum	Hourly Minimum
Jan	28.2	60	-1	27.4	64	-3
Feb	30.4	62	-1	29.2	69	-6
Mar	41.7	76	9	42.1	82	7
Apr	52.9	86	27	53.0	87	25
May	61.9	84	39	63.1	91	30
Jun	69.4	90	49	69.7	94	44
Jul	74.8	94	55	76.0	98	50
Aug	74.5	91	54	75.8	95	49
Sep	67.5	89	45	68.5	98	40
Oct	54.3	76	33	54.1	82	30
Nov	46.2	71	25	46.3	76	22
Dec	36.5	67	-4	35.2	70	2
Annual	53.1	94	-1	53.4	98	-6

Source: U.S. Department of Commerce, Local Climatological Data - Annual Summary with Comparative Data - Wilmington, Delaware, Environmental Data Service, NOAA, 1977-1981.

[1] (°F-32) x 0.555 = °C.

TABLE 2.3-8

WILMINGTON NWS TEMPERATURE MEANS AND EXTREMES

Months	TEMPERATURE (°F)[1] Mean[2]	Maximum[3]	Minimum[3]
Jan	32.0	75.0	-4.0
Feb	33.6	74.0	-6.0
Mar	41.6	86.0	- 6.0
Apr	52.3	91.0	22.0
May	62.4	95.0	30.0
Jun	71.4	99.0	41.0
Jul	75.8	102.0	50.0
Aug	74.1	101.0	46.0
Sep	67.9	100.0	36.0
Oct	57.2	91.0	24.0
Nov	45.7	85.0	14.0
Dec	34.7	72.0	- 2.0
Annual	54.0	102.0	-6.0

(1) (°F-32) x 0.555 = °C
(2) Period of record 1941 - 1970.
(3) Period of record 1948 - 1981.

Source: U.S. Department of Commerce, Local Climatological Data - Annual Summary with Comparative Data - Wilmington, Delaware, Environmental Data Service, NOAA, 1977-1981.

TABLE 2.3-9

ON-SITE DEW POINT TEMPERATURE MEANS AND EXTREMES
JANUARY, 1977 - DECEMBER, 1981

Combined Months	DEW POINT TEMPERATURE (°C) Mean	Hourly Maximum	Hourly Minimum
Jan	-7.5	12.8	-23.4
Feb	-6.6	12.5	-20.5
Mar	-1.5	14.7	-21.7
Apr	3.6	18.3	-13.1
May	10.4	21.1	-12.2
Jun	14.6	24.7	-1.6
Jul	18.3	26.7	4.4
Aug	18.8	28.4	6.1
Sep	14.4	26.1	-1.1
Oct	6.9	19.7	-5.6
Nov	2.3	18.3	-13.3
Dec	-3.6	15.8	-24.7
Annual	5.1	28.4	-24.7

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TABLE 2.3-10

ON-SITE HOURLY DEW POINT TEMPERATURE FREQUENCY DISTRIBUTIONS
JANUARY, 1977 - DECEMBER, 1981

Dew Point Temperature (°C)	MONTH											
	Jan		Feb		Mar		Apr		May		Jun	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
27.5 - 29.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
25.0 - 27.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
22.5 - 24.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	51	1.5
20.0 - 22.4	0	0.0	0	0.0	0	0.0	0	0.0	39	1.3	428	12.8
17.5 - 19.9	0	0.0	0	0.0	0	0.0	1	0.0	332	10.9	672	20.0
15.0 - 17.4	0	0.0	0	0.0	0	0.0	68	1.9	473	15.6	662	19.7
12.5 - 14.9	2	0.1	1	0.0	47	1.3	251	7.2	445	14.7	527	15.7
10.0 - 12.4	34	0.9	36	1.2	94	2.6	325	9.3	434	14.3	436	13.0
7.5 - 9.9	48	1.3	86	3.0	257	7.1	411	11.8	386	12.7	260	7.8
5.0 - 7.4	70	1.9	108	3.7	314	8.6	489	14.0	330	10.9	171	5.1
2.5 - 4.9	121	3.3	126	4.3	377	10.3	467	13.4	251	8.3	98	2.9
0.0 - 2.4	162	4.4	159	5.5	409	11.2	484	13.8	185	6.1	42	1.3
-2.5 - -0.1	334	9.2	286	9.9	614	16.9	311	8.9	97	3.2	7	0.2
-5.0 - -2.6	550	15.1	300	10.3	444	12.2	330	9.4	45	1.5	0	0.0
-7.5 - -5.1	486	13.3	318	11.0	397	10.9	203	5.8	10	0.3	0	0.0
-10.0 - -7.6	484	13.3	455	15.7	272	7.5	108	3.1	4	0.1	0	0.0
-12.5 - -10.1	519	14.2	468	16.1	231	6.3	43	1.2	2	0.1	0	0.0
-15.0 - -12.6	427	11.7	301	10.4	113	3.1	4	0.1	0	0.0	0	0.0
-17.5 - -15.1	259	7.1	162	5.6	44	1.2	0	0.0	0	0.0	0	0.0
-20.0 - -17.6	104	2.9	95	3.3	22	0.6	0	0.0	0	0.0	0	0.0
-22.5 - -20.1	45	1.2	2	0.1	8	0.2	0	0.0	0	0.0	0	0.0
-25.0 - -22.6	4	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	3,649	100.0	2,903	100.0	3,643	100.0	3,495	100.0	3,033	100.0	3,354	100.0

TABLE 2.3-10 (Continued)

Dew Point Temperature (°C)	MONTH													
	Jul		Aug		Sep		Oct		Nov		Dec		Annual	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
27.5 - 29.9	0	0.0	3	0.1	0	0.0	0	0.0	0	0.0	0	0.0	3	0.0
25.0 - 27.4	24	0.9	35	1.4	8	0.3	0	0.0	0	0.0	0	0.0	67	0.2
22.5 - 24.9	377	13.8	391	15.9	42	1.7	0	0.0	0	0.0	0	0.0	861	2.4
20.0 - 22.4	805	29.4	885	36.1	304	12.6	0	0.0	0	0.0	0	0.0	2,461	6.7
17.5 - 19.9	611	22.3	354	14.4	425	17.5	73	2.6	19	0.7	0	0.0	2,487	6.8
15.0 - 17.4	362	13.2	330	13.5	510	21.1	223	8.0	75	2.7	10	0.3	2,713	7.4
12.5 - 14.9	255	9.3	196	8.0	368	15.2	250	8.9	149	5.3	3	0.1	2,494	6.8
10.0 - 12.4	186	6.8	158	6.4	303	12.5	305	10.9	153	5.5	28	0.9	2,492	6.8
7.5 - 9.9	77	2.8	79	3.2	194	8.0	303	10.8	261	9.3	116	3.6	2,478	6.8
5.0 - 7.4	41	1.5	21	0.9	121	5.0	507	18.1	346	12.4	186	5.8	2,704	7.4
2.5 - 4.9	1	0.0	0	0.0	121	5.0	597	21.3	311	11.1	261	8.2	2,731	7.5
0.0 - 2.4	0	0.0	0	0.0	22	0.9	319	11.4	344	12.3	419	13.2	2,545	7.0
-2.5 - -0.1	0	0.0	0	0.0	4	0.2	158	5.6	398	14.2	442	13.9	2,651	7.3
-5.0 - -2.6	0	0.0	0	0.0	0	0.0	60	2.1	414	14.8	479	15.0	2,622	7.2
-7.5 - -5.1	0	0.0	0	0.0	0	0.0	4	0.1	217	7.8	359	11.2	1,994	5.5
-10.0 - -7.6	0	0.0	0	0.0	0	0.0	0	0.0	92	3.3	263	8.3	1,678	4.6
-12.5 - -10.1	0	0.0	0	0.0	0	0.0	0	0.0	18	0.6	282	8.9	1,563	4.3
-15.0 - -12.6	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0	244	7.7	1,090	3.0
-17.5 - -15.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	64	2.0	529	1.5
-20.0 - -17.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	14	0.4	235	0.6
-22.5 - -20.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	0.2	62	0.2
-25.0 - -22.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	0.2	11	0.0
Total	2,739	100.0	2,452	100.0	2,422	100.0	2,799	100.0	2,798	100.0	3,184	100.0	36,471	100.0

TABLE 2.3-11

ON-SITE DIURNAL DEW POINT TEMPERATURE
JANUARY, 1977 - DECEMBER, 1981

	ABSOLUTE HUMIDITY (g/m^3)												
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	-7.5	-6.7	-1.3	3.9	10.5	15.1	18.5	19.0	14.6	7.2	2.6	-3.3	5.3
2	-7.5	-6.8	-1.5	3.8	10.5	15.0	18.5	19.1	14.5	7.2	2.5	-3.4	5.2
3	-7.5	-6.7	-1.6	3.7	10.4	14.9	18.5	18.8	14.4	7.1	2.5	-3.6	5.2
4	-7.6	-6.9	-1.8	3.7	10.5	14.8	18.3	18.8	14.4	6.9	2.3	-3.7	5.0
5	-7.6	-6.9	-1.8	3.7	10.5	14.8	18.3	18.8	14.4	6.9	2.3	-3.7	5.0
6	-7.7	-6.9	-1.8	3.7	10.4	14.7	18.3	18.8	14.3	6.8	2.2	-3.8	5.0
7	-7.7	-6.8	-2.0	3.8	10.4	14.8	18.4	18.8	14.2	6.7	2.2	-3.9	5.0
8	-7.7	-6.8	-1.9	3.7	10.4	14.7	18.3	18.8	14.3	6.8	2.2	-3.8	5.0
9	-7.6	-6.8	-2.0	3.4	10.1	14.7	18.3	18.8	14.4	7.0	2.2	-3.8	4.9
10	-7.7	-6.8	-2.1	2.9	10.1	14.5	18.2	18.6	14.2	7.0	2.2	-3.7	4.8
11	-7.6	-6.8	-2.0	2.8	9.9	14.2	17.8	18.5	14.1	6.8	2.1	-3.7	4.7
12	-7.7	-6.8	-2.0	2.9	9.8	14.3	17.8	18.4	14.2	6.6	2.1	-3.9	4.7
13	-7.7	-6.8	-1.9	3.0	9.8	14.1	17.7	18.4	14.2	6.6	2.1	-3.8	4.7
14	-7.5	-6.8	-1.7	2.9	9.7	13.9	17.7	18.3	14.5	6.3	2.0	-3.9	4.8
15	-7.3	-6.7	-1.6	2.9	9.9	14.0	17.8	18.4	14.6	6.5	2.0	3.8	4.9
16	-7.3	-6.7	-1.5	3.0	9.8	14.1	17.9	18.5	14.4	6.6	2.2	-3.7	4.9
17	-7.3	-6.7	-1.4	3.1	10.0	14.2	18.0	18.6	14.4	6.8	2.5	-3.4	5.1
18	-7.3	-6.4	-1.1	3.6	10.1	14.3	18.4	18.7	14.7	7.3	2.7	-3.1	5.3
19	-7.1	-6.1	-0.8	3.9	10.7	14.6	18.7	18.9	14.8	7.3	2.6	-3.1	5.5
20	-7.1	-5.9	-0.7	4.3	11.0	14.9	18.8	19.1	14.8	7.3	2.6	-3.1	5.6
21	-7.2	-6.0	-0.6	4.3	11.3	15.2	18.8	19.2	14.7	7.2	2.6	-3.3	5.7
22	-7.3	-6.1	-0.7	4.3	11.5	15.3	18.9	19.2	14.7	7.1	2.5	-3.2	5.7
23	-7.4	-6.1	-0.8	4.3	11.3	15.2	18.8	19.1	14.6	7.1	2.4	-3.5	5.5
24	-7.5	-6.2	-0.8	4.1	11.0	15.1	18.8	19.0	14.4	7.1	2.4	-3.6	5.4

TABLE 2.3-12

WILMINGTON NWS PRECIPITATION MEANS AND EXTREMES

	PRECIPITATION (centimeters (inches))			
Month	Mean[1]	Monthly[2] Maximum	Monthly[2] Minimum	Twenty-Four Hour[2] Maximum
Jan	7.1 (2.85)	21.0 (8.41)	1.3 (0.52)	5.3 (2.12)
Feb	6.9 (2.75)	17.6 (7.02)	2.1 (0.83)	5.7 (2.29)
Mar	9.4 (3.74)	15.5 (6.22)	2.0 (0.81)	7.8 (3.11)
Apr	8.0 (3.20)	16.4 (6.57)	2.8 (1.12)	6.4 (2.56)
May	8.4 (3.35)	18.4 (7.35)	0.6 (0.22)	5.9 (2.35)
Jun	8.1 (3.24)	18.7 (7.49)	1.1 (0.44)	10.9 (4.35)
Jul	10.8 (4.31)	18.8 (7.51)	0.4 (0.16)	15.6 (6.24)
Aug	10.0 (3.98)	30.2(12.09)	0.6 (0.25)	10.3 (4.11)
Sep	8.6 (3.42)	23.8 (9.53)	2.1 (0.82)	14.1 (5.62)
Oct	6.5 (2.60)	16.0 (6.41)	0.5 (0.21)	9.7 (3.88)
Nov	8.7 (3.49)	19.6 (7.84)	1.2 (0.49)	9.6 (3.83)
Dec	8.3 (3.32)	19.8 (7.90)	0.5 (0.19)	5.6 (2.22)
Annual	100.6(40.25)	30.2(12.09)	0.4 (0.16)	15.6 (6.24)

(1) Period of record [illegible] 1970.
(2) Period of record [illegible] 1981.

Source: U.S. Department of Commerce, Local Climatological Data - Annual Summary with Comparative Data - Wilmington, Delaware, Environmental Data Service, NOAA, 1977-1981.

TABLE 2.3-13

WILMINGTON NWS SNOWFALL MEANS AND EXTREMES[1]

Months	SNOWFALL (centimeters (inches)) Mean		Monthly Maximum		24-Hour Maximum	
Jan	15.5	(6.2)	43.0	(17.2)	28.0	(11.2)
Feb	16.0	(6.4)	68.8	(27.5)	41.3	(16.5)
Mar	9.5	(3.8)	50.8	(20.3)	39.0	(15.6)
Apr	0.3	(0.1)	2.8	(1.1)	2.8	(1.1)
May		T[2]		T		T
Jun		-		-		-
Jul		-		-		-
Aug		-		-		-
Sep		-		-		-
Oct	0.3	(0.1)	6.3	(2.5)	6.3	(2.5)
Nov	2.8	(1.1)	29.8	(11.9)	29.8	(11.9)
Dec	9.0	(3.6)	53.8	(21.5)	31.0	(12.4)
Annual	53.3	(21.3)	68.8	(27.5)	41.3	(16.5)

(1) Period of record = 1948 - 1980.

(2) T = Trace.

Source: U.S. Department of Commerce, Local Climatological Data - Annual Summary with Comparative Data - Wilmington Delaware, Environmental Data Service, NOAA, 1980.

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Table 2.3-14

METEOROLOGICAL INSTRUMENTATION

HEIGHT ABOVE TOWER BASE (FEET)	SENSED PARAMETER	RECORDED PARAMETER	INSTRUMENT AND CHARACTERISTICS	STRIP RECORDERS
300	Wind Speed	Wind Speed	Climet - Model 011, 3 cup Anemometer. Threshold 0.6 mph, distance constant < 5 ft, operating range 0 to 110, accuracy ± 1% or 0.15 mph whichever is greater.	Esterline - Angus Model LS25
	Wind Direction	Wind Direction	Climet - Model 012-10 wind vane. Threshold 0.75 mph, distance constant < 3.3 ft, damping ratio 0.4.	Esterline - Angus Model LS25
	Temperature(1)	Temperature Difference	Climet - Model 016-1 Motor Aspirated(3) Temperature Shield with Climent 015-3 Thermistor accuracy ± 0.15°C.	Speedomax Multi-Point Leeds & Northroup
150	Wind Speed Wind Direction Temperature (2)	Same as above	Same as above	Same as above
33	Wind Speed Wind Direction	Same as above	Same as above	Same as above
	Temperature-Differential T_{300}-T_{33}(1) T_{150}-T_{33}(2)			
	Dew Point	Dew Point	EG&G Model SM 110 Accuracy ±0.5°F	Westronics M11E
	Temperature-Ambient	Temperature	Climent - Model 016-1 Motor Aspirated Temperature Shield with Climent 015-3 Thermistor accuracy ± 0.15°C.	Leeds & Northroup Speedomax Multi-Point Recorder
6	Barometric Pressure	Barometric Pressure	Climent - Model 014-90 Pressure Transducer. Range 28-32 in. Hg.	Esterline - Angus Model A
3	Rainfall	Rainfall	Model 0501 Weighing Rain Gage	Esterline - Angus Model A

(1) Temperature taken as part of Temperature Differential Measurement T_{300} -T_{33}
(2) Temperature taken as part of Temperature Differential Measurement T_{150} -T_{33}
(3) Paired Climet 015-3 Thermistor. Accuracy ±0.1°C.

TABLE 2.3-15

COMPARISON OF ON-SITE AND
WILMINGTON NWS STABILITY FREQUENCY DISTRIBUTIONS

Stability Class	FIVE YEAR CONCURRENT PERIOD[1] Artificial Island[3] (%)	FIVE YEAR CONCURRENT PERIOD[1] Wilmington NWS[4] (%)	TEN YEAR PERIOD[2] Wilmington NWS[4] (%)
Extremely Unstable (A)	1.1	0.2	0.3
Moderately Unstable (B)	2.2	4.0	4.0
Slightly Unstable (C)	2.0	10.9	10.9
Neutral (D)	38.6	54.4	53.8
Slightly Stable (E)	43.7	15.0	15.1
Moderately Stable (F)	10.2	12.5	13.0
Extremely Stable (G)	2.2	3.0	3.0

(1)January, 1977 - December, 1981.

(2)January, 1972 - December, 1981.

(3)Stability determined from temperature difference data measured on the site tower, (300-33 ft).

(4)Stability determined by the STAR program consistent with Turner's method.

TABLE 2.3-16

ACCIDENT X/Q ESTIMATES
(sec/m^3)

ESTIMATES	TIME FOLLOWING ACCIDENT					
	2 Hours	8 Hours	16 Hours	3 Days	26 Days	Annual
EAB 0.90 Kilometers (0.56 miles)						
Conservative Estimate (5%)	1.9E-04	9.2E-05	6.4E-05	2.9E-05	9.2E-06	2.3E-06
Realistic Estimate (50%)	6.3E-05	3.6E-05	2.8E-05	1.5E-05	6.5E-06	2.3E-06
LPZ 8.0 Kilometers (5.0 miles)						
Conservative Estimate (5%)	1.9E-05	8.0E-06	5.2E-06	2.0E-06	5.2E-07	9.9E-08
Realistic Estimate (50%)	4.8E-06	2.5E-06	1.8E-06	9.1E-07	3.4E-07	9.9E-08

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TABLE 2.3-17

SOUTH VENT X/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE X/Q BY SECTOR

(SEC/M**3)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
(1) DISTANCE MILES								
.25	6.107E-07	5.767E-07	5.016E-07	8.392E-07	1.048E-06	1.425E-06	6.728E-07	5.573E-07
.50	2.076E-07	2.021E-07	1.831E-07	3.188E-07	3.956E-07	5.272E-07	2.540E-07	2.022E-07
.75	1.371E-07	1.392E-07	1.252E-07	2.202E-07	2.679E-07	3.519E-07	1.778E-07	1.435E-07
1.00	1.123E-07	1.181E-07	1.042E-07	1.792E-07	2.117E-07	2.746E-07	1.463E-07	1.222E-07
1.50	9.256E-08	1.005E-07	8.561E-08	1.376E-07	1.539E-07	1.965E-07	1.129E-07	1.013E-07
2.00	7.891E-08	8.660E-08	7.239E-08	1.108E-07	1.194E-07	1.510E-07	9.064E-08	8.516E-08
2.50	6.757E-08	7.433E-08	6.157E-08	9.106E-08	9.575E-08	1.208E-07	7.415E-08	7.193E-08
3.00	5.822E-08	6.400E-08	5.366E-08	7.615E-08	7.862E-08	9.830E-08	6.170E-08	6.126E-08
3.40	5.182E-08	5.689E-08	4.753E-08	6.669E-08	6.825E-08	8.515E-08	5.391E-08	5.415E-08
3.50	5.039E-08	5.530E-08	4.616E-08	6.464E-08	6.602E-08	8.234E-08	5.222E-08	5.258E-08
3.60	4.902E-08	5.378E-08	4.487E-08	6.268E-08	6.392E-08	7.969E-08	5.062E-08	5.108E-08
3.70	4.772E-08	5.234E-08	4.363E-08	6.083E-08	6.193E-08	7.718E-08	4.910E-08	4.966E-08
3.80	4.648E-08	5.096E-08	4.245E-08	5.907E-08	6.004E-08	7.480E-08	4.766E-08	4.830E-08
3.90	4.529E-08	4.964E-08	4.133E-08	5.740E-08	5.825E-08	7.255E-08	4.629E-08	4.701E-08
4.00	4.543E-08	4.975E-08	4.025E-08	5.581E-08	5.655E-08	7.041E-08	4.498E-08	4.577E-08
4.10	4.430E-08	4.848E-08	3.923E-08	5.429E-08	5.494E-08	6.838E-08	4.374E-08	4.459E-08
4.20	4.321E-08	4.728E-08	3.824E-08	5.284E-08	5.340E-08	6.644E-08	4.255E-08	4.347E-08
4.30	4.217E-08	4.612E-08	3.730E-08	5.146E-08	5.193E-08	6.460E-08	4.142E-08	4.239E-08
4.40	4.117E-08	4.501E-08	3.640E-08	5.013E-08	5.053E-08	6.284E-08	4.034E-08	4.135E-08
4.50	4.021E-08	4.394E-08	3.554E-08	4.887E-08	4.920E-08	6.117E-08	3.931E-08	4.036E-08
4.60	3.929E-08	4.292E-08	3.471E-08	4.766E-08	4.792E-08	5.957E-08	3.832E-08	3.941E-08
4.70	3.841E-08	4.194E-08	3.391E-08	4.650E-08	4.671E-08	5.804E-08	3.738E-08	3.850E-08
4.80	3.756E-08	4.100E-08	3.315E-08	4.539E-08	4.554E-08	5.658E-08	3.647E-08	3.762E-08
4.90	3.674E-08	4.009E-08	3.241E-08	4.433E-08	4.443E-08	5.519E-08	3.561E-08	3.678E-08
5.00	4.013E-08	4.360E-08	3.575E-08	5.545E-08	4.572E-08	5.385E-08	3.477E-08	3.597E-08
7.50	2.495E-08	2.687E-08	2.199E-08	3.240E-08	2.735E-08	3.240E-08	2.131E-08	2.261E-08
10.00	1.967E-08	2.344E-08	1.836E-08	2.255E-08	2.289E-08	2.241E-08	1.484E-08	1.710E-08
15.00	1.148E-08	1.324E-08	1.047E-08	1.287E-08	1.280E-08	1.311E-08	8.777E-09	1.012E-08
20.00	7.796E-09	8.810E-09	7.017E-09	8.621E-09	8.475E-09	8.904E-09	5.998E-09	6.950E-09
25.00	5.757E-09	6.423E-09	5.137E-09	6.309E-09	6.155E-09	6.574E-09	4.447E-09	5.148E-09
30.00	4.799E-09	4.985E-09	4.004E-09	4.896E-09	4.739E-09	5.122E-09	3.475E-09	4.034E-09
35.00	3.858E-09	4.004E-09	3.223E-09	3.942E-09	3.800E-09	4.145E-09	2.817E-09	3.268E-09
40.00	3.193E-09	3.312E-09	2.713E-09	3.362E-09	3.138E-09	3.455E-09	2.347E-09	2.720E-09
45.00	2.702E-09	2.801E-09	2.295E-09	2.841E-09	2.651E-09	2.935E-09	1.997E-09	2.313E-09
50.00	2.327E-09	2.411E-09	1.977E-09	2.444E-09	2.280E-09	2.536E-09	1.728E-09	1.999E-09

TABLE 2.3-17 (CONTINUED)

WIND DIRECTION BEARING	NNE 202,5	NE 225,0	ENE 247,5	E 270,0	ESE 292,5	SE 315,0	SSE 337,5	S 360,0
DISTANCE MILES								
,25	3,890E-07	4,224E-07	2,270E-07	1,781E-07	1,695E-07	8,937E-07	8,685E-07	7,181E-07
,50	1,466E-07	1,578E-07	8,646E-08	6,411E-08	5,831E-08	3,047E-07	3,016E-07	2,474E-07
,75	1,084E-07	1,174E-07	6,390E-08	4,771E-08	4,175E-08	1,901E-07	1,913E-07	1,614E-07
1,00	9,532E-08	1,030E-07	5,627E-08	4,439E-08	3,725E-08	1,434E-07	1,483E-07	1,303E-07
1,50	8,138E-08	8,700E-08	4,849E-08	4,248E-08	3,387E-08	1,042E-07	1,109E-07	1,096E-07
2,00	6,924E-08	7,347E-08	4,177E-08	3,884E-08	3,024E-08	8,241E-08	8,934E-08	9,150E-08
2,50	5,877E-08	6,208E-08	3,583E-08	3,452E-08	2,656E-08	6,771E-08	7,418E-08	7,731E-08
3,00	5,181E-08	5,284E-08	3,086E-08	3,224E-08	2,371E-08	5,952E-08	6,286E-08	6,612E-08
3,40	4,571E-08	4,668E-08	2,743E-08	2,881E-08	2,121E-08	5,227E-08	5,551E-08	5,863E-08
3,50	4,436E-08	4,531E-08	2,666E-08	2,804E-08	2,065E-08	5,070E-08	5,390E-08	5,696E-08
3,60	4,308E-08	4,402E-08	2,592E-08	2,729E-08	2,011E-08	4,920E-08	5,236E-08	5,538E-08
3,70	4,186E-08	4,278E-08	2,522E-08	2,658E-08	1,959E-08	4,778E-08	5,089E-08	5,387E-08
3,80	4,070E-08	4,160E-08	2,456E-08	2,590E-08	1,909E-08	4,644E-08	4,950E-08	5,244E-08
3,90	3,959E-08	4,048E-08	2,392E-08	2,525E-08	1,862E-08	4,516E-08	4,817E-08	5,107E-08
4,00	3,854E-08	3,995E-08	2,433E-08	2,840E-08	1,877E-08	4,504E-08	4,999E-08	4,976E-08
4,10	3,753E-08	3,890E-08	2,371E-08	2,765E-08	1,831E-08	4,384E-08	4,867E-08	4,850E-08
4,20	3,656E-08	3,790E-08	2,311E-08	2,693E-08	1,787E-08	4,268E-08	4,740E-08	4,730E-08
4,30	3,564E-08	3,694E-08	2,254E-08	2,625E-08	1,745E-08	4,159E-08	4,619E-08	4,616E-08
4,40	3,476E-08	3,603E-08	2,199E-08	2,560E-08	1,705E-08	4,054E-08	4,503E-08	4,506E-08
4,50	3,391E-08	3,515E-08	2,147E-08	2,497E-08	1,666E-08	3,953E-08	4,392E-08	4,400E-08
4,60	3,310E-08	3,431E-08	2,096E-08	2,437E-08	1,628E-08	3,857E-08	4,286E-08	4,299E-08
4,70	3,232E-08	3,350E-08	2,048E-08	2,380E-08	1,593E-08	3,765E-08	4,184E-08	4,202E-08
4,80	3,157E-08	3,272E-08	2,002E-08	2,324E-08	1,558E-08	3,677E-08	4,087E-08	4,108E-08
4,90	3,085E-08	3,198E-08	1,957E-08	2,271E-08	1,525E-08	3,592E-08	3,994E-08	4,019E-08
5,00	3,268E-08	4,029E-08	2,471E-08	2,618E-08	1,738E-08	4,412E-08	4,965E-08	3,932E-08
7,50	2,002E-08	2,370E-08	1,471E-08	1,575E-08	1,078E-08	2,620E-08	2,952E-08	2,500E-08
10,00	1,546E-08	1,612E-08	1,009E-08	1,086E-08	7,701E-09	2,034E-08	2,317E-08	2,193E-08
15,00	8,916E-09	9,287E-09	5,864E-09	6,365E-09	4,589E-09	1,150E-08	1,308E-08	1,284E-08
20,00	6,003E-09	6,243E-09	3,966E-09	4,328E-09	3,667E-09	7,675E-09	8,723E-09	9,615E-09
25,00	4,406E-09	4,580E-09	2,921E-09	3,200E-09	2,674E-09	5,610E-09	6,373E-09	7,016E-09
30,00	3,418E-09	3,551E-09	2,271E-09	2,717E-09	2,067E-09	4,343E-09	4,935E-09	5,432E-09
35,00	2,755E-09	2,862E-09	1,834E-09	2,183E-09	1,662E-09	3,498E-09	3,974E-09	4,369E-09
40,00	2,285E-09	2,373E-09	1,524E-09	1,807E-09	1,376E-09	2,901E-09	3,295E-09	3,618E-09
45,00	1,937E-09	2,011E-09	1,293E-09	1,529E-09	1,165E-09	2,454E-09	2,793E-09	3,064E-09
50,00	1,670E-09	1,734E-09	1,116E-09	1,317E-09	1,004E-09	2,121E-09	2,409E-09	2,641E-09

HCGS OLER

TABLE 2.3-18

NORTH VENT X/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE X/Q BY SECTOR

(SEC/M**3)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	SSW 22,5	SW 45,0	WSW 67,5	W 90,0	WNW 112,5	NW 135,0	NNW 157,5	N 180,0
(1) DISTANCE MILES								
,25	1,890E-06	1,846E-06	1,582E-06	2,588E-06	2,935E-06	3,795E-06	2,070E-06	1,938E-06
,50	6,375E-07	6,372E-07	5,617E-07	9,160E-07	1,035E-06	1,315E-06	7,346E-07	6,781E-07
,75	3,996E-07	4,108E-07	3,581E-07	5,730E-07	6,409E-07	8,088E-07	4,653E-07	4,331E-07
1,00	2,959E-07	3,101E-07	2,664E-07	4,155E-07	4,573E-07	5,738E-07	3,385E-07	3,202E-07
1,50	1,997E-07	2,123E-07	1,784E-07	2,649E-07	2,816E-07	3,514E-07	2,149E-07	2,109E-07
2,00	1,477E-07	1,577E-07	1,311E-07	1,886E-07	1,958E-07	2,434E-07	1,522E-07	1,532E-07
2,50	1,149E-07	1,227E-07	1,015E-07	1,429E-07	1,459E-07	1,809E-07	1,148E-07	1,177E-07
3,00	9,259E-08	9,867E-08	8,225E-08	1,128E-07	1,138E-07	1,409E-07	9,028E-08	9,382E-08
3,40	7,982E-08	8,491E-08	7,063E-08	9,617E-08	9,640E-08	1,192E-07	7,679E-08	8,038E-08
3,50	7,714E-08	8,202E-08	6,819E-08	9,271E-08	9,281E-08	1,148E-07	7,399E-08	7,757E-08
3,60	7,461E-08	7,929E-08	6,589E-08	8,946E-08	8,944E-08	1,106E-07	7,137E-08	7,493E-08
3,70	7,221E-08	7,672E-08	6,372E-08	8,640E-08	8,628E-08	1,067E-07	6,890E-08	7,244E-08
3,80	6,995E-08	7,428E-08	6,168E-08	8,351E-08	8,330E-08	1,030E-07	6,657E-08	7,008E-08
3,90	6,781E-08	7,198E-08	5,974E-08	8,079E-08	8,050E-08	9,953E-08	6,438E-08	6,786E-08
4,00	6,684E-08	7,095E-08	5,791E-08	7,821E-08	7,785E-08	9,625E-08	6,230E-08	6,576E-08
4,10	6,487E-08	6,882E-08	5,617E-08	7,578E-08	7,534E-08	9,315E-08	6,034E-08	6,376E-08
4,20	6,299E-08	6,681E-08	5,452E-08	7,347E-08	7,297E-08	9,021E-08	5,849E-08	6,187E-08
4,30	6,121E-08	6,489E-08	5,295E-08	7,128E-08	7,073E-08	8,743E-08	5,672E-08	6,007E-08
4,40	5,951E-08	6,307E-08	5,146E-08	6,920E-08	6,860E-08	8,480E-08	5,505E-08	5,836E-08
4,50	5,790E-08	6,133E-08	5,004E-08	6,722E-08	6,658E-08	8,230E-08	5,346E-08	5,673E-08
4,60	5,635E-08	5,968E-08	4,868E-08	6,534E-08	6,466E-08	7,992E-08	5,195E-08	5,518E-08
4,70	5,488E-08	5,8[illegible]-08	4,739E-08	6,355E-08	6,283E-08	7,766E-08	5,051E-08	5,370E-08
4,80	5,348E-08	5,6[illegible]	4,616E-08	6,184E-08	6,109E-08	7,550E-08	4,914E-08	5,229E-08
4,90	5,213E-08	5,51[illegible]	4,498E-08	6,021E-08	5,944E-08	7,345E-08	4,783E-08	5,094E-08
5,00	5,404E-08	5,721E-08	4,709E-08	6,738E-08	5,959E-08	7,149E-08	4,658E-08	4,965E-08
7,50	3,195E-08	3,360E-08	2,761E-08	3,836E-08	3,429E-08	4,132E-08	2,719E-08	2,941E-08
10,00	2,315E-08	2,543E-08	2,059E-08	2,597E-08	2,559E-08	2,785E-08	1,843E-08	2,090E-08
15,00	1,324E-08	1,430E-08	1,162E-08	1,463E-08	1,426E-08	1,580E-08	1,058E-08	1,200E-08
20,00	8,885E-09	9,508E-09	7,735E-09	9,732E-09	9,424E-09	1,064E-08	7,112E-09	8,088E-09
25,00	6,514E-09	6,926E-09	5,642E-09	7,090E-09	6,834E-09	7,784E-09	5,216E-09	5,929E-09
30,00	5,170E-09	5,351E-09	4,370E-09	5,477E-09	5,257E-09	6,026E-09	4,045E-09	4,605E-09
35,00	4,158E-09	4,299E-09	3,513E-09	4,399E-09	4,211E-09	4,852E-09	3,260E-09	3,710E-09
40,00	3,444E-09	3,556E-09	2,918E-09	3,670E-09	3,475E-09	4,027E-09	2,704E-09	3,076E-09
45,00	2,916E-09	3,009E-09	2,469E-09	3,101E-09	2,934E-09	3,411E-09	2,292E-09	2,607E-09
50,00	2,513E-09	2,591E-09	2,127E-09	2,668E-09	2,522E-09	2,939E-09	1,976E-09	2,248E-09

TABLE 2.3-18 (CONTINUED)

WIND DIRECTION BEARING	NNE 202,5	NE 225,0	ENE 247,5	E 270,0	ESE 292,5	SE 315,0	SSE 337,5	S 360,0
(1) DISTANCE MILES								
.25	1,565E-06	1,701E-06	8,347E-07	6,956E-07	5,690E-07	2,130E-06	2,186E-06	2,273E-06
.50	5,623E-07	6,051E-07	3,041E-07	2,488E-07	1,962E-07	7,204E-07	7,557E-07	7,750E-07
.75	3,610E-07	3,868E-07	1,998E-07	1,685E-07	1,305E-07	4,343E-07	4,643E-07	4,791E-07
1,00	2,676E-07	2,855E-07	1,514E-07	1,330E-07	1,019E-07	3,091E-07	3,360E-07	3,504E-07
1,50	1,760E-07	1,867E-07	1,026E-07	9,594E-08	7,291E-08	1,979E-07	2,175E-07	2,369E-07
2,00	1,276E-07	1,348E-07	7,601E-08	7,348E-08	5,572E-08	1,417E-07	1,567E-07	1,722E-07
2,50	9,775E-08	1,030E-07	5,918E-08	5,835E-08	4,424E-08	1,083E-07	1,202E-07	1,327E-07
3,00	7,921E-08	8,187E-08	4,769E-08	4,950E-08	3,659E-08	8,851E-08	9,620E-08	1,065E-07
3,40	6,769E-08	7,000E-08	4,106E-08	4,277E-08	3,169E-08	7,584E-08	8,266E-08	9,164E-08
3,50	6,529E-08	6,752E-08	3,966E-08	4,134E-08	3,065E-08	7,320E-08	7,982E-08	8,852E-08
3,60	6,303E-08	6,519E-08	3,834E-08	3,999E-08	2,967E-08	7,071E-08	7,715E-08	8,558E-08
3,70	6,090E-08	6,299E-08	3,709E-08	3,872E-08	2,874E-08	6,837E-08	7,463E-08	8,280E-08
3,80	5,889E-08	6,092E-08	3,592E-08	3,752E-08	2,786E-08	6,616E-08	7,225E-08	8,018E-08
3,90	5,700E-08	5,897E-08	3,480E-08	3,638E-08	2,702E-08	6,408E-08	7,000E-08	7,770E-08
4,00	5,520E-08	5,754E-08	3,469E-08	3,879E-08	2,681E-08	6,295E-08	7,039E-08	7,535E-08
4,10	5,350E-08	5,577E-08	3,365E-08	3,761E-08	2,603E-08	6,104E-08	6,822E-08	7,312E-08
4,20	5,189E-08	5,409E-08	3,266E-08	3,650E-08	2,529E-08	5,923E-08	6,620E-08	7,100E-08
4,30	5,036E-08	5,249E-08	3,172E-08	3,543E-08	2,459E-08	5,751E-08	6,428E-08	6,898E-08
4,40	4,891E-08	5,098E-08	3,082E-08	3,442E-08	2,392E-08	5,587E-08	6,246E-08	6,707E-08
4,50	4,752E-08	4,953E-08	2,997E-08	3,346E-08	2,328E-08	5,432E-08	6,072E-08	6,524E-08
4,60	4,621E-08	4,816E-08	2,916E-08	3,254E-08	2,268E-08	5,283E-08	5,907E-08	6,350E-08
4,70	4,495E-08	4,685E-08	2,839E-08	3,167E-08	2,209E-08	5,142E-08	5,749E-08	6,183E-08
4,80	4,375E-08	4,560E-08	2,765E-08	3,084E-08	2,154E-08	5,007E-08	5,599E-08	6,025E-08
4,90	4,261E-08	4,441E-08	2,694E-08	3,004E-08	2,100E-08	4,879E-08	5,455E-08	5,873E-08
5,00	4,346E-08	4,958E-08	3,073E-08	3,250E-08	2,264E-08	5,344E-08	6,026E-08	5,727E-08
7,50	2,532E-08	2,827E-08	1,764E-08	1,880E-08	1,338E-08	3,092E-08	3,483E-08	3,431E-08
10,00	1,815E-08	1,891E-08	1,184E-08	1,269E-08	9,245E-09	2,171E-08	2,455E-08	2,609E-08
15,00	1,026E-08	1,069E-08	6,720E-09	7,258E-09	5,351E-09	1,233E-08	1,392E-08	1,496E-08
20,00	6,831E-09	7,120E-09	4,486E-09	4,871E-09	3,856E-09	8,253E-09	9,317E-09	1,034E-08
25,00	4,979E-09	5,190E-09	3,276E-09	3,571E-09	2,815E-09	6,044E-09	6,823E-09	7,503E-09
30,00	3,844E-09	4,007E-09	2,532E-09	2,857E-09	2,176E-09	4,686E-09	5,290E-09	5,858E-09
35,00	3,088E-09	3,219E-09	2,036E-09	2,297E-09	1,751E-09	3,779E-09	4,266E-09	4,719E-09
40,00	2,554E-09	2,663E-09	1,686E-09	1,901E-09	1,450E-09	3,136E-09	3,542E-09	3,914E-09
45,00	2,160E-09	2,252E-09	1,427E-09	1,609E-09	1,228E-09	2,661E-09	3,005E-09	3,319E-09
50,00	1,859E-09	1,939E-09	1,229E-09	1,386E-09	1,059E-09	2,297E-09	2,595E-09	2,864E-09

HCGS OLER

TABLE 2.3-19

SOUTH VENT DEPLETED X/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE DEPLETED X/Q BY SECTOR

(SEC/M**3)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
(1) DISTANCE MILES								
.25	5.689E-07	5.374E-07	4.676E-07	7.826E-07	9.770E-07	1.329E-06	6.280E-07	5.194E-07
.50	1.895E-07	1.849E-07	1.677E-07	2.927E-07	3.629E-07	4.834E-07	2.335E-07	1.854E-07
.75	1.241E-07	1.266E-07	1.140E-07	2.011E-07	2.438E-07	3.197E-07	1.628E-07	1.312E-07
1.00	1.016E-07	1.076E-07	9.489E-08	1.632E-07	1.916E-07	2.480E-07	1.336E-07	1.119E-07
1.50	8.459E-08	9.260E-08	7.853E-08	1.257E-07	1.393E-07	1.771E-07	1.033E-07	9.337E-08
2.00	7.267E-08	8.036E-08	6.677E-08	1.015E-07	1.082E-07	1.362E-07	8.311E-08	7.891E-08
2.50	6.249E-08	6.923E-08	5.696E-08	8.361E-08	8.677E-08	1.085E-07	6.804E-08	6.882E-08
3.00	5.398E-08	5.972E-08	4.977E-08	6.998E-08	7.124E-08	8.871E-08	5.662E-08	5.698E-08
3.40	4.805E-08	5.308E-08	4.407E-08	6.126E-08	6.177E-08	7.675E-08	4.942E-08	5.035E-08
3.50	4.671E-08	5.159E-08	4.280E-08	5.935E-08	5.973E-08	7.419E-08	4.785E-08	4.888E-08
3.60	4.544E-08	5.017E-08	4.159E-08	5.755E-08	5.781E-08	7.178E-08	4.637E-08	4.748E-08
3.70	4.423E-08	4.881E-08	4.044E-08	5.584E-08	5.599E-08	6.949E-08	4.497E-08	4.615E-08
3.80	4.308E-08	4.752E-08	3.934E-08	5.421E-08	5.427E-08	6.733E-08	4.363E-08	4.488E-08
3.90	4.197E-08	4.628E-08	3.829E-08	5.266E-08	5.264E-08	6.528E-08	4.236E-08	4.367E-08
4.00	4.218E-08	4.646E-08	3.729E-08	5.119E-08	5.108E-08	6.334E-08	4.116E-08	4.252E-08
4.10	4.112E-08	4.527E-08	3.633E-08	4.979E-08	4.961E-08	6.149E-08	4.001E-08	4.141E-08
4.20	4.010E-08	4.414E-08	3.542E-08	4.845E-08	4.821E-08	5.973E-08	3.891E-08	4.036E-08
4.30	3.913E-08	4.309E-08	3.454E-08	4.717E-08	4.687E-08	5.806E-08	3.787E-08	3.935E-08
4.40	3.820E-08	4.201E-08	3.370E-08	4.595E-08	4.559E-08	5.646E-08	3.687E-08	3.839E-08
4.50	3.731E-08	4.101E-08	3.289E-08	4.479E-08	4.438E-08	5.494E-08	3.592E-08	3.746E-08
4.60	3.645E-08	4.005E-08	3.212E-08	4.367E-08	4.322E-08	5.349E-08	3.501E-08	3.657E-08
4.70	3.562E-08	3.913E-08	3.138E-08	4.260E-08	4.211E-08	5.211E-08	3.414E-08	3.572E-08
4.80	3.483E-08	3.824E-08	3.067E-08	4.158E-08	4.105E-08	5.078E-08	3.330E-08	3.490E-08
4.90	3.407E-08	3.739E-08	2.999E-08	4.060E-08	4.003E-08	4.952E-08	3.250E-08	3.411E-08
5.00	3.748E-08	4.092E-08	3.332E-08	5.167E-08	4.139E-08	4.830E-08	3.174E-08	3.336E-08
7.50	2.246E-08	2.450E-08	1.991E-08	2.506E-08	2.431E-08	2.872E-08	1.920E-08	2.076E-08
10.00	1.721E-08	2.072E-08	1.613E-08	1.638E-08	1.991E-08	1.951E-08	1.317E-08	1.561E-08
15.00	7.773E-09	8.115E-09	6.863E-09	8.374E-09	7.727E-09	1.119E-08	7.650E-09	8.799E-09
20.00	4.981E-09	5.070E-09	4.309E-09	5.247E-09	4.789E-09	7.507E-09	5.168E-09	5.952E-09
25.00	3.519E-09	3.519E-09	3.000E-09	3.646E-09	3.304E-09	5.495E-09	3.799E-09	4.284E-09
30.00	2.654E-09	2.625E-09	2.240E-09	2.711E-09	2.439E-09	4.227E-09	2.934E-09	3.307E-09
35.00	1.882E-09	2.010E-09	1.667E-09	2.104E-09	1.887E-09	3.385E-09	2.356E-09	2.587E-09
40.00	1.510E-09	1.614E-09	1.360E-09	1.739E-09	1.511E-09	2.800E-09	1.947E-09	2.128E-09
45.00	1.244E-09	1.330E-09	1.097E-09	1.326E-09	1.242E-09	2.360E-09	1.644E-09	1.790E-09
50.00	1.045E-09	1.118E-09	9.219E-10	1.114E-09	1.042E-09	2.020E-09	1.413E-09	1.533E-09

TABLE 2.3-19 (CONTINUED)

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
(1) DISTANCE MILES								
.25	3.625E-07	3.935E-07	2.115E-07	1.660E-07	1.578E-07	8.320E-07	8.091E-07	6.687E-07
.50	1.347E-07	1.448E-07	7.943E-08	5.878E-08	5.326E-08	2.782E-07	2.756E-07	2.258E-07
.75	9.962E-08	1.078E-07	5.870E-08	4.380E-08	3.806E-08	1.714E-07	1.731E-07	1.461E-07
1.00	8.782E-08	9.482E-08	5.182E-08	4.108E-08	3.418E-08	1.287E-07	1.334E-07	1.178E-07
1.50	7.553E-08	8.062E-08	4.501E-08	3.990E-08	3.158E-08	9.520E-08	9.998E-08	1.002E-07
2.00	6.451E-08	6.834E-08	3.894E-08	3.675E-08	2.845E-08	7.398E-08	8.084E-08	8.408E-08
2.50	5.484E-08	5.785E-08	3.349E-08	3.277E-08	2.510E-08	6.095E-08	6.725E-08	7.121E-08
3.00	4.847E-08	4.927E-08	2.887E-08	3.073E-08	2.249E-08	5.386E-08	5.703E-08	6.095E-08
3.40	4.273E-08	4.350E-08	2.564E-08	2.746E-08	2.013E-08	4.728E-08	5.031E-08	5.400E-08
3.50	4.146E-08	4.222E-08	2.492E-08	2.672E-08	1.959E-08	4.584E-08	4.882E-08	5.246E-08
3.60	4.025E-08	4.100E-08	2.423E-08	2.601E-08	1.908E-08	4.447E-08	4.741E-08	5.098E-08
3.70	3.910E-08	3.984E-08	2.357E-08	2.533E-08	1.859E-08	4.318E-08	4.607E-08	4.958E-08
3.80	3.801E-08	3.874E-08	2.294E-08	2.468E-08	1.812E-08	4.195E-08	4.479E-08	4.825E-08
3.90	3.697E-08	3.768E-08	2.234E-08	2.405E-08	1.767E-08	4.078E-08	4.358E-08	4.697E-08
4.00	3.597E-08	3.721E-08	2.278E-08	2.719E-08	1.784E-08	4.077E-08	4.546E-08	4.575E-08
4.10	3.502E-08	3.622E-08	2.219E-08	2.641E-08	1.740E-08	3.966E-08	4.424E-08	4.459E-08
4.20	3.411E-08	3.529E-08	2.163E-08	2.572E-08	1.698E-08	3.861E-08	4.307E-08	4.348E-08
4.30	3.324E-08	3.439E-08	2.109E-08	2.506E-08	1.658E-08	3.760E-08	4.196E-08	4.241E-08
4.40	3.241E-08	3.353E-08	2.057E-08	2.443E-08	1.620E-08	3.664E-08	4.089E-08	4.139E-08
4.50	3.162E-08	3.271E-08	2.008E-08	2.383E-08	1.583E-08	3.573E-08	3.987E-08	4.041E-08
4.60	3.085E-08	3.192E-08	1.960E-08	2.325E-08	1.547E-08	3.485E-08	3.889E-08	3.947E-08
4.70	3.012E-08	3.116E-08	1.915E-08	2.270E-08	1.513E-08	3.401E-08	3.796E-08	3.857E-08
4.80	2.942E-08	3.043E-08	1.871E-08	2.216E-08	1.480E-08	3.320E-08	3.707E-08	3.770E-08
4.90	2.874E-08	2.974E-08	1.829E-08	2.165E-08	1.448E-08	3.243E-08	3.621E-08	3.687E-08
5.00	3.058E-08	3.799E-08	2.339E-08	2.510E-08	1.662E-08	4.063E-08	4.587E-08	3.607E-08
7.50	1.824E-08	1.857E-08	1.172E-08	1.262E-08	9.659E-09	2.000E-08	2.271E-08	2.264E-08
10.00	1.374E-08	1.191E-08	7.602E-09	8.238E-09	6.744E-09	1.469E-08	1.684E-08	1.968E-08
15.00	6.122E-09	6.313E-09	4.090E-09	4.472E-09	3.854E-09	6.771E-09	7.700E-09	8.539E-09
20.00	3.896E-09	4.006E-09	2.620E-09	2.883E-09	2.948E-09	4.227E-09	4.804E-09	6.032E-09
25.00	2.739E-09	2.810E-09	1.850E-09	2.046E-09	1.401E-09	2.933E-09	3.332E-09	3.704E-09
30.00	2.048E-09	2.098E-09	1.388E-09	1.677E-09	1.038E-09	2.177E-09	2.473E-09	2.751E-09
35.00	1.601E-09	1.638E-09	1.088E-09	1.057E-09	8.047E-10	1.690E-09	1.916E-09	2.132E-09
40.00	1.293E-09	1.321E-09	8.801E-10	8.480E-10	6.460E-10	1.358E-09	1.539E-09	1.712E-09
45.00	1.070E-09	1.093E-09	7.299E-10	6.977E-10	5.295E-10	1.114E-09	1.265E-09	1.411E-09
50.00	9.037E-10	9.220E-10	6.173E-10	5.863E-10	4.451E-10	9.374E-10	1.065E-09	1.187E-09

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TABLE 2.3-20

NORTH VENT DEPLETED X/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE DEPLETED X/Q BY SECTOR

(SEC/M**3)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
(1) DISTANCE MILES								
.25	1.458E-06	1.584E-06	7.774E-07	6.479E-07	9.298E-07	1.984E-06	2.036E-06	2.116E-06
.50	5.140E-07	5.528E-07	2.784E-07	2.279E-07	1.793E-07	6.970E-07	6.904E-07	7.071E-07
.75	3.259E-07	3.488E-07	1.811E-07	1.534E-07	1.183E-07	3.897E-07	4.185E-07	4.313E-07
1.00	2.388E-07	2.543E-07	1.359E-07	1.205E-07	9.186E-08	2.733E-07	2.989E-07	3.117E-07
1.50	1.554E-07	1.644E-07	9.146E-08	8.682E-08	6.572E-08	1.722E-07	1.910E-07	2.090E-07
2.00	1.120E-07	1.180E-07	6.753E-08	6.649E-08	5.027E-08	1.225E-07	1.366E-07	1.509E-07
2.50	8.547E-08	8.976E-08	5.246E-08	5.277E-08	3.991E-08	9.315E-08	1.042E-07	1.157E-07
3.00	6.919E-08	7.104E-08	4.219E-08	4.490E-08	3.303E-08	7.604E-08	8.300E-08	9.240E-08
3.40	5.892E-08	6.052E-08	3.623E-08	3.872E-08	2.856E-08	6.478E-08	7.100E-08	7.916E-08
3.50	5.678E-08	5.833E-08	3.497E-08	3.741E-08	2.761E-08	6.246E-08	6.849E-08	7.638E-08
3.60	5.477E-08	5.627E-08	3.379E-08	3.617E-08	2.672E-08	6.027E-08	6.612E-08	7.377E-08
3.70	5.288E-08	5.433E-08	3.267E-08	3.500E-08	2.587E-08	5.822E-08	6.389E-08	7.131E-08
3.80	5.109E-08	5.250E-08	3.161E-08	3.390E-08	2.507E-08	5.628E-08	6.179E-08	6.898E-08
3.90	4.941E-08	5.077E-08	3.061E-08	3.285E-08	2.430E-08	5.444E-08	5.981E-08	6.678E-08
4.00	4.781E-08	4.955E-08	3.059E-08	3.532E-08	2.415E-08	5.355E-08	6.037E-08	6.469E-08
4.10	4.630E-08	4.798E-08	2.965E-08	3.403E-08	2.344E-08	5.186E-08	5.842E-08	6.272E-08
4.20	4.487E-08	4.650E-08	2.876E-08	3.299E-08	2.276E-08	5.027E-08	5.663E-08	6.084E-08
4.30	4.352E-08	4.509E-08	2.791E-08	3.200E-08	2.212E-08	4.876E-08	5.494E-08	5.906E-08
4.40	4.223E-08	4.375E-08	2.711E-08	3.105E-08	2.151E-08	4.733E-08	5.332E-08	5.737E-08
4.50	4.100E-08	4.248E-08	2.634E-08	3.016E-08	2.092E-08	4.597E-08	5.179E-08	5.575E-08
4.60	3.984E-08	4.127E-08	2.562E-08	2.931E-08	2.037E-08	4.467E-08	5.033E-08	5.422E-08
4.70	3.873E-08	4.012E-08	2.492E-08	2.850E-08	1.983E-08	4.344E-08	4.894E-08	5.275E-08
4.80	3.767E-08	3.902E-08	2.426E-08	2.772E-08	1.933E-08	4.226E-08	4.762E-08	5.136E-08
4.90	3.666E-08	3.797E-08	2.362E-08	2.698E-08	1.884E-08	4.113E-08	4.635E-08	5.002E-08
5.00	3.761E-08	4.319E-08	2.742E-08	2.944E-08	2.050E-08	4.587E-08	5.210E-08	4.874E-08
7.50	1.946E-08	2.076E-08	1.312E-08	1.399E-08	1.008E-08	2.254E-08	2.560E-08	2.794E-08
10.00	1.318E-08	1.296E-08	8.217E-09	8.789E-09	6.530E-09	1.480E-08	1.694E-08	2.044E-08
15.00	6.393E-09	6.638E-09	4.228E-09	4.542E-09	3.448E-09	7.223E-09	8.156E-09	9.377E-09
20.00	3.969E-09	4.121E-09	2.632E-09	2.835E-09	2.342E-09	4.519E-09	5.102E-09	6.084E-09
25.00	2.740E-09	2.845E-09	1.820E-09	1.965E-09	1.467E-09	3.141E-09	3.546E-09	3.959E-09
30.00	2.023E-09	2.100E-09	1.345E-09	1.507E-09	1.087E-09	2.334E-09	2.635E-09	2.938E-09
35.00	1.565E-09	1.625E-09	1.042E-09	1.107E-09	8.411E-10	1.815E-09	2.050E-09	2.267E-09
40.00	1.252E-09	1.300E-09	8.343E-10	8.887E-10	6.753E-10	1.460E-09	1.649E-09	1.823E-09
45.00	1.029E-09	1.068E-09	6.859E-10	7.311E-10	5.564E-10	1.205E-09	1.361E-09	1.503E-09
50.00	8.629E-10	8.962E-10	5.757E-10	6.145E-10	4.679E-10	1.015E-09	1.147E-09	1.266E-09

DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
(1) DISTANCE MILES								
.25	1.760E-06	1.720E-06	1.474E-06	2.411E-06	2.734E-06	3.535E-06	1.929E-06	1.805E-06
.50	5.816E-07	5.822E-07	5.135E-07	8.362E-07	9.434E-07	1.198E-06	6.715E-07	6.194E-07
.75	3.596E-07	3.711E-07	3.235E-07	5.152E-07	5.745E-07	7.238E-07	4.191E-07	3.905E-07
1.00	2.634E-07	2.775E-07	2.382E-07	3.684E-07	4.031E-07	5.047E-07	3.006E-07	2.852E-07
1.50	1.762E-07	1.886E-07	1.581E-07	2.317E-07	2.438E-07	3.031E-07	1.880E-07	1.857E-07
2.00	1.298E-07	1.396E-07	1.157E-07	1.638E-07	1.677E-07	2.076E-07	1.320E-07	1.342E-07
2.50	1.007E-07	1.083E-07	8.926E-08	1.235E-07	1.240E-07	1.530E-07	9.886E-08	1.027E-07
3.00	8.090E-08	8.687E-08	7.223E-08	9.714E-08	9.613E-08	1.183E-07	7.738E-08	8.158E-08
3.40	6.952E-08	7.453E-08	6.182E-08	8.249E-08	8.102E-08	9.962E-08	6.553E-08	6.966E-08
3.50	6.713E-08	7.194E-08	5.964E-08	7.944E-08	7.790E-08	9.578E-08	6.308E-08	6.717E-08
3.60	6.487E-08	6.950E-08	5.759E-08	7.659E-08	7.499E-08	9.216E-08	6.078E-08	6.483E-08
3.70	6.275E-08	6.719E-08	5.565E-08	7.390E-08	7.226E-08	8.880E-08	5.862E-08	6.263E-08
3.80	6.073E-08	6.501E-08	5.383E-08	7.138E-08	6.969E-08	8.563E-08	5.659E-08	6.054E-08
3.90	5.883E-08	6.295E-08	5.210E-08	6.899E-08	6.727E-08	8.265E-08	5.467E-08	5.858E-08
4.00	5.807E-08	6.214E-08	5.046E-08	6.674E-08	6.498E-08	7.983E-08	5.286E-08	5.672E-08
4.10	5.627E-08	6.019E-08	4.892E-08	6.460E-08	6.283E-08	7.717E-08	5.115E-08	5.496E-08
4.20	5.460E-08	5.83AE-08	4.745E-08	6.259E-08	6.080E-08	7.466E-08	4.953E-08	5.329E-08
4.30	5.302E-08	5.667E-08	4.605E-08	6.067E-08	5.887E-08	7.229E-08	4.800E-08	5.170E-08
4.40	5.151E-08	5.504E-08	4.473E-08	5.886E-08	5.704E-08	7.003E-08	4.654E-08	5.019E-08
4.50	5.007E-08	5.349E-08	4.346E-08	5.713E-08	5.531E-08	6.790E-08	4.516E-08	4.876E-08
4.60	4.871E-08	5.201E-08	4.226E-08	5.550E-08	5.367E-08	6.587E-08	4.385E-08	4.740E-08
4.70	4.740E-08	5.061E-08	4.112E-08	5.394E-08	5.211E-08	6.395E-08	4.260E-08	4.610E-08
4.80	4.616E-08	4.92AE-08	4.002E-08	5.245E-08	5.062E-08	6.212E-08	4.141E-08	4.486E-08
4.90	4.497E-08	4.798E-08	3.898E-08	5.103E-08	4.921E-08	6.037E-08	4.028E-08	4.367E-08
5.00	4.698E-08	5.014E-08	4.118E-08	5.830E-08	4.957E-08	5.871E-08	3.920E-08	4.254E-08
7.50	2.468E-08	2.596E-08	2.137E-08	2.801E-08	2.618E-08	3.247E-08	2.207E-08	2.432E-08
10.00	1.693E-08	1.863E-08	1.507E-08	1.770E-08	1.875E-08	2.107E-08	1.449E-08	1.676E-08
15.00	8.289E-09	8.532E-09	7.053E-09	8.982E-09	8.437E-09	1.143E-08	7.978E-09	7.973E-09
20.00	5.195E-09	5.309E-09	4.385E-09	5.570E-09	5.216E-09	7.399E-09	5.216E-09	5.079E-09
25.00	3.611E-09	3.674E-09	3.032E-09	3.843E-09	3.592E-09	5.279E-09	3.747E-09	3.566E-09
30.00	2.762E-09	2.721E-09	2.249E-09	2.840E-09	2.649E-09	3.996E-09	2.848E-09	2.669E-09
35.00	2.016E-09	2.07AE-09	1.737E-09	2.190E-09	2.048E-09	3.156E-09	2.257E-09	2.085E-09
40.00	1.618E-09	1.666E-09	1.399E-09	1.771E-09	1.638E-09	2.573E-09	1.845E-09	1.683E-09
45.00	1.333E-09	1.372E-09	1.137E-09	1.422E-09	1.346E-09	2.085E-09	1.544E-09	1.393E-09
50.00	1.121E-09	1.152E-09	9.558E-10	1.194E-09	1.129E-09	1.772E-09	1.317E-09	1.176E-09

HCGS OLER

TABLE 2.3-21

SOUTH VENT D/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE D/Q BY SECTOR

(1/M**2)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
(1) DISTANCE MILES								
.25	6.015E-09	5.920E-09	5.967E-09	1.192E-08	1.674E-08	2.343E-08	9.897E-09	6.075E-09
.50	2.435E-09	2.546E-09	2.630E-09	4.993E-09	6.687E-09	9.216E-09	4.274E-09	2.639E-09
.75	1.481E-09	1.582E-09	1.646E-09	3.047E-09	3.971E-09	5.398E-09	2.613E-09	1.657E-09
1.00	1.010E-09	1.097E-09	1.146E-09	2.069E-09	2.639E-09	3.545E-09	1.780E-09	1.157E-09
1.50	5.754E-10	6.353E-10	6.646E-10	1.167E-09	1.456E-09	1.928E-09	1.008E-09	6.731E-10
2.00	3.773E-10	4.192E-10	4.372E-10	7.541E-10	9.325E-10	1.225E-09	6.539E-10	4.435E-10
2.50	2.765E-10	3.090E-10	3.216E-10	5.458E-10	6.690E-10	8.724E-10	4.748E-10	3.266E-10
3.00	2.029E-10	2.270E-10	2.361E-10	3.998E-10	4.898E-10	6.383E-10	3.482E-10	2.397E-10
3.40	1.641E-10	1.837E-10	1.909E-10	3.230E-10	3.955E-10	5.151E-10	2.814E-10	1.939E-10
3.50	1.563E-10	1.749E-10	1.818E-10	3.074E-10	3.763E-10	4.901E-10	2.679E-10	1.846E-10
3.60	1.490E-10	1.668E-10	1.733E-10	2.929E-10	3.586E-10	4.670E-10	2.553E-10	1.760E-10
3.70	1.422E-10	1.592E-10	1.655E-10	2.796E-10	3.422E-10	4.456E-10	2.437E-10	1.680E-10
3.80	1.359E-10	1.522E-10	1.581E-10	2.671E-10	3.270E-10	4.257E-10	2.329E-10	1.605E-10
3.90	1.301E-10	1.457E-10	1.513E-10	2.556E-10	3.128E-10	4.072E-10	2.228E-10	1.536E-10
4.00	1.246E-10	1.396E-10	1.450E-10	2.447E-10	2.995E-10	3.899E-10	2.134E-10	1.472E-10
4.10	1.195E-10	1.339E-10	1.390E-10	2.347E-10	2.872E-10	3.737E-10	2.047E-10	1.411E-10
4.20	1.147E-10	1.285E-10	1.335E-10	2.252E-10	2.756E-10	3.586E-10	1.964E-10	1.355E-10
4.30	1.102E-10	1.235E-10	1.283E-10	2.163E-10	2.647E-10	3.444E-10	1.887E-10	1.302E-10
4.40	1.060E-10	1.188E-10	1.234E-10	2.080E-10	2.545E-10	3.311E-10	1.815E-10	1.252E-10
4.50	1.021E-10	1.144E-10	1.187E-10	2.002E-10	2.449E-10	3.186E-10	1.747E-10	1.205E-10
4.60	9.833E-11	1.102E-10	1.144E-10	1.928E-10	2.359E-10	3.069E-10	1.683E-10	1.161E-10
4.70	9.481E-11	1.063E-10	1.103E-10	1.859E-10	2.274E-10	2.958E-10	1.622E-10	1.120E-10
4.80	9.149E-11	1.025E-10	1.064E-10	1.793E-10	2.193E-10	2.853E-10	1.565E-10	1.080E-10
4.90	8.835E-11	9.903E-11	1.028E-10	1.731E-10	2.117E-10	2.754E-10	1.511E-10	1.043E-10
5.00	9.758E-11	1.053E-10	1.060E-10	2.160E-10	2.060E-10	2.660E-10	1.460E-10	1.008E-10
7.50	5.536E-11	5.770E-11	5.632E-11	1.344E-10	1.023E-10	1.304E-10	7.170E-11	4.956E-11
10.00	7.253E-11	7.383E-11	6.618E-11	9.791E-11	1.024E-10	7.924E-11	4.371E-11	3.997E-11
15.00	4.601E-11	3.680E-11	4.021E-11	5.892E-11	5.089E-11	3.936E-11	2.183E-11	2.196E-11
20.00	3.081E-11	2.264E-11	2.658E-11	3.882E-11	3.127E-11	2.434E-11	1.356E-11	1.501E-11
25.00	1.971E-11	1.514E-11	1.715E-11	2.509E-11	2.087E-11	1.665E-11	9.369E-12	9.977E-12
30.00	9.874E-12	1.089E-11	1.166E-11	1.759E-11	1.501E-11	1.242E-11	7.054E-12	7.821E-12
35.00	7.463E-12	8.218E-12	8.658E-12	1.304E-11	1.136E-11	9.765E-12	5.595E-12	5.997E-12
40.00	5.856E-12	6.460E-12	5.489E-12	8.166E-12	8.925E-12	8.095E-12	4.687E-12	4.844E-12
45.00	4.728E-12	5.225E-12	4.442E-12	6.598E-12	7.213E-12	6.864E-12	4.007E-12	4.038E-12
50.00	3.905E-12	4.319E-12	3.672E-12	5.450E-12	5.959E-12	5.900E-12	3.465E-12	3.422E-12

TABLE 2.3-21 (CONTINUED)

WIND DIRECTION BEARING	NNE 202.5	NE 225.0	ENE 247.5	E 270.0	ESE 292.5	SE 315.0	SSE 337.5	S 360.0
(1) DISTANCE MILES								
.25	3.950E-09	4.354E-09	2.605E-09	1.610E-09	1.534E-09	9.403E-09	8.360E-09	6.434E-09
.50	1.850E-09	2.043E-09	1.223E-09	7.618E-10	6.315E-10	3.906E-09	3.597E-09	2.773E-09
.75	1.219E-09	1.350E-09	4.093E-10	5.075E-10	3.909E-10	2.321E-09	2.244E-09	1.759E-09
1.00	8.849E-10	9.763E-10	5.891E-10	3.729E-10	2.707E-10	1.943E-09	1.555E-09	1.243E-09
1.50	5.345E-10	5.866E-10	3.568E-10	2.285E-10	1.563E-10	8.504E-10	8.975E-10	7.337E-10
2.00	3.589E-10	3.907E-10	2.399E-10	1.552E-10	1.030E-10	5.441E-10	5.877E-10	4.892E-10
2.50	2.687E-10	2.908E-10	1.799E-10	1.173E-10	7.583E-11	3.900E-10	4.307E-10	3.640E-10
3.00	1.975E-10	2.134E-10	1.322E-10	8.635E-11	5.565E-11	2.854E-10	3.159E-10	2.675E-10
3.40	1.599E-10	1.726E-10	1.070E-10	6.996E-11	4.500E-11	2.304E-10	2.554E-10	2.165E-10
3.50	1.522E-10	1.644E-10	1.019E-10	6.664E-11	4.284E-11	2.192E-10	2.431E-10	2.062E-10
3.60	1.452E-10	1.567E-10	9.717E-11	6.356E-11	4.084E-11	2.089E-10	2.318E-10	1.966E-10
3.70	1.386E-10	1.496E-10	9.278E-11	6.070E-11	3.899E-11	1.994E-10	2.212E-10	1.877E-10
3.80	1.325E-10	1.430E-10	8.869E-11	5.804E-11	3.726E-11	1.905E-10	2.114E-10	1.794E-10
3.90	1.268E-10	1.368E-10	8.489E-11	5.556E-11	3.566E-11	1.822E-10	2.023E-10	1.717E-10
4.00	1.215E-10	1.311E-10	8.134E-11	5.782E-11	3.416E-11	1.745E-10	1.938E-10	1.645E-10
4.10	1.166E-10	1.257E-10	7.802E-11	5.580E-11	3.276E-11	1.672E-10	1.858E-10	1.578E-10
4.20	1.119E-10	1.207E-10	7.491E-11	5.393E-11	3.144E-11	1.605E-10	1.784E-10	1.515E-10
4.30	1.075E-10	1.159E-10	7.199E-11	5.220E-11	3.021E-11	1.542E-10	1.714E-10	1.456E-10
4.40	1.035E-10	1.115E-10	6.925E-11	5.059E-11	2.906E-11	1.484E-10	1.648E-10	1.401E-10
4.50	9.960E-11	1.073E-10	6.668E-11	4.909E-11	2.797E-11	1.429E-10	1.587E-10	1.349E-10
4.60	9.598E-11	1.034E-10	6.425E-11	4.770E-11	2.695E-11	1.374E-10	1.528E-10	1.300E-10
4.70	9.256E-11	9.972E-11	6.196E-11	4.641E-11	2.598E-11	1.324E-10	1.474E-10	1.253E-10
4.80	8.932E-11	9.622E-11	5.980E-11	4.521E-11	2.507E-11	1.277E-10	1.422E-10	1.209E-10
4.90	8.627E-11	9.292E-11	5.775E-11	4.409E-11	2.421E-11	1.235E-10	1.373E-10	1.168E-10
5.00	8.797E-11	1.248E-10	7.414E-11	5.799E-11	3.191E-11	1.619E-10	1.770E-10	1.129E-10
7.50	4.631E-11	8.120E-11	4.674E-11	4.046E-11	2.039E-11	1.045E-10	1.126E-10	5.585E-11
10.00	5.631E-11	6.014E-11	3.397E-11	3.109E-11	1.571E-11	7.342E-11	8.019E-11	8.178E-11
15.00	3.460E-11	3.693E-11	2.052E-11	1.970E-11	9.638E-12	3.627E-11	3.962E-11	5.080E-11
20.00	2.293E-11	2.449E-11	1.352E-11	1.319E-11	7.228E-12	2.221E-11	2.427E-11	2.368E-11
25.00	1.474E-11	1.570E-11	8.730E-12	8.440E-12	4.817E-12	1.480E-11	1.617E-11	1.578E-11
30.00	1.030E-11	1.095E-11	6.118E-12	4.408E-12	3.457E-12	1.062E-11	1.161E-11	1.133E-11
35.00	7.611E-12	8.087E-12	4.536E-12	3.330E-12	2.612E-12	8.024E-12	8.771E-12	8.560E-12
40.00	5.868E-12	6.227E-12	3.506E-12	2.612E-12	2.049E-12	6.299E-12	6.881E-12	6.715E-12
45.00	4.666E-12	4.947E-12	2.796E-12	2.108E-12	1.654E-12	5.083E-12	5.553E-12	5.421E-12
50.00	3.800E-12	4.027E-12	2.283E-12	1.740E-12	1.365E-12	4.196E-12	4.584E-12	4.476E-12

HCGS OLER

TABLE 2.3-22

NORTH VENT D/Q AT GROUND LEVEL
LONG TERM ROUTINE GASEOUS RELEASES
ANNUAL AVERAGE D/Q BY SECTOR

(1/M**2)

(1) 1 MILE=
1.61 KILOMETERS

WIND DIRECTION BEARING	SSW 22.5	SW 45.0	WSW 67.5	W 90.0	WNW 112.5	NW 135.0	NNW 157.5	N 180.0
(1) DISTANCE MILES								
.25	1.499E-08	1.505E-08	1.393E-08	2.769E-08	3.546E-08	4.704E-08	2.300E-08	1.730E-08
.50	5.487E-09	5.652E-09	5.267E-09	9.977E-09	1.258E-08	1.660E-08	8.459E-09	6.337E-09
.75	3.102E-09	3.229E-09	3.014E-09	5.549E-09	6.923E-09	9.114E-09	4.746E-09	3.570E-09
1.00	1.972E-09	2.070E-09	1.933E-09	3.468E-09	4.286E-09	5.635E-09	2.989E-09	2.257E-09
1.50	1.033E-09	1.095E-09	1.023E-09	1.779E-09	2.174E-09	2.853E-09	1.549E-09	1.175E-09
2.00	6.446E-10	6.852E-10	6.401E-10	1.098E-09	1.335E-09	1.750E-09	9.600E-10	7.301E-10
2.50	4.509E-10	4.811E-10	4.492E-10	7.593E-10	9.183E-10	1.203E-09	6.672E-10	5.089E-10
3.00	3.296E-10	3.518E-10	3.285E-10	5.545E-10	6.701E-10	8.781E-10	4.874E-10	3.721E-10
3.40	2.659E-10	2.839E-10	2.651E-10	4.471E-10	5.400E-10	7.077E-10	3.931E-10	3.004E-10
3.50	2.531E-10	2.702E-10	2.523E-10	4.254E-10	5.137E-10	6.733E-10	3.741E-10	2.859E-10
3.60	2.412E-10	2.575E-10	2.404E-10	4.054E-10	4.893E-10	6.415E-10	3.564E-10	2.725E-10
3.70	2.301E-10	2.457E-10	2.295E-10	3.868E-10	4.668E-10	6.120E-10	3.401E-10	2.601E-10
3.80	2.199E-10	2.348E-10	2.193E-10	3.696E-10	4.459E-10	5.846E-10	3.249E-10	2.486E-10
3.90	2.104E-10	2.247E-10	2.098E-10	3.535E-10	4.264E-10	5.592E-10	3.108E-10	2.379E-10
4.00	2.034E-10	2.169E-10	2.009E-10	3.386E-10	4.083E-10	5.354E-10	2.977E-10	2.279E-10
4.10	1.951E-10	2.081E-10	1.927E-10	3.246E-10	3.914E-10	5.133E-10	2.854E-10	2.186E-10
4.20	1.875E-10	1.999E-10	1.850E-10	3.116E-10	3.756E-10	4.926E-10	2.739E-10	2.099E-10
4.30	1.803E-10	1.923E-10	1.777E-10	2.994E-10	3.608E-10	4.733E-10	2.632E-10	2.018E-10
4.40	1.736E-10	1.851E-10	1.710E-10	2.880E-10	3.469E-10	4.551E-10	2.531E-10	1.942E-10
4.50	1.673E-10	1.784E-10	1.646E-10	2.772E-10	3.338E-10	4.380E-10	2.437E-10	1.870E-10
4.60	1.613E-10	1.720E-10	1.586E-10	2.671E-10	3.216E-10	4.220E-10	2.348E-10	1.803E-10
4.70	1.558E-10	1.661E-10	1.530E-10	2.576E-10	3.100E-10	4.069E-10	2.264E-10	1.740E-10
4.80	1.505E-10	1.605E-10	1.477E-10	2.487E-10	2.992E-10	3.927E-10	2.185E-10	1.681E-10
4.90	1.456E-10	1.552E-10	1.427E-10	2.402E-10	2.889E-10	3.793E-10	2.111E-10	1.625E-10
5.00	1.630E-10	1.772E-10	1.574E-10	2.588E-10	2.684E-10	3.666E-10	2.040E-10	1.572E-10
7.50	9.522E-11	1.049E-10	8.958E-11	1.453E-10	1.494E-10	1.833E-10	1.017E-10	7.917E-11
10.00	7.182E-11	7.477E-11	6.490E-11	9.757E-11	1.034E-10	1.127E-10	6.251E-11	7.004E-11
15.00	4.226E-11	3.699E-11	3.498E-11	5.397E-11	5.111E-11	5.675E-11	3.150E-11	3.988E-11
20.00	2.763E-11	2.264E-11	2.218E-11	3.455E-11	3.131E-11	3.512E-11	1.953E-11	2.580E-11
25.00	1.785E-11	1.515E-11	1.458E-11	2.257E-11	2.088E-11	2.350E-11	1.314E-11	1.678E-11
30.00	9.865E-12	1.098E-11	9.611E-12	1.574E-11	1.500E-11	1.702E-11	9.574E-12	1.184E-11
35.00	7.453E-12	8.294E-12	7.251E-12	1.176E-11	1.139E-11	1.299E-11	7.355E-12	8.824E-12
40.00	5.846E-12	6.505E-12	5.472E-12	8.142E-12	8.899E-12	1.062E-11	5.916E-12	6.859E-12
45.00	4.719E-12	5.250E-12	4.421E-12	6.574E-12	7.187E-12	8.680E-12	4.883E-12	5.498E-12
50.00	3.896E-12	4.335E-12	3.651E-12	5.429E-12	5.935E-12	7.246E-12	4.106E-12	4.509E-12

TABLE 2.3-22 (CONTINUED)

WIND DIRECTION BEARING	NNE 202,5	NE 225,0	ENE 247,5	E 270,0	ESE 292,5	SE 315.0	SSE 337,5	S 360,0
(1) DISTANCE MILES								
.25	1,324E-08	1,442E-08	7,375E-09	4,966E-09	4,210E-09	1,951E-08	1,774E-08	1,654E-08
.50	4,915E-09	5,356E-09	2,810E-09	1,934E-09	1,643E-09	7,068E-09	6,738E-09	6,243E-09
.75	2,785E-09	3,040E-09	1,626E-09	1,132E-09	8,733E-10	3,959E-09	3,894E-09	3,608E-09
1,00	1,768E-09	1,931E-09	1,052E-09	7,383E-10	5,549E-10	2,494E-09	2,521E-09	2,338E-09
1,50	9,238E-10	1,010E-09	5,618E-10	3,981E-10	2,904E-10	1,298E-09	1,348E-09	1,260E-09
2,00	5,749E-10	6,282E-10	3,531E-10	2,511E-10	1,810E-10	8,009E-10	8,466E-10	7,918E-10
2,50	4,013E-10	4,385E-10	2,491E-10	1,778E-10	1,269E-10	5,566E-10	5,966E-10	5,584E-10
3,00	2,942E-10	3,209E-10	1,822E-10	1,309E-10	9,308E-11	4,085E-10	4,361E-10	4,088E-10
3,40	2,379E-10	2,587E-10	1,472E-10	1,062E-10	7,541E-11	3,301E-10	3,518E-10	3,304E-10
3,50	2,265E-10	2,462E-10	1,401E-10	1,012E-10	7,186E-11	3,143E-10	3,347E-10	3,145E-10
3,60	2,160E-10	2,346E-10	1,335E-10	9,661E-11	6,858E-11	2,997E-10	3,189E-10	2,998E-10
3,70	2,063E-10	2,239E-10	1,275E-10	9,236E-11	6,555E-11	2,862E-10	3,043E-10	2,863E-10
3,80	1,973E-10	2,140E-10	1,218E-10	8,843E-11	6,275E-11	2,736E-10	2,907E-10	2,737E-10
3,90	1,889E-10	2,048E-10	1,166E-10	8,478E-11	6,015E-11	2,620E-10	2,781E-10	2,620E-10
4,00	1,811E-10	1,978E-10	1,128E-10	8,857E-11	5,801E-11	2,519E-10	2,702E-10	2,511E-10
4,10	1,738E-10	1,898E-10	1,083E-10	8,582E-11	5,577E-11	2,418E-10	2,594E-10	2,409E-10
4,20	1,671E-10	1,824E-10	1,041E-10	8,331E-11	5,369E-11	2,324E-10	2,494E-10	2,314E-10
4,30	1,607E-10	1,755E-10	1,002E-10	8,100E-11	5,175E-11	2,237E-10	2,400E-10	2,225E-10
4,40	1,548E-10	1,690E-10	9,655E-11	7,889E-11	4,994E-11	2,155E-10	2,312E-10	2,142E-10
4,50	1,492E-10	1,630E-10	9,312E-11	7,696E-11	4,825E-11	2,078E-10	2,229E-10	2,064E-10
4,60	1,440E-10	1,573E-10	8,990E-11	7,520E-11	4,667E-11	2,007E-10	2,152E-10	1,990E-10
4,70	1,391E-10	1,519E-10	8,687E-11	7,359E-11	4,519E-11	1,939E-10	2,079E-10	1,921E-10
4,80	1,345E-10	1,469E-10	8,403E-11	7,212E-11	4,380E-11	1,876E-10	2,011E-10	1,856E-10
4,90	1,302E-10	1,422E-10	8,136E-11	7,079E-11	4,250E-11	1,816E-10	1,947E-10	1,795E-10
5,00	1,389E-10	1,541E-10	8,819E-11	7,064E-11	5,297E-11	1,941E-10	2,087E-10	1,737E-10
7,50	7,851E-11	8,866E-11	5,096E-11	4,441E-11	3,448E-11	1,111E-10	1,194E-10	8,763E-11
10,00	5,727E-11	6,078E-11	3,505E-11	3,226E-11	2,555E-11	7,351E-11	8,030E-11	8,058E-11
15,00	3,292E-11	3,46AE-11	2,007E-11	1,947E-11	1,569E-11	3,631E-11	3,967E-11	4,642E-11
20,00	2,134E-11	2,242E-11	1,298E-11	1,283E-11	7,235E-12	2,224E-11	2,430E-11	2,369E-11
25,00	1,384E-11	1,454E-11	8,427E-12	8,248E-12	4,820E-12	1,482E-11	1,619E-11	1,579E-11
30,00	9,728E-12	1,022E-11	5,925E-12	4,409E-12	3,464E-12	1,063E-11	1,162E-11	1,136E-11
35,00	7,225E-12	7,590E-12	4,403E-12	3,331E-12	2,617E-12	8,034E-12	8,774E-12	8,580E-12
40,00	5,588E-12	5,86AE-12	3,406E-12	2,612E-12	2,052E-12	6,299E-12	6,881E-12	6,729E-12
45,00	4,456E-12	4,679E-12	2,717E-12	2,108E-12	1,656E-12	5,083E-12	5,553E-12	5,430E-12
50,00	3,638E-12	3,820E-12	2,219E-12	1,740E-12	1,367E-12	4,196E-12	4,584E-12	4,483E-12

TABLE 2.3-23

NATIONAL AND STATE AMBIENT AIR QUALITY
STANDARDS FOR TSP

	24-HOUR STANDARD (ug/m^3)		ANNUAL STANDARD (ug/m^3)	
	Primary	Secondary	Primary	Secondary
NAAQS	260	150	75	60
Delaware	200	150	70	60
Maryland	160	140	75	65
New Jersey	260	150	75	60
Pennsylvania	260	150	75	60

TABLE 2.3-24

MEAN NUMBER OF DAYS AT WILMINGTON NWS WITH FOG, HAZE AND/OR SMOKE

Months	FOG		HAZE and/or SMOKE
	Visibility < 11.3 km (<7 mi)	Visibility < 0.4 km (<0.25 mi)	
Jan	12	4	11
Feb	10	4	10
Mar	12	3	10
Apr	11	3	10
May	14	2	14
Jun	16	2	18
Jul	14	2	21
Aug	16	2	20
Sep	15	2	18
Oct	13	4	14
Nov	12	3	12
Dec	13	4	11
Annual	156	34	167

Source: U.S. Department of Commerce, Airport Climatological Summary - Climatography of the United States No. 90 (1965 - 1974), Wilmington, Delaware, January, 1979.

TABLE 2.3-25

ON-SITE RELATIVE HUMIDITY MEANS AND EXTREMES
JANUARY 1977 - DECEMBER 1981

Combined Months	RELATIVE HUMIDITY (%) Mean	Hourly Maximum	Hourly Minimum
Jan	66	100	28
Feb	64	100	23
Mar	64	100	18
Apr	62	100	15
May	71	100	18
Jun	70	100	18
Jul	73	100	30
Aug	76	100	32
Sep	74	100	30
Oct	72	100	31
Nov	71	100	19
Dec	69	100	20
Annual	69	100	15

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TABLE 2.3-26

ON-SITE HOURLY RELATIVE HUMIDITY FREQUENCY DISTRIBUTIONS
JANUARY, 1977 - DECEMBER, 1981

Relative Humidity (%)	MONTH											
	Jan		Feb		Mar		Apr		May		Jun	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
100	23	0.7	45	1.6	12	0.3	72	2.1	150	5.0	54	1.8
95 to 99	165	4.7	148	5.2	184	5.1	217	6.4	280	9.4	158	5.2
90 to 94	271	7.7	173	6.0	264	7.4	240	7.0	299	10.1	256	8.4
85 to 89	157	4.5	156	5.4	239	6.7	227	6.6	301	10.1	310	10.2
80 to 84	188	5.4	126	4.4	209	5.8	199	5.8	258	8.7	302	9.9
75 to 79	205	5.9	126	4.4	259	7.2	197	5.8	218	7.3	310	10.2
70 to 74	270	7.7	173	6.0	258	7.2	221	6.5	212	7.1	266	8.7
65 to 69	401	11.4	259	9.0	255	7.1	231	6.8	166	5.6	285	9.3
60 to 64	471	13.4	287	10.0	257	7.2	194	5.7	179	6.0	244	8.0
55 to 59	453	12.9	370	12.9	317	8.8	216	6.3	165	5.5	210	6.9
50 to 54	434	12.4	372	13.0	312	8.7	246	7.2	157	5.3	169	5.5
45 to 49	281	8.0	287	10.0	327	9.1	263	7.7	165	5.5	174	5.7
40 to 44	132	3.8	177	6.2	270	7.5	243	7.1	111	3.7	142	4.7
35 to 39	38	1.1	107	3.7	237	6.6	196	5.7	105	3.5	91	3.0
30 to 34	12	0.3	39	1.4	118	3.3	183	5.4	102	3.4	57	1.9
25 to 29	3	0.1	19	0.7	51	1.4	160	4.7	78	2.6	19	0.6
20 to 24	0	0.0	3	0.1	13	0.4	91	2.7	267	0.9	4	0.1
15 to 19	0	0.0	0	0.0	3	0.1	21	0.6	4	0.1	1	0.0
10 to 14	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5 to 9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
0 to 4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	3,504	100.0	2,867	100.0	3,585	100.0	3,417	100.0	2,976	100.0	3,052	100.0

TABLE 2.3-26 (Continued)

Relative Humidity (%)	MONTH													
	Jul		Aug		Sep		Oct		Nov		Dec		Annual	
	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent	Sum	Percent
100	39	1.5	59	2.4	24	1.0	111	4.1	83	3.2	108	3.5	780	2.2
95 to 99	184	7.0	151	6.2	140	5.9	203	7.5	277	10.6	215	7.0	2,322	6.6
90 to 94	280	10.6	294	12.0	283	11.9	240	8.9	276	10.6	252	8.2	3,128	8.9
85 to 89	313	11.9	351	14.4	279	11.7	215	7.9	171	6.6	187	6.1	2,906	8.2
80 to 84	306	11.6	330	13.5	301	12.6	249	9.2	129	4.9	196	6.4	2,793	7.9
75 to 79	267	10.1	318	13.0	286	12.0	223	8.2	168	6.4	227	7.4	2,804	8.0
70 to 74	245	9.3	240	9.8	229	9.6	272	10.0	214	8.2	246	8.0	2,846	8.1
65 to 69	216	8.2	155	6.3	184	7.7	255	9.4	255	9.8	270	8.8	2,932	8.3
60 to 64	188	7.1	138	5.7	183	7.7	225	8.3	211	8.1	286	9.4	2,863	8.1
55 to 59	194	7.4	134	5.5	157	6.6	197	7.3	248	9.5	309	10.1	2,970	8.4
50 to 54	133	5.0	105	4.3	127	5.3	184	6.8	202	7.7	261	8.5	2,702	7.7
45 to 49	111	4.2	90	3.7	87	3.7	152	5.6	177	6.8	213	7.0	2,327	6.6
40 to 44	81	3.1	47	1.9	54	2.3	110	4.1	97	3.7	158	5.2	1,622	4.6
35 to 39	70	2.7	29[a]	1.2	42	1.8	58	2.1	59	2.3	70	2.3	1,102	3.1
30 to 34	13	0.5	3	0.1	9	0.4	15	0.6	23	0.9	42	1.4	616	1.8
25 to 29	0	0.0	0	0.0	0	0.0	0	0.0	13	0.5	14	0.5	357	1.0
20 to 24	0	0.0	0	0.0	0	0.0	0	0.0	7	0.3	6	0.2	150	0.4
15 to 19	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0	30	0.1
10 to 14	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
5 to 9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
0 to 4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	2,640	100.0	2,444	100.0	2,385	100.0	2,709	100.0	2,611	100.0	3,060	100.0	35,250	100.0

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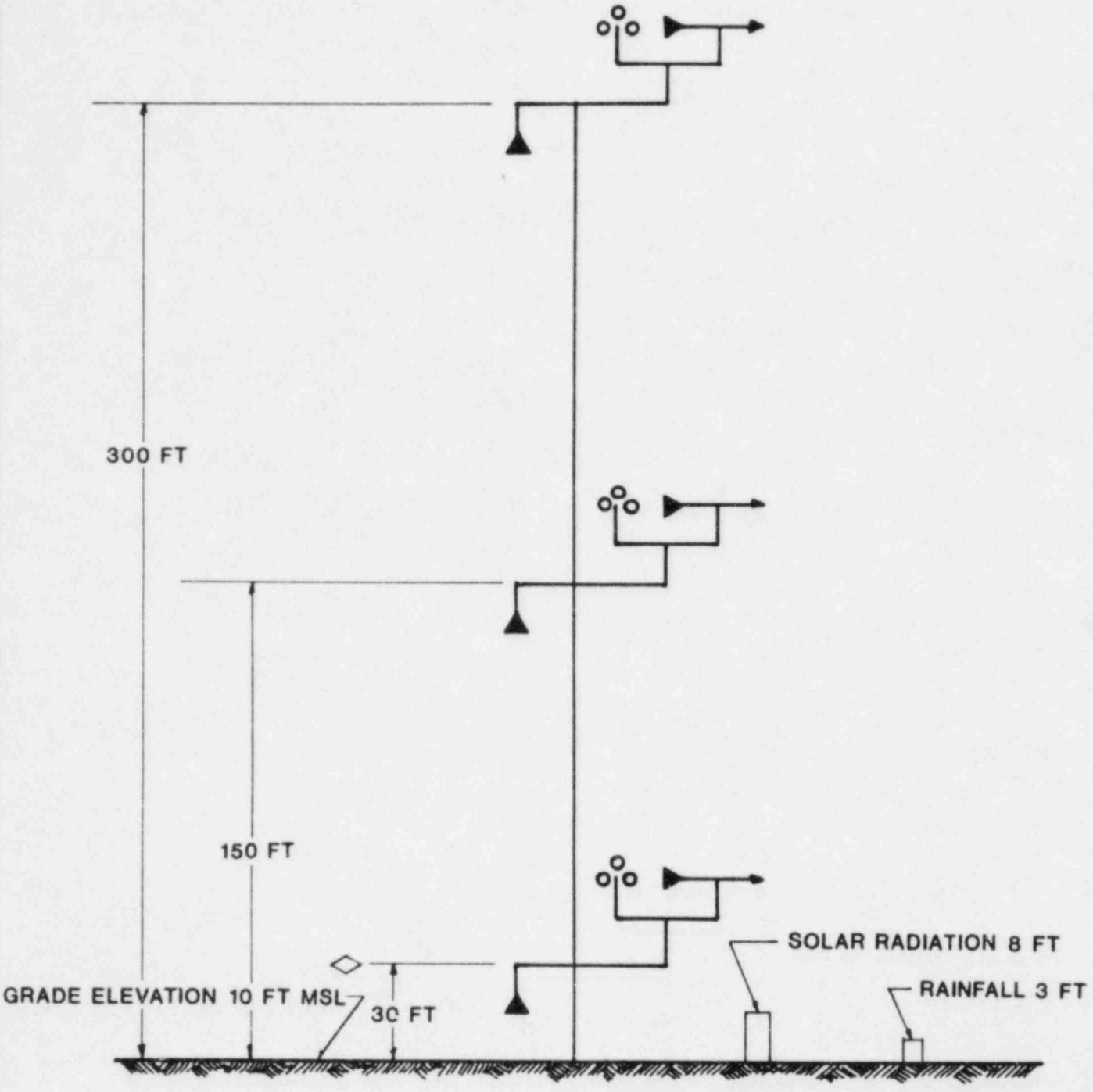
TABLE 2.3-27

ON-SITE DIURNAL RELATIVE HUMIDITY VARIATIONS
JANUARY, 1977 - DECEMBER, 1981

Hour	RELATIVE HUMIDITY (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	68.4	67.4	68.6	68.9	77.8	77.7	80.7	83.3	81.0	77.6	75.9	72.9	74.5
2	69.3	68.2	69.5	70.0	79.3	79.0	82.1	84.7	82.4	78.6	76.1	73.0	75.4
3	70.3	70.2	69.8	71.1	80.4	79.9	83.1	85.7	82.8	79.7	76.8	73.0	76.3
4	71.0	70.9	70.1	72.5	81.4	81.3	84.6	85.8	83.8	80.8	77.4	74.0	77.2
5	71.2	71.0	70.5	72.8	82.6	81.8	84.8	87.1	84.7	81.2	77.4	74.3	77.7
6	71.7	71.8	71.5	73.7	82.4	81.7	85.4	87.7	85.3	82.1	77.4	74.9	78.2
7	72.5	72.0	69.9	68.0	77.5	77.6	82.3	86.6	83.9	82.8	77.4	74.7	76.4
8	72.5	72.0	69.9	68.0	77.5	77.6	82.3	86.6	83.9	82.8	77.4	74.7	76.4
9	70.7	69.0	65.4	62.7	72.4	73.5	77.0	82.4	81.0	79.9	74.4	73.5	72.8
10	67.2	65.0	61.2	57.4	68.0	68.7	72.3	76.4	74.2	73.7	69.4	70.3	68.0
11	64.5	60.8	57.7	54.5	63.7	64.4	67.0	71.3	69.2	67.5	66.0	66.4	63.9
12	62.0	57.8	55.7	52.5	61.2	61.5	63.9	67.8	65.6	63.2	62.7	63.2	61.0
13	60.2	55.4	54.0	51.8	58.8	59.0	61.5	66.1	63.9	60.8	61.2	61.5	59.1
14	60.2	53.8	53.8	50.6	57.4	57.3	60.0	64.4	62.9	58.5	60.1	59.5	57.9
15	59.5	52.9	53.0	50.4	57.7	56.7	58.9	63.2	62.1	58.5	60.0	58.9	57.3
16	59.3	53.4	53.6	50.8	58.4	57.8	59.7	63.6	61.2	58.6	61.4	60.1	57.9
17	60.4	54.1	54.9	51.8	59.8	58.6	60.5	64.7	62.1	60.6	65.3	62.7	59.3
18	62.6	57.4	58.3	54.5	61.9	59.8	63.0	66.7	64.9	64.6	68.0	65.7	62.0
19	64.5	61.0	62.0	58.0	66.2	63.1	66.0	69.4	68.3	67.5	69.9	67.1	64.9
20	66.1	62.9	64.1	61.9	70.5	66.6	69.6	73.0	71.5	70.0	71.4	68.6	67.7
21	66.8	64.4	66.0	64.6	73.3	71.0	73.3	76.3	74.2	72.4	72.8	69.1	70.0
22	67.5	66.0	66.7	66.3	76.5	73.3	75.8	78.1	76.7	73.3	73.4	70.2	71.5
23	67.6	67.4	67.8	67.6	77.5	74.7	78.0	79.6	78.3	75.1	73.8	70.8	72.7
24	67.8	67.4	68.8	68.4	77.6	76.0	79.7	81.3	79.1	76.8	74.7	71.4	73.6

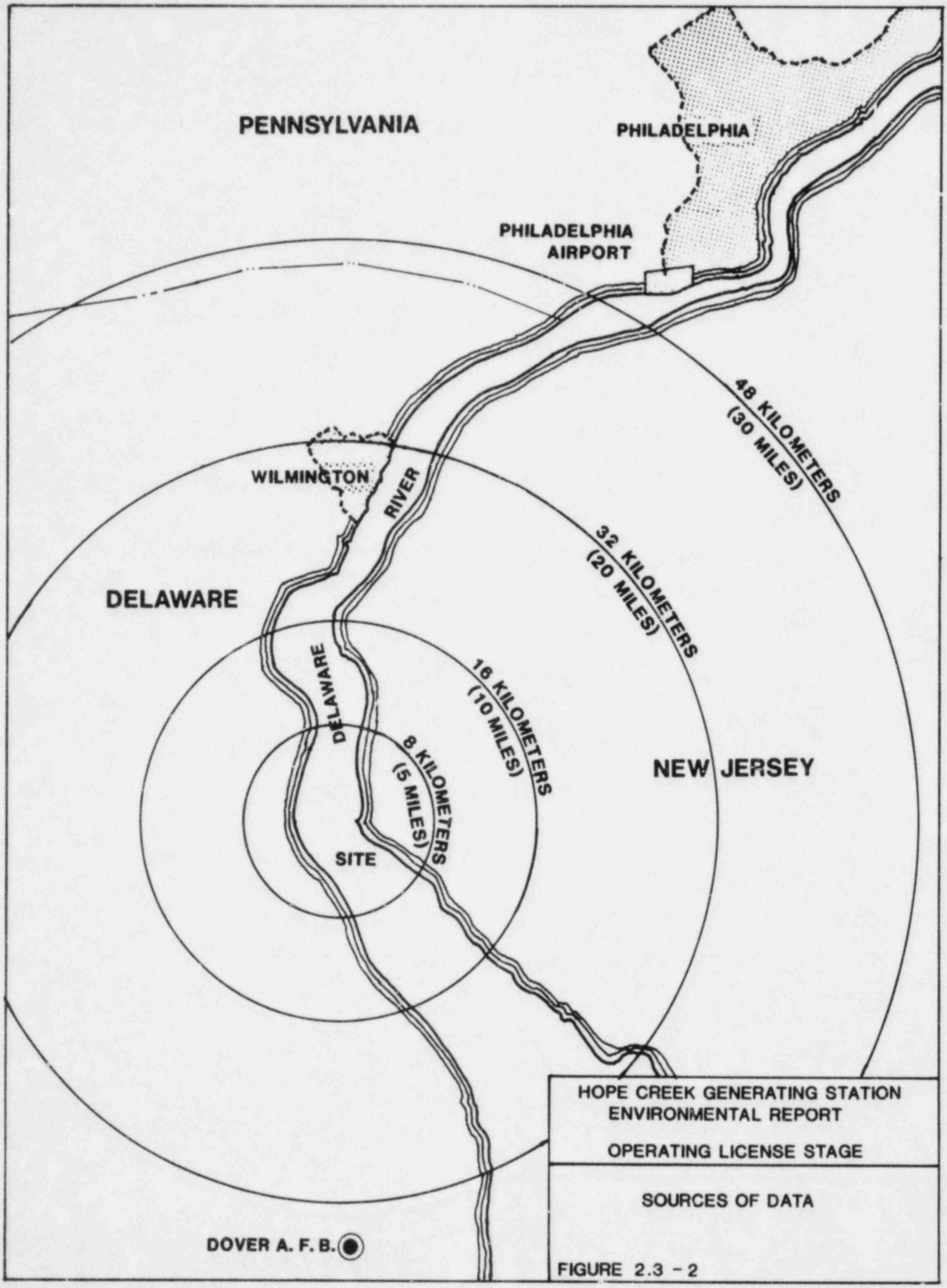


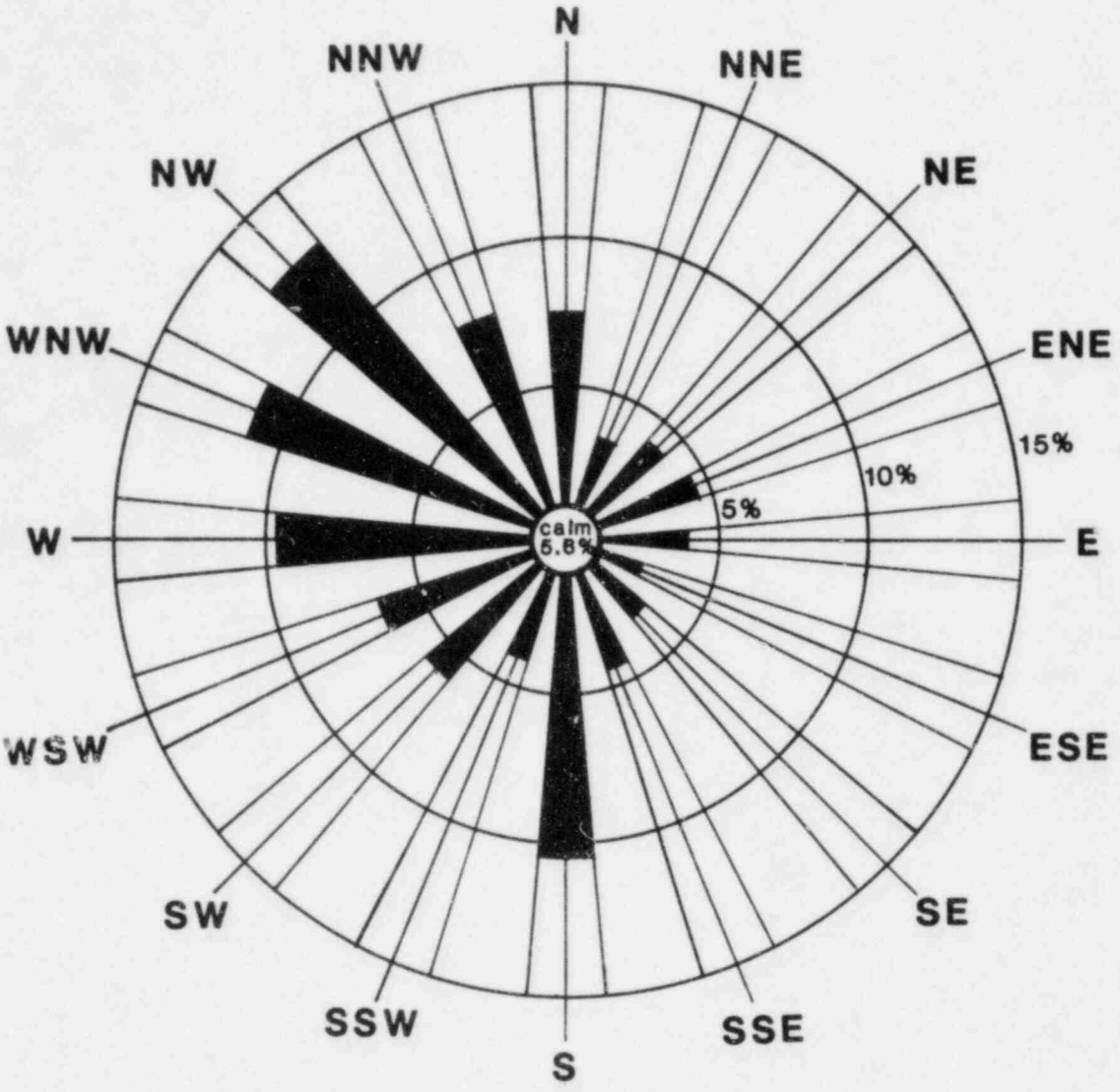
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

METEOROLOGICAL TOWER
SCHEMATIC

FIGURE 2.3 - 1


PENNSYLVANIA
PHILADELPHIA
PHILADELPHIA AIRPORT
48 KILOMETERS (30 MILES)
WILMINGTON
RIVER
32 KILOMETERS (20 MILES)
DELAWARE
DELAWARE
16 KILOMETERS (10 MILES)
8 KILOMETERS (5 MILES)
NEW JERSEY
SITE
DOVER A. F. B.
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE
SOURCES OF DATA
FIGURE 2.3 - 2



NOTE:
INSTRUMENT HEIGHT 6.1 METERS
(20 FEET)

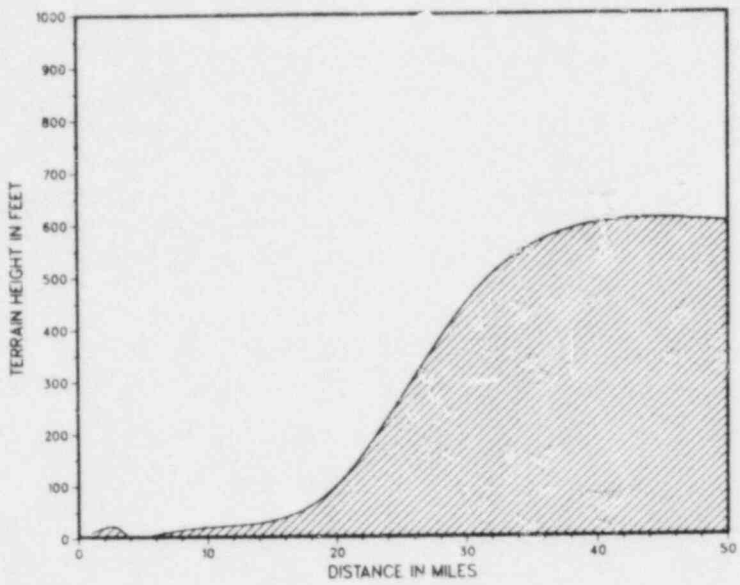
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

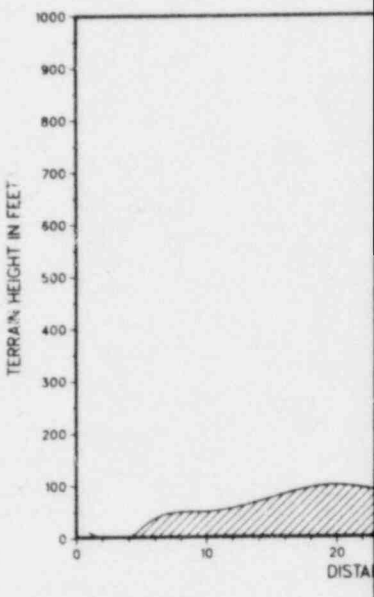
WILMINGTON, DELAWARE NWS
WIND ROSE 1972-1981

FIGURE 2.3 - 3

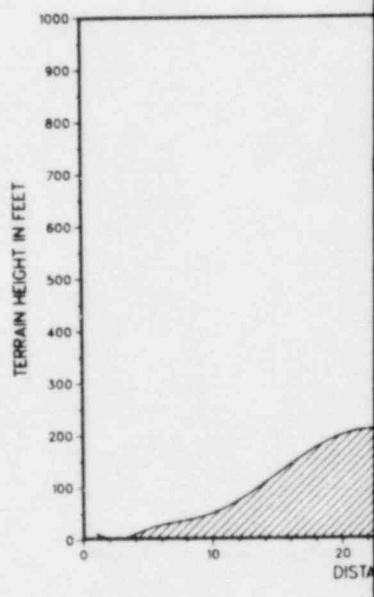
DIRECTION NORTH



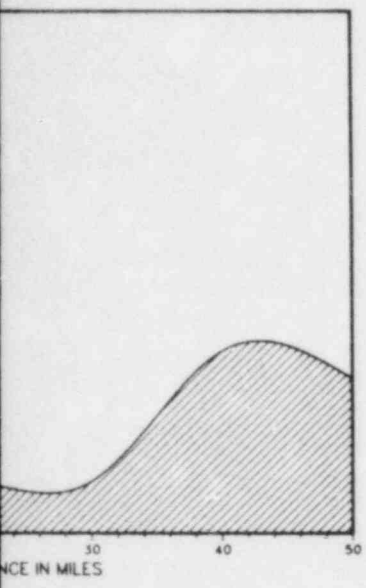
DIRECTION N



DIRECTIO



ORTH-NORTHEAST



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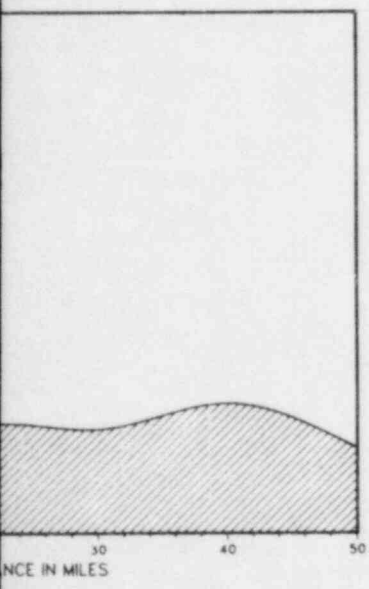
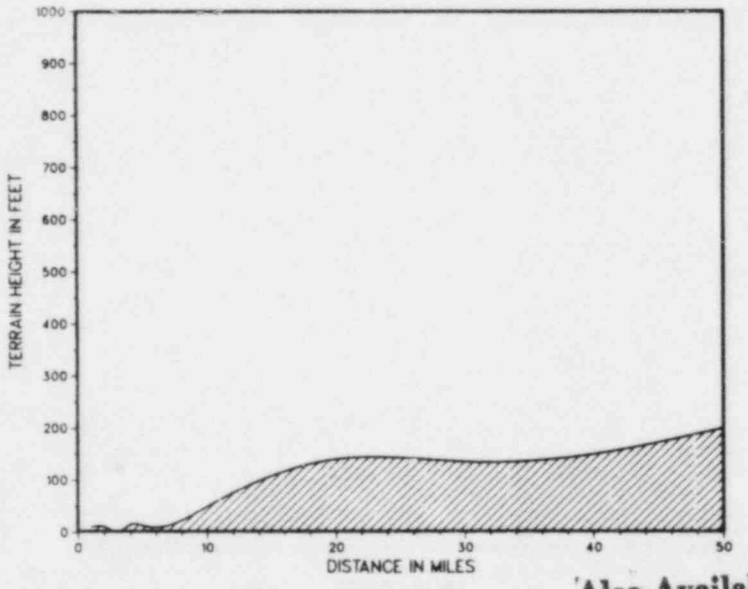
N NORTHEAST



DIRECTION EAST-NORTHEAST



Also Available On
Aperture Card

SCALE IN FEET/MILES
1 FOOT 0.3048 METERS)
(1 MILE 1.61 KILOMETERS)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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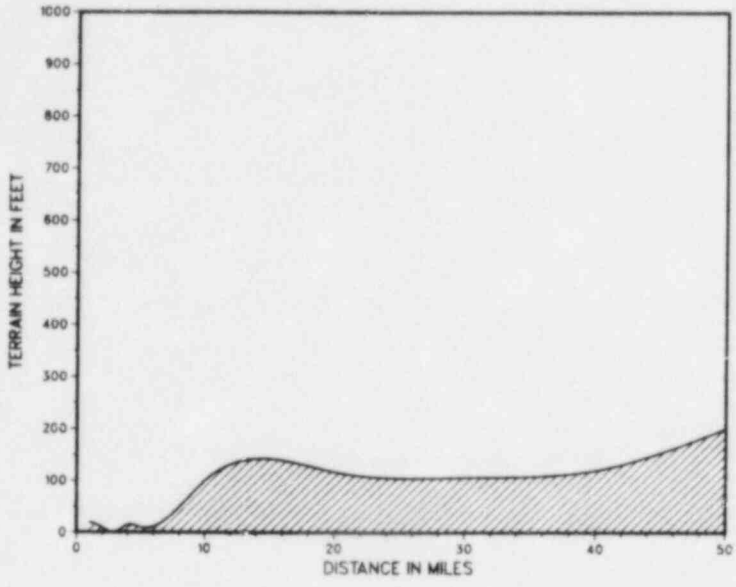
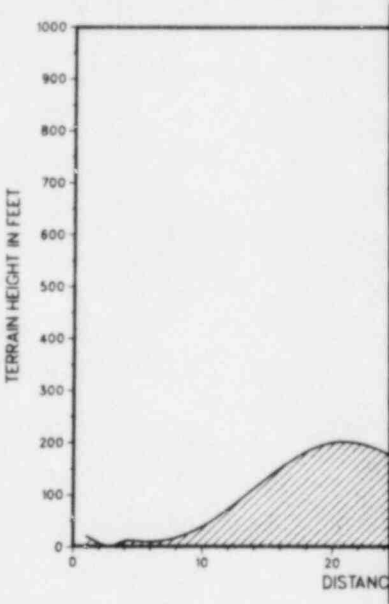
TERRAIN VS DISTANCE

FIGURE 2.3 - 4

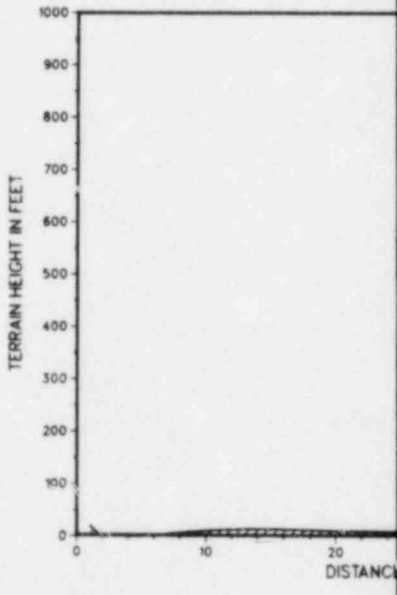
DIRECTION EAST



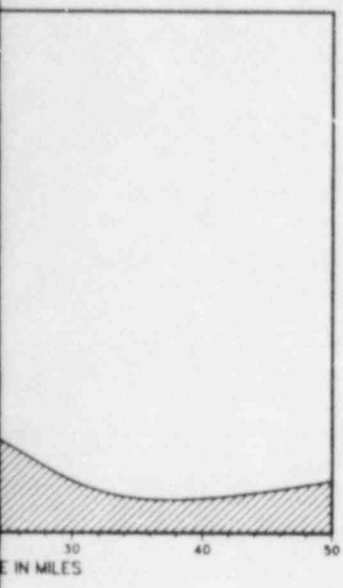
DIRECTION E



DIRECTION



AST-SOUTHEAST



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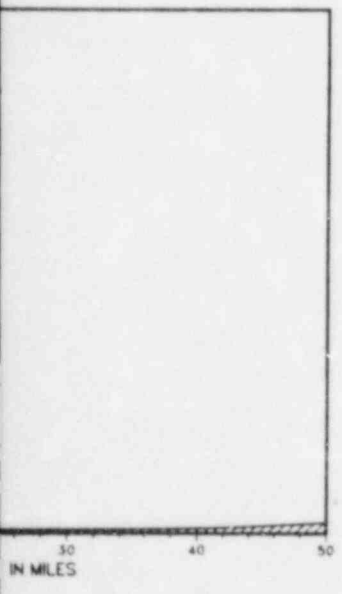
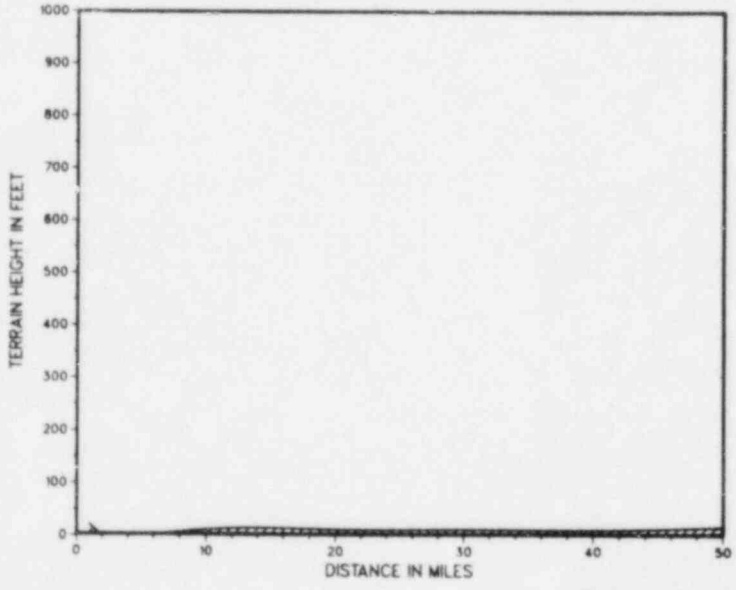
APERTURE
CARD

SOUTHEAST

DIRECTION SOUTH-SOUTHEAST





Also Available On
Aperture Card

SCALE IN FEET/MILES
(1 FOOT 0.3048 METERS)
(1 MILE 1.61 KILOMETERS)

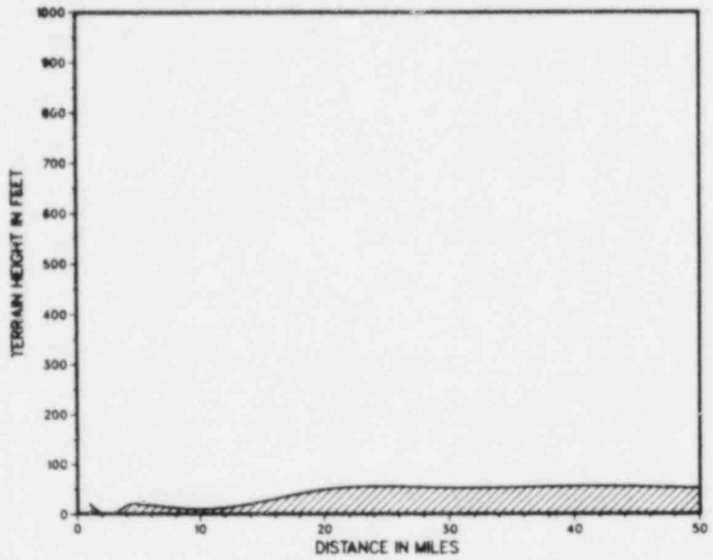
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

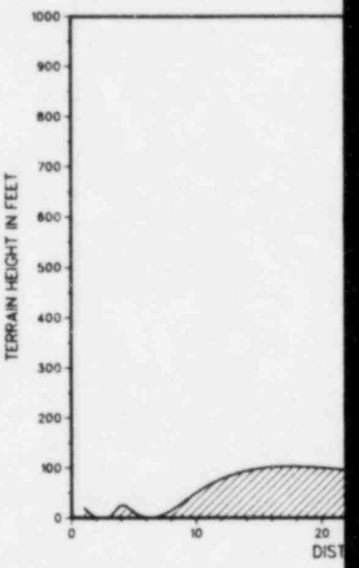
TERRAIN VS DISTANCE

FIGURE 2.3 - 5

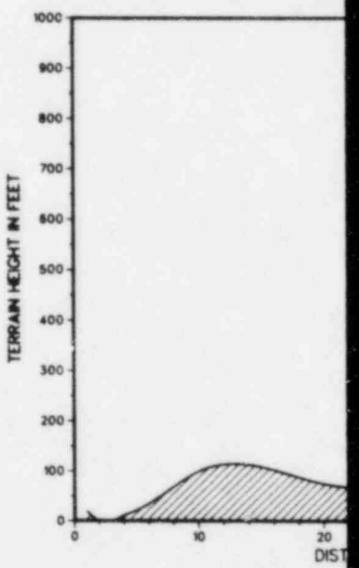
DIRECTION SOUTH



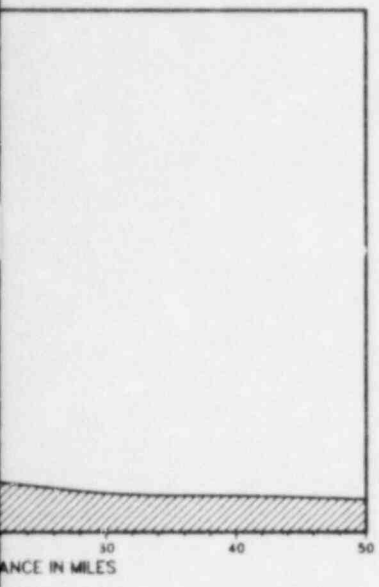
DIRECTION



DIRECTI



SOUTH-SOUTHWEST



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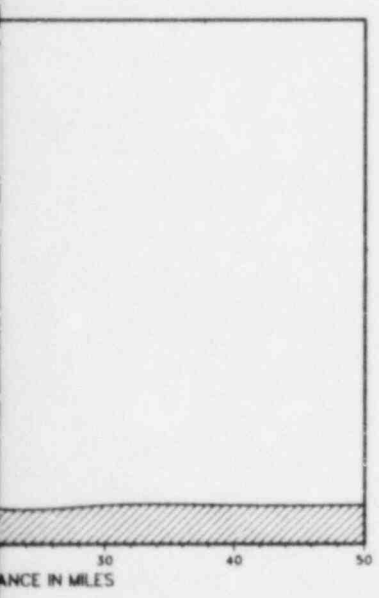
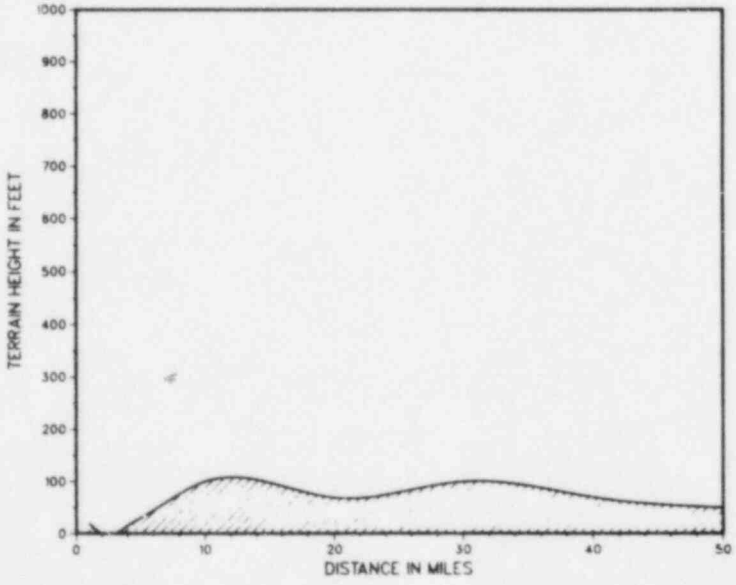
CARD

ON SOUTHWEST



DIRECTION WEST-SOUTHWEST



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SCALE IN FEET/MILES
(1 FOOT = 0.3048 METERS)
(1 MILE = 1.61 KILOMETERS)

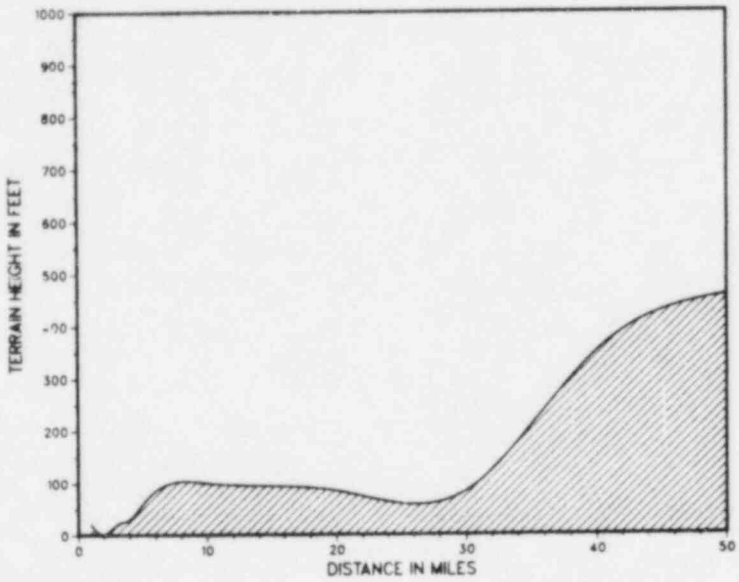
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

TERRAIN VS DISTANCE

FIGURE 2.3 - 6

DIRECTION WEST



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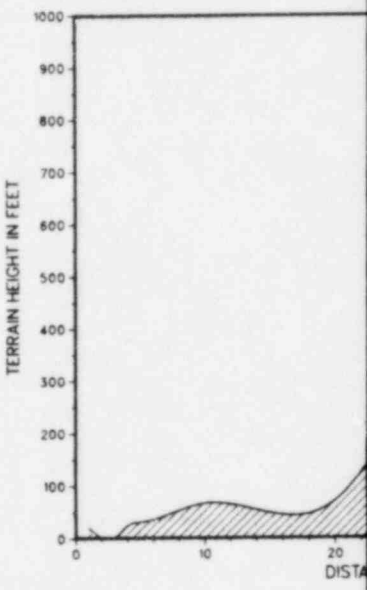

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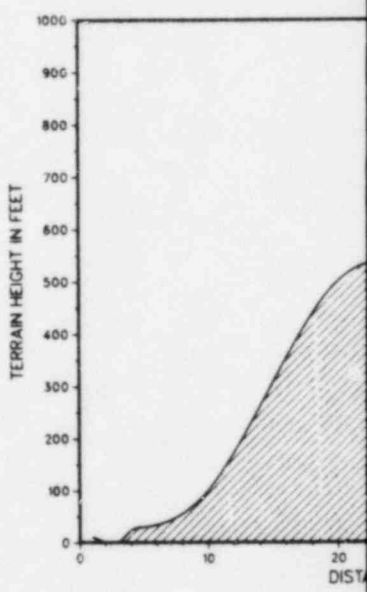
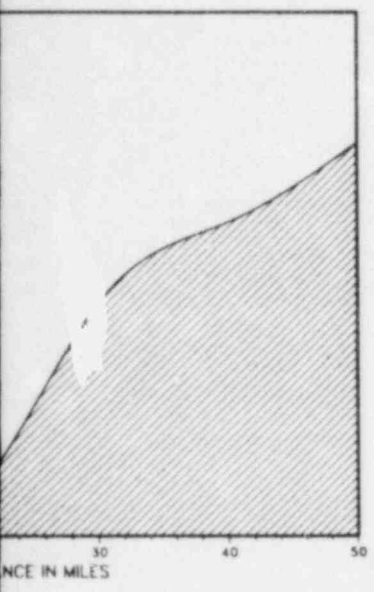
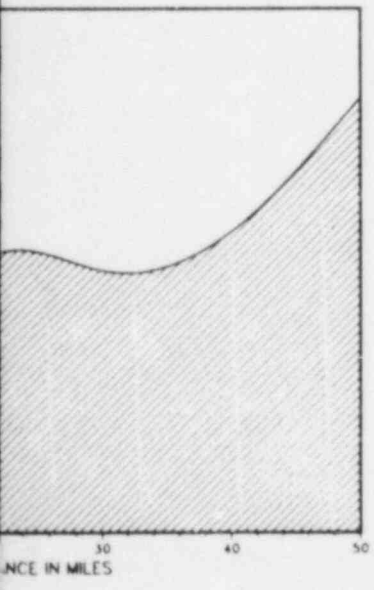


WEST-NORTHWEST

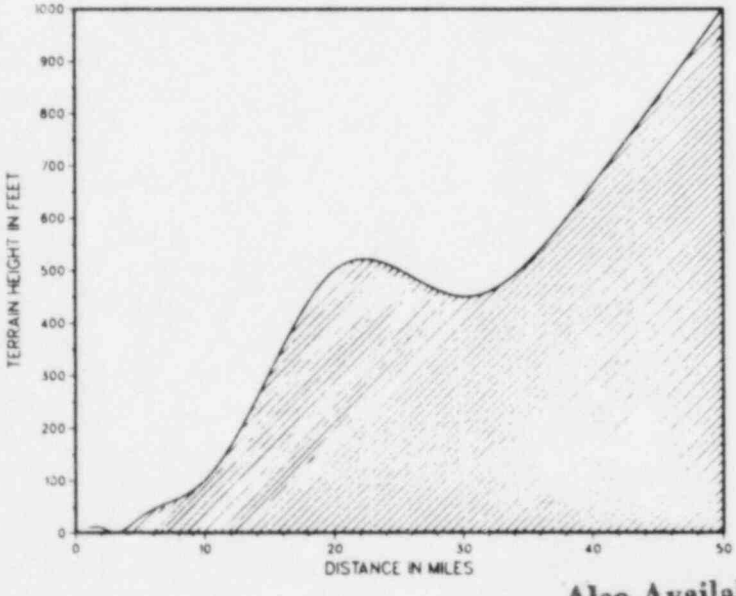


PRC
APERTURE
CARD

ON NORTHWEST



DIRECTION NORTH-NORTHWEST



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SCALE IN FEET/MILES
(1 FOOT= 0.3048 METERS)
(1 MILE = 1.61 KILOMETERS)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

TERRAIN VS DISTANCE

FIGURE 2.3 -7

8306290435 -30

2.4 HYDROLOGY

2.4.1 SURFACE WATER HYDROLOGY

2.4.1.1 Physiography

The current status of the hydrosphere at the HCGS site is similar to that at the construction permit stage.

The Delaware River Estuary, as defined by the DRBC, extends from Liston Point (Delaware River Mile 48.2) to the head of the tide above Trenton at River Mile (RM) 133.4. The generating station is within this estuary, located approximately 3.9 kilometers (2.4 miles) upstream of the Liston Point transect. The Delaware River extends upstream from RM 133.4, and the Delaware Bay lies below RM 48.2.

The largest tributaries of the Delaware River in the estuarian zone are the Schuylkill and Lehigh Rivers in Pennsylvania; the Christina River in Delaware; the Assunpink, Crosswicks, Rancocas and Salem Rivers, and Big Timber, Hope and Alloways Creeks in New Jersey. The Chesapeake and Delaware (C&D) Canal, which connects the Delaware River with Chesapeake Bay, is located about 11 kilometers (seven miles) north of the HCGS site.

The Delaware River Estuary System drains a basin of 36,000 square kilometers (13,900 square miles), which includes parts of Delaware, New Jersey, Pennsylvania, and 21 square kilometers (8 square miles) in Maryland (Figure 2.4-1). The contributory flows from those tributaries discharging into the Delaware River appear in Table 2.4-1. Approximately 25,100 square kilometers (9,700 square miles) of the drainage area consists of consolidated rock aquifers of low capacity; as a result, the basin tends to drain quickly with highly fluctuating discharges into the estuary at Trenton (Reference 2.4-1).

The mean annual precipitation (from 1921-1950) in the basin is 112 centimeters (44 inches), which is equivalent to 1.8×10^{13} liters (4.7×10^{12} gallons) per year. Freshwater drainage entering the river below Trenton augments this flow. As Table 2.4-1 shows, the average freshwater discharge near the site is 645,000 liters per second (22,765 cubic feet per second). In comparison, the average tidal flow (measured at Wilmington, Delaware, approximately 32 kilometers (20 miles) upstream of the site) is 11,328,000 liters per second (400,000 cubic feet per second). Thus, tidal flow dominates over freshwater discharge for control of flow velocities at the site (Reference

2.4-2). Even the maximum recorded discharge of 9,317,300 liters per second (329,000 cubic feet per second), that occurred at Trenton on August 20, 1955 (Reference 2.4-1), is lower than the typical tidal flows described above.

The tide in the Delaware Estuary is semi-diurnal in character. There are two high waters and two low waters in a tidal day, with comparatively little diurnal inequality (Figure 2.4-2). Reedy Point is the tide gage station nearest to the site, as Figure 2.4-3 shows. The tides at the gage have the following characteristics (Reference 2.4-1):

a.	Mean tide range	5.8 feet
b.	Spring tide range	6.0 feet
c.	Local mean sea level (MSL)	2.6 feet above mean low water
d.	10 percent exceedance high tide	6.6 feet

Winds exert a significant influence on tidal changes in the estuary. On November 25, 1950, strong easterly winds brought about the highest tide ever recorded, 8.5 feet above MSL. Strong downstream winds generated the lowest tide of record, 8.6 feet below MSL, on December 31, 1962. On this basis, the maximum recorded tidal range is 5.2 meters (17.1 feet).

Delaware River velocities near the HCGS si _ are dependent on tidal stage and flow. Figure 2.4-2 summarizes typical velocity patterns, as defined by measured conditions, and as predicted in the Delaware Estuary Model of the Corps of Engineers (Waterways Experiment Station, Vicksburg, Mississippi). Main channel current measurements (Reference 2.4-2) have been superimposed to show the overall current regime.

Physio-Chemical Description

The Delaware Estuary is well mixed. It is essentially homogeneous vertically; salinity averages 10 to 15 parts per thousand, with vertical variations limited to about one part per thousand (see Section 2.4.1.2). Some variations in salinity exist across the estuary due to Coriolis and other forces; these forces can concentrate lesser salinities on the Delaware Shore and greater salinities on the New Jersey side (Reference 2.4-2).

As described above, typical tidal fluctuations are vigorous enough to produce homogeneity in the estuary. Only in the lower Delaware Bay, where tidal velocities are much less, does vertical stratification begin to develop.

Section 5.1.2 discusses in detail the dilution and dispersion of thermal and chemical discharges from HCGS.

As discussed at the Construction Permit stage, secondary or nontidal flows can affect the dispersion of effluent below HCGS. As one travels downward from the upstream freshwater end of the estuary, there is an increasing amount of nontidal circulation. The relationship of this nontidal circulation to the transport of materials seaward, although not quantitatively established for HCGS, is of interest in a qualitative overview. Based on computations using the vertical salinity measurements taken in conjunction with biological assessments, the net nontidal circulation in the station vicinity due to Coriolis forces, wind stress and gravity-induced circulation produces salinity levels one-third of those in the lower bay. Other estimates of nontidal flow as high as six times or more the net freshwater supply are suggested (Reference 2.4-2).

Flood History

Figure 2.4-4 provides the relationship between Delaware River water levels and site elevations. As shown, plant grade is 12.5 feet above MSL, which lies 4.0 feet above historical high water.

Tidal and non-tidal forces influence Delaware River water levels at the site. Table 2.4-2 gives recent flood history of the Delaware River (based on datum at the Trenton gaging station). The recurrence intervals for period of record floods are also listed. As indicated, the one-percent flood would have a peak discharge at Trenton, 135.1 kilometers (83.9 miles) upstream, of 8,600 cubic meters per second (305,000 cubic feet per second).

As described above, the maximum recorded tide near HCGS, generated by strong easterly winds and heavy precipitation, was 8.5 feet above MSL. Table 2.4-3 summarizes other tidal floods of record in the vicinity of the site.

Other flood-producing events include the probable maximum tsunami and single or multiple dam breaks; however, the most critical combination of flood-producing phenomena results from the postulated occurrence of the probable maximum hurricane (PMH) surge with wave runup coincident with the 10 percent exceedance high tide. The postulated maximum wave runup to 34.8 feet above MSL occurs along the southeast face of the reactor building and a small corner face of the auxiliary building.

These areas are floodproofed and structurally reinforced to withstand the static and dynamic effects of the flood and coincident waves up to a level of 37.2 feet above MSL, or 2.4 feet above the maximum water runup height of 34.8 feet above MSL (Reference 2.4-1).

Table 2.4-4 gives the postulated flood-producing phenomena described above and the resultant water levels at the site.

In accordance with Executive Order No. 11988 concerning flood plain management, the following information describes how the 100-year flood would affect or be affected by HCGS.

In the most recent Federal Emergency Management Agency (FEMA) maps for Lower Alloways Creek, New Jersey, the 100-year flood has an elevation of nine feet above MSL (Reference 2.4-3). As described previously, final plant grade is 12.5 feet above MSL. Thus, the station should not alter the floodway of the one-percent flood, nor should receding water carry with it significant amounts of debris associated with the facility.

Bathymetry

As Section 2.4.1.2 discusses, suspended sediment load in the river varies greatly. The added impact of fluctuating river velocity often results in altered profiles of the river bottom. Figures 2.4-5, 2.4-6, 2.4-7 and 2.4-8 depict the extent to which those contours, within 600 meters (2,000 feet) of the site, changed during an 18-month study period.

Generally, river bottom elevations near the service water intake structure are about 70 feet PSD (distance above PSE&G baseline datum); over the course of the study period, however, this figure ranged from a low of 68 feet to a high of 74 feet PSD. Figure 2.4-9 provides the most recent detailed view of Delaware River bottom elevations near the HCGS site; it is based on a bathymetric river survey conducted in September, 1982.

Proceeding due west, away from the shoreline of Artificial Island, the bathymetry reflects smooth, shallow slopes in gently rolling contours. Up to 760 meters (2,500 feet) from the intake structure, bottom elevations range from 64 feet to 72 feet PSD (Figure 2.4-4). (These elevations maybe reduced to MSL by subtracting 89 feet; thus, 72 feet PSD is equal to 17 feet below MSL). At times, mounding is evident at various points in the river bottom, but these are transient, and can be attributed to fluctuating suspended solids levels and flow patterns in the river.

2.4.1.2 Surface Water Quality

Surface water quality data for the Delaware River are derived from samples obtained from three stations near the site from 1971 through 1982. Section 6.1.1 provides details of the sampling program.

The Delaware River is highly industrialized north of the HCGS site. Table 2.4-5 summarizes the results of data collected at three U.S.G.S. sampling stations upstream of Artificial Island. The data reflect at least 10 years of testing and give maximum, minimum and mean values for specific conductance, temperature, pH and dissolved oxygen.

Water quality deteriorates as the river flows south into the industrial areas below Trenton. Near Chester and Wilmington, the dissolved oxygen level has dropped to zero on several occasions. This oxygen sag indicates heavy pollution loading. Waste stream discharges from sewage and industrial treatment facilities are largely responsible for elevated concentrations of various pollutants and for depressed dissolved oxygen levels.

Tables 2.4-6 and 2.4-7 list water quality data for the river in the site region. Table 2.4-6 shows seasonal influences on various water quality parameters. Table 2.4-7 ranks each constituent according to the frequency with which specific values have occurred over the past 11 years.

Temperature

Delaware River water temperature near the site varies seasonally; it ranges from an average monthly low of 1.4°C (34.5°F) in February to an average monthly high of 27.1°C (80.8°F) in August. In data collected at the Salem Generating Station from 1977 through 1982, the minimum recorded temperature was -0.9°C (30.4°F), which occurred in February, 1982. The maximum monthly temperature was 30.5°C (86.9°F) in August, 1980. Table 2.4-5 gives monthly maxima, minima and averages for this same time period.

The estuary where HCGS is situated is well mixed; little stratification of temperature occurs. In a study performed by Ichthyological Associates (Reference 2.4-2) from 1970-1976, surface and bottom samples in the study area (see Figure 2.4-10) showed the river to be essentially homothermous throughout the year. Variance in water temperature between northern and southern portions of the study area was slight. Occasionally, the temperature was somewhat higher (approximately 1°C or 2°F) upstream during spring and summer months.

Vertical gradients of a few tenths of a degree centigrade were usually the maximum observed. Occasionally, surface and bottom temperature varied by 1 to 2°C (2 to 4°F),but such occurrences were neither regular nor predictable. Surface temperature, which reflected short term weather changes, was usually higher than bottom temperature from mid-April through late September. Bottom temperature was higher from early November through late February or early March.

Salinity

The salinity of the Delaware Estuary ranges from polyhaline (18 to 30 parts per thousand), at the mouth of the estuary, to the limnetic zone (0.0 to 0.5 parts per thousand), from Marcus Hook to Trenton. These salinity zones can be displaced in either direction depending on freshwater flow, tidal stage and meteorological conditions. HCGS is in the mesohaline zone (5 to 18 parts per thousand) during periods of low flow, and the oligohaline (0.5 to 5.0 parts per thousand) at all other times.

Seasonal changes are linked to upstream freshwater discharge and the extent of saltwater intrusion from the bay. A study by Ichthyological Associates (I.A.) (Reference 2.4-2) showed that mean salinity typically ranges from near 0 parts per thousand during high river runoff in winter and spring to 10 to 12 parts per thousand during low river runoff in summer and fall. Salinity was most frequently below three parts per thousand from December through May, and salinity exceeded six parts per thousand most frequently from August through October. Salinity was usually higher at bottom than at surface.

Daily salinity differences, both longitudinal and vertical, were more pronounced than temperature differences. Occasionally, gradients to 11 parts per thousand were measured between upstream and downstream stations, most often during summer and fall. Vertical differences essentially did not occur from November through March; from late April through September, however, differences as great as 2.0 parts per thousand per meter depth existed. These gradients were transient, as follow-up sampling several hours later found no stratification.

Dissolved Oxygen

Dissolved oxygen (D.O.) concentrations are dependent on a variety of physical, chemical (oxidation-reduction) and biological factors. The D.O. concentration is strongly influenced by wind agitation, water temperature, the presence of oxygen-consuming (reducing) substances in municipal and industrial effluents, and photosynthetic activity.

As Table 2.4-6 shows, D.O. varies seasonally. Over the past eleven years of the PSE&G sampling program, D.O. levels exceeded 4.7 parts per million 95 percent of the time, and 10.4 parts per million in 25 percent of the samples. The median D.O. level in the river near the site is 7.6 parts per million, a level that is indicative of a well-aerated body of water (Table 2.4-7).

Studies performed by I.A. from 1970 through 1976 (Reference 2.4-2) show that the Delaware Estuary is homogeneous in the site region. Surface concentrations tend to be higher than those at the bottom, but rarely by more than 1.0 part per million. This slight difference is attributable to surface agitation.

Occasionally, D.O. levels are greater downstream. This difference reflects greater distance from oxygen-depleting urban areas upstream.

Suspended Sediment, Turbidity and Total Dissolved Solids

Total solids loading proximate to the site depends on tidal flow, currents and freshwater discharge quality. Turbidity as nephelometric turbidity units (ntu), which is a measure of the particle-induced, light-scattering property of water, characterizes the level of suspended solids (TSS) in the water column. Both parameters tend to increase during spring flushing, when increased freshwater discharges cause scouring of riverbed soils, leading to increased sediment loading near the site (see Table 2.4-6 for seasonal fluctuation).

As Table 2.4-7 shows, the median concentration of suspended solids near the site is 109 milligrams per liter. The median turbidity is 38 ntu. Over the course of the sampling program, the TSS was at or below 270 milligrams per liter 95 percent of the time. Similarly, the 95 percent level for turbidity is 135 ntu. In five percent of the samples, TSS and turbidity fell at or below 40 milligrams per liter and eight ntu, respectively.

Whereas TSS and turbidity tend to increase with concomitant freshwater discharge, total dissolved solids (TDS) is dependent on Delaware River tidal stage. When freshwater discharges diminish (i.e., during drought periods) or, more typically, during flood tide, TDS near the site increases dramatically. As Table 2.4-3 shows, the median TDS value is 6,280 milligrams per liter. Ninety-five percent of the samples taken near the station have been at or below 12,648 milligrams per liter, and five percent fell below 644 milligrams per liter.

pH and Alkalinity

The pH and alkalinity of the river in the site vicinity are fairly constant throughout the course of the year and over varying tidal conditions. The median pH is 7.1. A pH of 6.5 is exceeded in five percent of the samples, and 95 percent of the time the hydrogen ion concentration does not exceed 7.7.

The buffering capacity of the Delaware River near the station, as reflected in alkalinity (as $CaCO_3$), consistently falls in the range of 30 to 70 milligrams per liter. The median concentration is 47.1 milligrams per liter (see Tables 2.4-6 and 2.4-7).

Chloride and Sulfate

Like TDS, levels of anionic species such as chloride (Cl^-) and sulfate (SO_4^{2-}) become elevated when tidal flows predominate over freshwater discharge (i.e., during droughts, flood tides, etc.). Therefore, a wide range of values for these ions is typical in the river.

For both chloride and sulfate, there is a ten-fold difference between the five-percent and 95-percent exceedance values (Table 2.4-7). The median chloride and sulfate concentrations are 3,725 milligrams per liter and 507 milligrams per liter, respectively.

Common Cations (NH_3^+, Iron, Sodium)

An extremely broad range of concentrations is typical of cations such as sodium (Na^+), ammonia (NH_3^+), iron (Fe^{2+}, Fe^{3+}) and copper (Cu^{2+}, Cu^{3+}), but the bases for their variations differ.

Sodium (20-fold change from five percent to 95 percent exceedance values; median equals 1,980 milligrams per liter) levels fluctuate for the same reason as TDS, chlorides and sulfate. Ammonia, iron and copper concentrations are influenced by wastewater discharges released from industrial centers along the Delaware River.

Ammonia values (as NH_3^+) range from 0.04 milligram per liter (five percent of the samples fall below) to 2.07 milligrams per liter (95 percent exceedance value). The median value was 0.31 milligram per liter. For iron, there was an approximate 100-fold increase from the five-percent (0.9 milligram per liter) to the 95-percent (7.02 milligrams per liter) exceedance levels. Median iron concentration was 1.91 milligrams per liter. Copper concentrations varied to a lesser extent (five-percent exceedance equals 0.01 milligram per liter, 95-percent exceedance equals 0.20 milligram per liter, median equal 0.3 milligram per liter).

Trace Pollutant

Table 2.4-9 provides trace pollutant levels observed in a recent water quality survey near the site. Cadmium and lead were found to exceed DRBC water quality objectives for Zone 5. The DRBC is aware of these conditions and believes they could be due to high natural (background) levels, incremental loading by industry along the river and the encroachment of non-point source pollution (Reference 2.4-5).

2.4.2 GROUNDWATER HYDROLOGY

2.4.2.1 Description

HCGS is located on Artificial Island in Lower Alloways Creek Township, New Jersey (Figure 2.1-2). The site lies within the Atlantic Coastal Plain, about 29 kilometers (18 miles) south of the Fall Line. Interbedded aquifers and aquicludes (some of the strata may be more accurately described as aquitards than aquicludes) of the Cretaceous, Tertiary and Quaternary Ages underlie the Coastal Plain. The strata composing these formations generally thicken and dip gently to the southeast. A generalized geologic cross section of the site, as shown in Figure 2.4-11, consists (in descending order from the land surface) of approximately 9 to 12 meters (30 to 40 feet) of blackish-gray clayey silt (hydraulic fill) overlying 2 to 3 meters (5 to 10 feet) of riverbed sand and gravel. The latter deposit is referred to as the shallow aquifer. Approximately 2 to 8 meters (5 to 25 feet) of grayish-brown clay underlies the riverbed sand and gravel. This clay is subdivided into an upper inorganic Quaternary Age unit and a lower layer of organic clay belonging to the Kirkwood Formation.

A second aquifer, composed of the basal sand of the Kirkwood Formation, the entire Vincentown Formation and the upper sands of the Hornerstown Formation, underlies the Kirkwood clay.

A direct hydraulic connection exists from one sand layer to the next. Therefore, for analytical purposes, the combination of these three sand units is referred to as the Vincentown (or "deep") Aquifer.

The basal sand of the Kirkwood Formation generally consists of 2 to 3 meters (5 to 10 feet) of reddish-brown micaceous, fine- to medium-grained sand, with varying amounts of silt. The Vincentown Formation consists of greenish-gray, silty fine- to

medium-grained glauconitic sand with some highly cemented zones. The bottom of the Vincentown Formation varies from depths of about 43 to 46 meters (140 to 150 feet) below the existing ground surface.

The Mount Laurel and Wenonah sands, referred to herein as the Mount Laurel-Wenonah aquifer, are separated from the overlying Vincentown Formation by a 12-meter (40-foot) thick aquitard consisting of the Hornerstown and Navesink Formations. The Hornerstown and Navesink Formations are dark green, fine- to medium-grained clayey sand. The Mount Laurel Formation, where it has been penetrated by test borings, observation wells and water supply wells, consists of greenish-brown, fine- to medium-grained sand with varying amounts of silt. The Wenonah sand is mainly composed of fine- to coarse-grained quartzose sands of white, yellow-red, rusty brown and black hues (Reference 2.4-6).

Underlying the Mount Laurel-Wenonah aquifer are the Marshalltown Formation; the Englishtown sand, the Woodbury clay; the Merchantville clay; and the Raritan and Magothy Formations. From this group, only the Raritan and Magothy Formations constitute a significant aquifer at the site. The remaining formations are aquitards and aquicludes (Reference 2.4-6).

In the strictest sense of the word, all of the soil formations underlying the HCGS site are hydraulically connected with each other, as none of the confining layers that separate the aquifers is completely impermeable. Whereas permeabilities range from about 21 cubic meters per day per square meter (524 gallons per day per square foot) for the shallow aquifer, 5 cubic meters per day per square meter (124 gallons per day per square foot) for the Vincentown aquifer, and 4 cubic meters per day per square meter (100 gallons per day per square foot) for the Mount Laurel-Wenonah aquifer, the permeabilities of the confining beds are significantly less. The estimated vertical permeability for the Hornerstown and Navesink formations is 0.02 cubic meter per day per square meter (0.4 gallon per day per square foot), and the Kirkwood clay is estimated at less than 0.2 cubic meter per day per square meter (5 gallons per day per square foot). Thus, the confining beds act as aquitards.

The aquifers described above are also hydraulically connected to the Delaware River to some extent. Outcrop patterns of the formations reveal that they are in physical contact with the river. Pumping of the shallow and Vincentown aquifers for site dewatering has caused a hydraulic gradient to extend

from the river toward the wells. In addition, these wells have been producing brackish water, which points to saltwater intrusion from the Delaware River.

Intrusion tends to influence the water quality of those wells whose outcrop zones are near the site. Thus, heavy pumping can cause a hydraulic gradient to exist from the river to the well field.

Whereas the more shallow aquifers have their outcrop zones near the site, the deeper Upper Raritan formation discharges about 16 kilometers (10 miles) to the north. Normally, the intrusion of brackish waters should not affect this aquifer; however, if sufficiently heavy pumping were to occur from the Upper Raritan aquifer by wells which could be installed in the future by other users, the hydraulic gradient in the Upper Raritan aquifer could be reversed, thereby allowing intrusion from the Delaware River (see Section 2.4.2.1.4).

In addition, heavy pumping of the Upper Raritan wells could draw salt water from the downdip parts of the aquifer south of the site. The water which exists downdip is probably connate water that existed in the aquifer from the time of deposition and was never flushed out by fresh water.

Following is a brief description of the major aquifers encountered at the site.

2.4.2.1.1 Shallow Aquifer

The shallow aquifer is composed of approximately 9 to 12 meters (30 to 40 feet) of fine-grained hydraulic fill, overlying Pleistocene sands (riverbed sands) and gravel, which are 2 to 3 meters (5 to 10 feet) thick. The fill material is a heterogeneous mixture of silt, fine sand and organic material which apparently was dredged from the channel of the Delaware River. The lateral extent of the sand layer is unknown, but it appears to exist in most areas of the site.

The shallow aquifer is hydraulically connected with the Delaware River. Natural water levels in the formation are essentially horizontal, and although changes in response to tides do occur, the horizontal component of groundwater movement under natural conditions is probably small.

The primary water-producing zone of the shallow aquifer consists of the riverbed sands. Recharge occurs by the infiltration of rainwater through the superficial soils. Percolation

tests performed in accordance with the United States Corps of Engineers Procedures reveal that the upper fill has an average permeability of 0.1 cubic meter per day per square meter (2.7 gallons per day per square foot). On the other hand, permeability values of the Pleistocene sands, as evaluated from grain size analyses, range from 2 to 4 cubic meters per day per square meter (50 to 150 gallons per day per square foot) (Reference 2.4-7). Permeability values based on pumping tests range from 21 to 23 cubic meters per day per square meter (524 to 556 gallons per day per square foot) based on an assumed average thickness of 2 meters (5 feet). If the average thickness is assumed to be 3 meters (10 feet), the permeability range becomes 10.7 to 11.3 cubic meters per day per square meter (262 to 278 gallons per day per square foot).

Thus, because of the difference in permeabilities, this formation is considered to be an unconfined, or phreatic, aquifer. Short term pump tests make the riverbed sands perform like a leaky artesian aquifer. This is reflected by the storage coefficients shown in Table 2.4-10.

No direct measurements of porosity were made on the riverbed sands; however, numerous sieve analyses were made which can be used to estimate the porosity and specific yield (effective porosity) using the graph given on page 24 of Todd (Reference 2.4-8). The average of the samples analyzed gave a 90 percent size of 6.5 millimeters. This method gives a porosity of 35 percent and a specific yield (effective porosity) of 28 percent.

It should be noted that the use of the term specific yield is appropriate only when the potentiometric surface is lowered in the sand, thereby allowing gravity drainage to take place. The estimates of porosity and effective porosity are based only on sieve analyses and should be used with caution.

Effects of Dewatering

The excavation for HCGS extends through the hydraulic fill and riverbed sands and into the Vincentown Formation to elevation 28 feet above grade (Public service Datum - PSD) (see Figure 2.4-11). (Figure 2.4-3 shows the relationship of PSD to MSL). The planned bottom of the excavation is below the natural piezometric level of the Vincentown aquifer (about elevation 93 to 97 feet above grade [PSD]). Therefore, it was necessary to utilize dewatering and monitoring operations which would allow the excavation to proceed without adversely affecting the integrity of the foundation soils or the stability of excavation slopes (Reference 2.4-9). Figures 2.4-12 and 2.4-13 show the location of the monitoring and dewatering wells, respectively (Reference 2.4-10).

In order to observe the impact of the dewatering system on the shallow aquifer, it should be noted that the expected flow is normally in a westerly or southwesterly direction toward the Delaware River. Thus, the land surface would be the zone of recharge and the Delaware River would be the zone of discharge. Figure 2.4-14 shows the water level contours in the shallow aquifer for January 16, 1976. At that time the dewatering system at the Salem Generating Station site directly south of the HCGS site was still in operation. As a result of the new dewatering operation, the groundwater in the shallow aquifer began to flow radially toward the HCGS excavation. Figure 2.4-15 (Reference 2.4-10) depicts this condition. As of May 17, 1978, the water level contour map (Figure 2.4-16) for the shallow aquifer reveals that the drawdown effect due to site dewatering extended only a short distance from the excavation.

The HCGS dewatering system will be decommissioned prior to HCGS operation. It is expected that this aquifer's normal flow pattern will return once pumping stops. For this reason, Section 4.3 is written as if this had already occurred.

Water Quality

Table 2.4-11 shows chemical analyses of water samples from the shallow aquifer. The table makes reference to well water quality observed before and after pumping from this formation began.

It can be seen that the shallow aquifer, with high specific conductance (6,000 to 11,000 umhos per centimeter), has an elevated salt content. Aquifer water quality is not seen to have been affected by the onset of pumping for site dewatering. This can be observed by comparing well "before pumping" and "after pumping" values.

Once decommissioning of the dewatering system takes place, it is expected that shallow aquifer flow regimes and water quality will return to pre-pumping conditions. Operation of HCGS does not involve removal or discharge of waters from or to the shallow aquifer; thus, it is not believed that station operation will affect the formation's water quality.

2.4.2.1.2 Vincentown Aquifer

The Vincentown aquifer is separated from the overlying shallow aquifer by the Quaternary and Kirkwood clay units. Because of hydraulic interconnections, the aquifer consists of the entire Vincentown Formation, the basal sands of the overlying Kirkwood Formation, and the upper sands of the underlying Hornerstown Formation. Table 2.4-10 provides aquifer characteristics, including porosity and specific yield.

The Vincentown Formation is about 20 meters (65 feet) thick, and is encountered at a depth of about 21 meters (70 feet). It consists of a fine- to medium-grained sand with occasional gravel, and is separated from the overlying shallow aquifer by about 11 meters (35 feet) of low permeability silty clay. Natural water levels in this formation are essentially level at the site, and the natural horizontal component of groundwater movement in this formation is probably negligible, except for oscillations caused by tides (Reference 2.4-11). The average tidal efficiency at the site was found to be seven percent (Reference 2.4-12).

The natural direction of groundwater flow in this aquifer is expected to be in a southwesterly direction (toward the Delaware River). Figure 2.4-17 depicts the Vincentown's piezometric contours approximately one year after the Salem Generating Station's dewatering system was decommissioned. This figure is believed to represent near-normal groundwater conditions. Operation of the HCGS dewatering system caused a large cone of depression in the Vincentown aquifer piezometric surface around the HCGS excavation. The piezometric level contour map for May 17, 1978, in Figure 2.4-18, shows this graphically. The map shows that the water in the Vincentown aquifer was flowing radially toward the HCGS excavation as a result of the operation of the HCGS dewatering system. It is expected that the flow pattern will retain the same configuration until dewatering is stopped.

Water Quality

Table 2.4-11 shows water quality in the Vincentown aquifer, as reflected in pre and post well pumping data from 1974. The formation exhibits a broad range of values for various parameters such as chlorides (2800 to 5100 milligrams per liter), sulfate (63 to 330 milligrams per liter) and specific conductance (8,000 to 16,000 umhos per centimeter). In general, water quality parameters in the Vincentown exist in the same range as those constituents in the shallow aquifer.

Figure 2.4-19, which shows contour lines of chloride concentration both before and after well pumping tests, reveals the effect of continued site dewatering on this aquifer's water quality. A clear shift in isochlors toward the pumping wells is apparent.

Station operation does not require withdrawal of water from the Vincentown aquifer. Thus, the end of site dewatering should return aquifer flow regimes and water quality to normal conditions.

Other Geologic Formations

The other water-bearing portions of the Vincentown aquifer consist of the Hornerstown Sand and Navesink Formations. The Hornerstown Sand conformably underlies the Vincentown Formation in New Jersey (Reference 2.4-13). It consists of a highly glauconitic, fine to medium dark green quartz sand, with large amounts of silt and traces of shell fragments.

At the site, the upper surface of the Hornerstown is generally encountered at elevation 30 feet below grade (PSD). Its thickness ranges from four to eight meters (14 to 25 feet). Hydrologically, the Hornerstown Sand is considered to be a leaky confining layer.

The field permeability of the Hornerstown Sand has been estimated at 1.2 cubic meter per day per square meter (30 gallons per day per square foot), and its vertical permeability at 0.02 cubic meter per day per square meter (0.4 gallon per day per square foot) (Reference 2.4-13). The upper sand of the Hornerstown Formation is considered hydraulically to be a part of the Vincentown aquifer.

The Navesink Formation unconformably underlies the Hornerstown Sand. It consists basically of fine glauconite sand with varying amounts of silt and clay. Its thickness is about six to seven meters (PSD) (20 to 22 feet). Its top occurs at approximately elevation 50 feet below grade (PSD). It does not extend to New Castle County, Delaware (Reference 2.4-11). Hydrologically, the Navesink Formation, together with the overlying Hornerstown sand, is considered to be a leaky confining layer.

2.4.2.1.3 Mount Laurel - Wenonah Aquifer

The Mount Laurel Sand and the underlying Wenonah Formation are considered to act as a single aquifer (Reference 2.4-11); this discussion treats them as such.

The Mount Laurel Sand underlies the Navesink Formation with a sharp, conformable contact. Its lithology varies in different areas from clay-sand interlayers to massive sand beds (Reference 2.4-11). In the vicinity of the study area, it is typically greenish-gray to brown at the top, containing fine to coarse glauconite quartz sand, with shell fragments and traces of mica at the bottom.

The Mount Laurel Formation crops out about 6 to 8 kilometers (4 to 5 miles) north of the site, with a NE-SW trending band which intersects the Delaware River. At the site, it is encountered at approximately elevation 65 feet below grade (PSD). Its thickness, as determined by Boreholes 201 and 206 and by Observation Wells A and G, varies between 32 and 35 meters (105 and 115 feet) and increases southeast.

The Wenonah Formation is characterized by gradational contacts, both at the bottom, into the Marshalltown Formation, and at the top, into the Mount Laurel Sand. The Wenonah Formation consists basically of a very fine to fine micaceous quartz sand, and clayey silt. The formation has a maximum thickness of 18 meters (60 feet) near Trenton, and thins out both to the northeast and to the southwest. The formation either disappears or thins out in Delaware.

The Mount Laurel Sand, together with the underlying Wenonah Formation, is one of the most important sources of water supply in New Jersey (Reference 2.4-13). In Delaware it is only a minor aquifer (Reference 2.4-11). Downdip from the formation outcrop, the aquifer has artesian characteristics. Recharge to the formation occurs from vertical leakage through overlying aquifers. In the outcrop area, discharge to local streams, as well as some recharge, takes place.

The quality of groundwater in the Mount Laurel-Wenonah Aquifer appears to be quite sensitive to drops in water levels caused by heavy pumpage. This fact is shown by an increase in salinity of water from public supply wells in the Salem area during the 1961 drought period, due to intrusion from the Delaware River (Reference 2.4-13). At the HCGS site, salinity increases toward the north, the northwest and possibly the east. The increase in salinity toward the margins of the site is attributable to active brackish water intrusion from the Delaware River and/or vertical leakage from the overlying formations.

Water Quality

The aquifer is characterized by wide variations in water quality (see Table 2.4-11). For example, samples have shown 20 to 7060 milligrams per liter chloride, up to 212 milligrams per liter sulfate, 20 to 3900 milligrams per liter sodium, 0.03 to 195 milligrams per liter total iron, 316 to over 7500 milligrams per liter total dissolved solids, 217 to 3280 total hardness, and 0.14 to 273 turbidity units. The variations in salinity are attributable to the presence of a brackish water intrusion taking place north of the site (probably where the Vincentown and the Mount Laurel-Wenonah Formations crop out under the Delaware River), or to vertical leakage through the Hornerstown and Navesink Formations. North of the HCGS site the Kirkwood clay pinches out, and the Hornerstown and Navesink formations appear to be sandier and more pervious. This increase in permeability reduces protection against saltwater intrusion into the Mount Laurel Formation (Reference 2.4-11).

Since operation of HCGS does not entail movement of water in or out of the Mount Laurel-Wenonah Aquifer, the facility should not alter water quality there.

Other Geologic Formations

The Marshalltown Formation underlies the Wenonah Formation with a sharp contact. It consists of a greenish-black, very fine to fine sand, and sandy clay. It is generally 3.1 to 4.6 meters (10 to 15 feet) thick throughout the region (Reference 2.4-11), although a thickness of about 38 meters (125 feet) has been reported.

Hydrologically, the Marshalltown Formation is a leaky confining layer, used by only a few domestic wells (Reference 2.4-13). The water quality is generally fair to poor for consumption because of its high iron content and turbidity, and its objectionable odor (Reference 2.4-13).

2.4.2.1.4 Raritan and Magothy Aquifer

The Raritan and Magothy formations are considered as a single unit because there is reason to believe that the aquifers in them are connected with each other at a distance, if not locally (Reference 2.4-6). Production wells at HCGS draw their water from the Upper Raritan formation.

The Magothy Formation is overlain by clay layers that prevent groundwater movement from shallow aquifers. The Raritan Formation is underlain by impermeable zones which prevent

hydraulic communication with deeper aquifers at the site. The combined Raritan-Magothy Formations have a maximum thickness of 145 meters (475 feet) near the outcrop area.

The outcrop areas for the two formations occupy about 49 square kilometers (19 square miles) in Salem County (about 16 kilometers (10 miles) north of the site) along the Delaware River), about 62 square kilometers (24 square miles) under the Delaware River, and more than 130 square kilometers (50 square miles) in the State of Delaware in a zone parallel to the C & D canal.

The Upper Raritan sands is one of the most productive aquifers in Delaware and New Jersey. Yields of up to 54 liters per second (860 gallons per minute) from individual wells have been reported in the outcrop area along the Delaware River in New Jersey (Reference 2.4-13) and in the industrial pumping centers near the C & D canal (Reference 2.4-14). Many of the aquifers are under artesian pressure, with transmissibility values of 186 to 435 cubic meters per day per meter (15,000 to 35,000 gallons per day per foot) and storage coefficients of 10^{-4}.

The major sources of recharge in the outcrop area include precipitation, infiltration from surface water bodies such as the Delaware River, and leakage from underlying or overlying formations. The natural zones of discharge for the Raritan-Magothy are also located in the outcrop areas. Thus, groundwater is discharged to streams (i.e. the C & D Canal in Delaware, portions of the Delaware River and Oldman's Creek in Salem County).

Salt water, found in the downdip portion of the aquifer (south of the site), probably has existed there from the time of original deposition. Although there is insufficient flow of fresh groundwater to flush the salt water out of the formation, there is sufficient freshwater head to prevent the saltwater interface from moving landward. It is probable that prior to large groundwater withdrawals from this aquifer (starting in 1957 and continuing to the present) there was a natural flow of fresh groundwater downdip from the recharge area in Delaware to the saltwater interface downdip of Artificial Island. At this time there was a combined flow of fresh and salt groundwater to the shallower, water-bearing zones and to the ground surface.

The natural regional groundwater flow in the Raritan-Magothy aquifer, as described in Reference 2.4-6, was to the southwest, south and southeast from the high intake areas in the state of Delaware (located about 24 to 29 kilometers (15 to 18

miles) northeast of the site). Prior to the time of large-scale groundwater withdrawal, the elevation of the piezometric surface of the Raritan-Magothy aquifer near the C & D Canal was about 20 feet above MSL. The surface had a downward slope to the south and southeast, reaching elevations on Artificial Island at, or slightly below, sea level.

Due to the large amounts of groundwater pumped from these aquifers along the C & D Canal, in Salem County near the Delaware River, at HCGS and at Salem Generating Station, cones of depression have been formed which divert part of this natural groundwater flow to these pumping centers. Increased pumpage of these aquifers in the C & D Canal area in Delaware caused a decline in the piezometric surface of 18 to 24 meters (60 to 80 feet) between 1954 and 1966 (Reference 2.4-15). This same pumping caused a decline in the piezometric surface of well No. 53B (Salem County) of 3 meters (11 feet) from 1959 to 1967 (Reference 2.4-14). Pumpage from the Raritan-Magothy near the Town of Salem and Carney's Point (29 kilometers (18 miles) north of HCGS) caused a lowering of piezometric surfaces, and increased the chloride content of the groundwater, from 444 milligrams per liter to 2057 milligrams per liter (near the Town of Salem) and from 132 milligrams per liter to 1040 milligrams per liter (near Carney's Point).

Groundwater Use

Water from the upper Raritan formation is used at the HCGS site for industrial, sanitary, potable and fire-protection purposes (see Section 3.3). No groundwater is intended for use in safety-related cooling systems (see Section 3.4).

HCGS is licensed by the NJDEP and the DRBC to pump a maximum of 68 million liters (18 million gallons) of water each month from two wells (HC-1 and HC-2) screened in the Upper Raritan Formation. Figure 2.4-20 shows the location of these wells.

The first wells installed in the Upper Raritan Formation at Artificial Island were Salem Production Well No. 5 (PW-5) and observation wells OW-A, OW-H and OW-I, which were in use in September, 1974. These wells have their screens at about 244 meters (800 feet) below ground surface.

Prior to the time of significant pumping from Salem Production Well No. 5, the static water levels in the wells (as of September 3, 1974) were:

Salem No. 5	14.0 feet below MSL
OW-I	12.0 feet below MSL
OW-A	16.0 feet below MSL
OW-H	13.0 feet below MSL

Based on this limited data, the gradient of the piezometric surface of the Upper Raritan between OW-I and OW-A was one meter (4 feet) in 1400 kilometers (4600 feet), or 1.40 meters (1.15 feet) per thousand, in a southeasterly direction. Salem Production Well No. 5 has been pumped on a limited basis from 1974 to the present time. Although no accurate pumpage figures are available, it is estimated that PW-5 was pumped at about 38 liters per second (600 gallons per minute) during this time. Recent pumpage (October, 1982) for this well is at the rate of about 567,800 liters (150,000 gallons) per day, or about 17.0 million liters (4.5 million gallons) per month. Water levels in Salem No. 5 varied from elevation 136 feet to 165 feet below MSL during October, 1982. At the time this well was completed (September, 1974) it was estimated that if the well was pumped at 51 liters per minute (800 gallons per minute) the future long-term pumping level would be approximately 134 feet below MSL, or lower. At OW-A, located 305 meters (1000 feet) southwest of PW-5, the piezometric surface in October, 1982 was about two meters (six feet) lower than it was in September, 1974.

The two HCGS production wells, HC-1 and HC-2, are approximately 244 meters (800 feet) deep and have a maximum capacity of 2500 liters per minute (650 gallons per minute). The wells are double-cased, with 51 to 66 centimeter (20 to 26 inch) casing down to the first formation, and 41 to 46 centimeter (16 to 18 inch) casing down to the aquifer. New Jersey State approved sealing is provided at the top of each well, and cement grout is installed around the full length of the casing. A screen and filtering gravel are installed in the aquifer at the lower end of each casing. The pumps are vertical turbine multi-stage and have above-ground motors. Hope Creek No. 1 well is located about 915 meters (3000 feet) northwest of Salem No. 5 Production Well and about 305 meters (1000 feet) southeast of OW-I. Records of pumpage from HC-1 and HC-2 since 1976 show that the wells have been pumped at rates varying from less than 11 million liters (3 million gallons) per month (June, 1980), to more than 43.5 million liters (11.5 million gallons) per month (August, 1981).

No historic data are available on groundwater levels in the HCGS production wells. As of October 15, 1982, the elevation of the piezometric surface at OW-I (located 305 meters (1000 feet) northwest of HC-1) was 67 feet below MSL. This represents a decline of 55 feet since September, 1974. The pumping

of wells HC-1, HC-2 and Salem PW-5 has caused a decline of the piezometric surface of the Upper Raritan aquifer from 1974 to the present time. The declines (in MSL) as measured in wells PW-5, OW-A and OW-I are:

Salem PW-5	14.0 foot decline in 1974, to 135 foot to 165 foot decline in October, 1982
OW-A	16.0 foot decline in 1974 to 22 foot decline in October, 1982
OW-I	12.0 foot decline in 1974 to 67 foot decline in October, 1982

Due to the limited information available on groundwater levels in the production wells and the observation wells installed at the site in the Upper Raritan aquifer, it is not possible to determine whether the present levels have been stabilized for some time or are continuing to drop. Also, it is not possible to determine if a significant portion of the decline of the piezometric surface at Artificial Island has been caused by the large groundwater withdrawals and the resulting cones of depression near the C & D Canal in Delaware, and in the northern part of Salem County near the Delaware River.

Evaluations have been made of the transmissibility and storage coefficient values of the Upper Raritan aquifer at Salem Generating Station (wells PW-5, OW-A) and near HCGS (OW-I). Transmissibility ranges from about 190 to 430 cubic meters per day per meter (15,000 to 35,000 gallons per day per foot), and the storage coefficient varies from 1.2 to 1.3 x 10^{-4}. Pump tests conducted in 1974 were used to derive these values.

Using the T and SC values in the Theis non-equilibrium well formula (see Reference 2.4-16) it is possible to check the actual (measured) drawdown in the production and observation wells with calculated values to determine the validity of the aquifer parameters. These parameters are used to evaluate the drawdown that would occur at various distances from the Hope Creek and Salem pumping centers, using expected pumping rates. For example, if PW-5 is pumped at a rate of 38 liters per second (600 gallons per minute), and HC-1 and HC-2 are pumped at a combined rate of 7 liters per second (116 gallons per minute) (about 19 million liters (5 million gallons) per month), the estimated drawdown would be more than 5 meters (15 feet) at a distance of 6 kilometers (4 miles) from the pumping center. This draw down would occur if the cone of depression did not intersect a recharge zone, or if leakage from underlying and overlying formations balances the pumping rate.

Studies by Dames and Moore in 1974 (Reference 2.4-17) indicate that the freshwater-saltwater interface in the Upper Raritan aquifer did not exist within a distance of about 4.2 kilometers (2.6 miles) southeast of the HCGS wells; however, heavy pumping of this aquifer could cause intrusion of brackish waters from the Delaware, or allow salt water downdip of the site to move updip to the wells. Sufficient data are not available to estimate when, and if, these events may occur. Observation well OW-H, located to the southeast of Salem Generating Station and HCGS, can be used as an outpost well to indicate if the saltwater wedge is moving toward the production wells from this direction.

Water Quality

Tables 2.4-12 and 2.4-13 show the water quality of the Raritan-Magothy aquifer as reflected by wells screened in the Upper Raritan formation. Table 2.4-12 characterizes the water quality in Salem Production Well 5 (see Figure 2.4-20) from July, 1977 through October, 1981. Table 2.4-13 traces HCGS Production Wells 1 and 2 from August, 1974 through January 7, 1982.

A comparison of both tables reveals that, although the three wells are located in the same aquifer, the water quality in Salem Well 5 is not necessarily equivalent to that in HCGS Wells 1 and 2. It should be noted that water quality in all wells changed in 1980-81. This change may be attributed to drought conditions in the Delaware River Basin during that time.

2.4.2.2 Regional Use of Groundwater

Nearly all water used for consumptive purposes within 40 kilometers (25 miles) of the site is groundwater. With the exception of the industries in the Wilmington, Delaware area, the major use of water is for domestic and agricultural purposes (Reference 2.4-18).

There are six towns in New Jersey within 40 kilometers (25 miles) of the proposed site that have public water supplies. There are five public water supplies in Delaware within 24 kilometers (15 miles) of the site. Table 2.4-14, "Public Water Supplies in the Site Region," shows data concerning these systems. Figure 2.4-21 shows their locations (Reference 2.4-18).

Nearly all domestic water supplies in this region are obtained from private wells other than those serving the generating stations. Most wells are 5 centimeters (2 inches) in diameter

and greater than 23 meters (75 feet) in depth. The aquifer commonly utilized in the vicinity of the site is the Mount Laurel - Wenonah Formation. Table 2.4-15, "Private Water Wells in the Vicinity of Site," presents information pertaining to these private systems. Figure 2.4-22 shows the locations of those wells.

The nearest residences to the site are about 5 kilometers (3 miles) distant. These are seasonal cottages, which are inhabited primarily during summer weekends. The water supply for these cottages is obtained from shallow driven wells, or in some cases it is carried in along with the other provisions (Reference 2.4-18).

Since most of the suppliers do not utilize the Upper Raritan, it is not believed that station groundwater use will have a negative impact on regional water systems.

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2.4-5 Personal communication between PSE&G and DRBC, December 17, 1982.

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2.4-11 Dames & Moore, "Report, Foundation Studies, Proposed Hope Creek Generating Station, Lower Alloways Creek Township, New Jersey," Public Service Electric and Gas Company, 1974.

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2.4-16 E. E. Johnson, Inc., Ground Water and Wells, St. Paul, Minnesota, 1966.

2.4-17 Dames and Moore, Ground Water Supply, Production Well No. 5, Salem Nuclear Generating Station, Public Service Electric and Gas Company, 1974.

2.4-18 Dames & Moore, "Report, Site Environmental Studies, Proposed Salem Nuclear Generating Station, New Jersey," Public Service Electric and Gas Company, 1971.

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TABLE 2.4-1

DRAINAGE AREAS AND GAGED RIVER FLOW OF
STREAMS TRIBUTARY TO DELAWARE RIVER AND BAY(1)

RIVER or STREAM	DRAINAGE AREA		AVERAGE DISCHARGE			
	Sq. Kilometers	Sq. Miles	(m^3/sec)	(ft^3/sec)	(m^3/min/km^2)	(ft^3/sec/sq mi)
Delaware at Trenton	17,560	6,780	331.6	11,710	1.14	1.73
Crosswicks Creek	218	84	4.3	152	1.20	1.82
Neshaminy	544	210	7.5	265	0.83	1.26
Rancocas, North Branch	287	111	4.6	162	0.96	1.46
Schuylkill at Philadelphia	4,903	1,893	76.9	2,715	0.95	1.44
Chester Creek	158	61	2.2	78	0.83	1.27
Brandywine Creek	743	287	10.7	378	0.87	1.32
White Clay Creek	228	88	3.4	119	0.91	1.36
Maurice River	293	113	5.0	176	1.02	1.56
Total Gaged (69.25%)	24,934	9,627	446.2	15,755	1.08	1.64
Ungaged Area (30.75%)	11,067	4,273	198.5	7,010(2)	1.08	1.64
Total Drainage Area	36,001	13,900	644.7	22,765	1.08	1.64

(1) Drainage areas greater than 130 square kilometers (50 square miles).
(2) Ungaged area multiplied by 1.08 equals average $m^3/min/km^2$ (1.64 average $ft^3/sec/mi^2$).

TABLE 2.4-2

PEAK DISCHARGE DATA FOR THE DELAWARE RIVER AT TRENTON, NEW JERSEY

PEAK DISCHARGES AND STAGES

Date		GAGE HEIGHT (meters)	GAGE HEIGHT (feet)	DISCHARGE (m^3/s)	DISCHARGE (cfs)
1904	October 11	6.3	20.7	8,354	295,000
1913	March 28	4.1	13.3	4,531	160,000
1925	February 13	4.0	13.0	4,361	154,000
1936	March 13	4.7	15.3	5,636	199,000
1936	March 19	5.1	16.7	6,429	227,000
1940	April 1	3.9	12.9	4,293	151,600
1942	May 24	4.1	13.4	4,565	161,200
1955	August 20	6.1	20.8	9,317	329,000

PEAK DISCHARGES AT SELECTED RECURRENCE INTERVALS

Recurrence Interval (years)	PEAK DISCHARGE (m^3/s)	PEAK DISCHARGE (cfs)
10	5,098	180,000
25	6,429	227,000
50	7,505	265,000
100	8,638	305,000

Location: Lat. 40° 13'18", Long. 74° 46'38"
Drainage Area: 6,780 square miles
Gage: Datum of gage is 7.8 feet above 1929 mean sea level datum.
Regulations: Some effects on peak flood regulation from Lake Hopatcong, Lake Wallenpaupak, Toronto Reservoir, Swinging Bridge Reservoir, Cliff Lake Reservoir, Wild Creek Reservoir, Neversink Reservoir, Pepacton Reservoir and other smaller reservoirs.

Sources:
U.S.G.S., 1981 (Reference 2.4-19).

TABLE 2.4-3

TIDAL FLOODS ON DELAWARE RIVER

STATION	DATE	TIDAL FLOOD STAGE (feet above MSL 1929/ADJ)
Lewes, DE	March 1962	7.9
	November 1950	7.2
	August 1933	6.1
Cohansey River, NJ	November 1950	8.6
	August 1933	7.0
Liston Point, DE	November 1950	8.5
	August 1933	7.8
Reedy Point, DE	March 1962	7.5
	November 1950	8.6
	August 1933	8.0
New Castle, DE	November 1950	8.5
	August 1933	8.1
Philadelphia, PA	August 1933	8.7

TABLE 2.4-4

POSTULATED FLOOD-PRODUCING PHENOMENA
ON THE DELAWARE RIVER NEAR HCGS

PHENOMENON	MAXIMUM STILLWATER LEVEL (feet, MSL)	MAXIMUM WAVE RUNUP ELEVATION (feet, MSL)
a. Probable maximum hurricane surge with coincident waves and 10% exceedance high tide	24.8	34.8/31.0
b. Single dam break		
1. Prepared Tocks Island dam with one-half of local pmf	9.0	21.6
2. Modified Francis E. Walter dam with one-half of local pmf	5.0	16.9
c. Multiple dam break - modified Cannonsville and Pepacton with potential domino-type hydrologic failure of proposed Tocks Island	13.5	26.3
d. Delaware River probable maximum flood	8.3	20.8
e. Probable maximum tsunami with coincident 10% exceedance high tide	6.0	18.1
f. Ice jam flood	<——Negligible——>	

TABLE 2.4-5

DELAWARE RIVER WATER QUALITY DATA
UPSTREAM OF ARTIFICIAL ISLAND

	DELAWARE RIVER AT TRENTON, NJ			DELAWARE RIVER AT CHESTER, PA			DELAWARE RIVER AT DELAWARE MEMORIAL BRIDGE, NEAR WILMINGTON, DE		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
Specific Conductance (micromhos/cm)	400	50	190	5900	111	300	12,700	100	2090
pH	10.2	5.3	8.1	8.7	5.5	6.7	9.3	4.2	6.6
Temperature (^{o}C)	34.0	0.0	12.27	33.0	Freezing	12.85	31.0	Freezing	15.0
Dissolved Oxygen (mg/l)	18.4	4.0	11.24	13.5	0.0	6.4	13.7	0.0	7.5

TABLE 2.4-6

SEASONAL (MONTHLY) VARIATIONS IN DELAWARE RIVER WATER QUALITY NEAR HCGS

PARAMETER	Alkalinity as $CaCO_3$ (ppm)			Ammonia as NH_3 (ppm)			Calcium as Ca (ppm)			Chloride as Cl (ppm)			Copper as Cu (ppm)		
MONTH	MEAN (1)	HIGH (2)	LOW (3)	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW
Jan.	53.3	72.7	31.1	1.19	1.93	0.48	98.2	188.0	49.7	3907.6	8333.3	1433.3	0.03	0.07	0.01
Feb.	50.3	69.3	35.2	1.09	2.09	0.32	82.7	131.3	33.3	3543.7	5433.3	1304.3	0.04	0.16	0.01
March	52.6	60.7	34.7	1.31	3.56	0.08	60.8	98.0	12.9	2499.9	4970.0	389.0	0.03	0.08	0.01
April	45.8	56.0	28.4	1.07	3.22	0.08	74.1	109.3	22.6	2373.6	4576.7	342.7	0.03	0.09	0.01
May	43.6	59.5	25.8	0.55	1.55	0.06	58.6	91.8	13.3	2067.5	3987.3	383.3	0.05	0.19	0.02
June	45.4	56.3	28.8	0.21	0.68	0.04	107.3	173.3	44.2	3192.2	4333.3	728.0	0.03	0.07	0.01
July	54.4	62.1	34.1	0.19	0.98	0.04	112.5	138.0	96.8	4187.2	5466.7	2900.0	0.05	0.12	0.01
Aug.	60.9	115.3	36.5	0.17	0.79	0.03	254.3	582.0	35.6	5218.3	6975.0	3400.0	0.10	0.47	0.01
Sept.	56.7	70.1	37.1	0.13	0.29	0.05	131.2	148.7	97.3	5576.3	6315.0	4375.0	0.05	0.12	0.02
Oct.	72.9	94.5	43.9	0.17	0.51	0.04	123.0	160.7	72.0	4885.4	7229.4	2374.3	0.07	0.17	0.01
Nov.	57.6	70.4	24.9	0.35	0.73	0.10	114.9	201.3	46.7	4866.8	8890.0	883.3	0.09	0.25	0.02
Dec.	49.7	69.7	26.7	0.85	1.70	0.26	84.4	150.7	20.0	3209.5	6533.3	362.5	0.04	0.16	0.01

(1)"Mean" represents the average of monthly averages for each month over the sampling period 1967-1982.
(2)"High" represents the maximum of monthly averages over the sampling period 1967-1982.
(3)"Low" represents the minimum of monthly averages over the sampling period 1967-1982.

TABLE 2.4-6 (Continued)

PARAMETER	Dissolved Oxygen as O_2 (ppm)			Iron as Fe (ppm)			Magnesium as Mg (ppm)			pH as pH			Sodium as Na (ppm)		
	(1)	(2)	(3)												
MONTH	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW
Jan.	12.5	13.8	8.3	2.12	6.40	0.05	260.1	494.7	104.3	7.0	7.6	6.5	1804.5	3104.0	640.0
Feb.	11.7	16.7	7.7	2.43	6.98	0.10	233.5	312.7	86.8	7.3	7.8	6.7	1892.7	2728.3	685.0
March	10.8	13.5	6.8	3.46	9.87	0.08	167.8	290.8	31.3	7.0	7.7	6.4	1384.9	2845.0	211.7
April	9.1	12.2	5.8	3.54	7.75	0.02	154.9	245.0	29.4	7.1	8.4	6.7	1385.4	2846.7	185.7
May	7.1	9.1	4.6	3.79	9.29	1.21	98.9	252.7	23.7	7.0	7.4	6.6	1119.5	2056.7	154.7
June	6.7	10.1	3.5	3.09	9.35	0.24	257.6	323.3	179.0	6.7	8.8	6.3	1742.5	2586.7	392.0
July	6.2	7.9	4.7	2.33	5.62	0.55	391.3	840.0	200.3	7.0	7.5	6.6	2348.4	3026.7	1510.0
Aug.	6.8	7.5	4.7	2.27	5.29	0.03	364.9	462.7	310.3	7.2	7.9	6.6	2593.4	3798.3	1683.3
Sept.	7.3	8.1	4.6	1.66	3.87	0.02	370.9	477.7	296.0	7.1	7.8	6.2	2889.9	3600.0	2021.3
Oct.	9.2	10.4	5.1	1.29	3.97	0.10	348.3	519.8	167.7	7.1	7.6	6.4	2776.3	4309.8	1550.0
Nov.	11.0	15.5	5.7	2.59	6.59	0.12	321.6	566.7	42.3	7.2	7.4	6.6	2652.1	4413.3	475.0
Dec.	11.3	12.6	6.5	3.53	6.78	0.84	222.6	433.3	18.8	7.2	7.7	6.9	1776.1	3513.3	346.0

(1)"Mean" represents the average of monthly averages for each month over the sampling period 1967-1982.
(2)"High" represents the maximum of monthly averages over the sampling period 1967-1982.
(3)"Low" represents the minimum of monthly averages over the sampling period 1967-1982.

TABLE 2.4-6 (Continued)

PARAMETER	Sulfate as SO_4 (ppm)			Total Dissolved Solids (ppm)			Total Suspended Solids (ppm)			Turbidity (ntu)		
	(1)	(2)	(3)									
MONTH	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW
Jan.	543.8	1306.3	259.3	6481.9	16641.3	2774.0	98.4	202.0	54.3	63.0	122.7	12.0
Feb.	563.5	945.0	149.3	6995.2	12042.7	1078.3	104.4	182.7	50.3	35.5	69.3	20.3
March	328.9	766.3	79.3	4056.1	10131.0	814.3	135.2	294.3	72.7	46.6	105.7	6.0
April	310.5	757.0	100.0	3545.8	9897.0	615.7	140.1	271.0	77.0	58.77	237.0	3.3
May	388.7	796.0	41.3	4583.8	7710.7	629.0	135.0	234.3	70.0	66.7	241.0	12.0
June	419.9	701.0	96.7	5183.1	8831.3	236.3	151.3	287.0	71.3	66.8	229.3	1.9
July	514.1	774.3	174.0	7206.5	11075.0	2736.3	118.8	264.0	55.8	50.7	106.1	14.3
Aug.	659.4	975.3	326.2	8417.7	13321.3	3301.0	102.8	263.7	23.3	41.8	144.7	15.3
Sept.	714.9	970.0	481.2	8985.6	12111.0	5277.3	111.7	168.8	62.7	42.8	110.0	0.5
Oct.	671.5	1071.7	155.5	8839.1	14305.0	1299.0	109.5	309.7	13.0	33.2	88.7	11.0
Nov.	608.8	1227.0	112.7	7440.4	16863.0	719.0	119.4	222.7	62.7	49.4	114.3	14.0
Dec.	475.9	996.0	75.8	5655.2	12755.0	592.0	139.6	256.7	70.7	46.9	105.0	4.5

(1)"Mean" represents the average of monthly averages for each month over the sampling period 1967-1982.
(2)"High" represents the maximum of monthly averages over the sampling period 1967-1982.
(3)"Low" represents the maximum of monthly averages over the sampling period 1967-1982.

TABLE 2.4-7

VARIATION IN CHEMICAL CHARACTERISTICS OF THE DELAWARE RIVER NEAR THE HOPE CREEK SITE[1]
(1968 - 1980)

		95%	90%	75%	50%	25%	10%	5%
TURBIDITY	(ntu)	135	105	60	38	23	13	8
DISSOLVED OXYGEN	(mg/l)	12.61	12.01	10.4	7.63	6.37	4.92	4.69
pH		7.7	7.6	7.4	7.1	6.9	6.7	6.5
ALKALINITY (as $CaCO_3$)	(mg/l)	69.3	64.7	56.7	47.1	39.7	34.1	30.1
TOTAL SUSPENDED SOLIDS (TSS)	(mg/l)	270	222	155	109	74	54	40
CALCIUM	(mg/l)	209	160	124	96	64	34	22
MAGNESIUM	(mg/l)	547	484	340	264	176	50	26
SODIUM	(mg/l)	4042	3672	2840	1980	1375	341	195
CHLORIDE	(mg/l)	7371	6585	5238	3725	2368	825	379
SULFATE[2]	(mg/l)	993	898	725	507	277	140	83
COPPER[2]	(mg/l)	0.203	0.13	0.05	0.03	0.02	0.01	0.01
IRON[2]	(mg/l)	7.02	5.80	3.44	1.91	0.89	0.28	0.09
TOTAL DISSOLVED SOLIDS (TDS)[2]	(mg/l)	12648	11758	9231	6280	3476	1242	644
AMMONIA[2] (NH_3+)	(mg/l)	2.072	1.67	0.92	0.313	0.1	0.06	0.41

[1]Values represent the percent of time that values were equal to or less than those shown.
[2]Data base from 1968 - 1976.

TABLE 2.4-8

DELAWARE RIVER
WATER TEMPERATURES[1]
(MARCH, 1977 - JULY, 1982)

MONTH	MINIMUM (°C)	AVERAGE (°C)	MAXIMUM (°C)[2]
January	0.2	2.4	10.0
February	-0.9	1.4	13.0
March	-0.2	6.2	18.6
April	1.2	12.2	18.1
May	13.7	18.9	24.2
June	18.8	23.6	28.0
July	22.3	27.1	30.3
August	23.2	26.7	30.5
September	18.9	24.6	28.7
October	12.6	17.5	22.2
November	5.9	9.5	21.6
December	0.7	4.9	13.0

(1) Based on the average of values recorded at Salem Generating Station intakes in service.

(2) May be influenced by short periods of Salem thermal plume recirculation during slack current.

TABLE 2.4-9

DELAWARE RIVER TRACE POLLUTANT
LEVELS NEAR HCGS (1)

PARAMETER	CONCENTRATION
Arsenic	0.012 mg/l
Barium	<1.25 mg/l
Cadmium	0.016 mg/l
Chromium	0.035 mg/l
Lead	0.132 mg/l
Mercury	0.0006 mg/l
Selenium	<0.001 mg/l
Zinc	0.057 mg/l
Fecal coliform	12/100 ml
MBAS	0.02 mg/l
Oil and grease	2.83 mg/l
Phenols	<0.001 mg/l

(1)Concentrations are the averages of three samples obtained monthly in August and September, 1982.

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TABLE 2.4-10

AQUIFER CHARACTERISTICS

AQUIFER	COEFFICIENT OF TRANSMISSIBILITY[1][3] m^3pd/m		gpd/ft		STORAGE COEFFICIENT, S[1][3]		PERMEABILITY, K[1][3] m^3pd/m^2		gpd/ft^2		POROSITY[2]	SPECIFIC YIELD (EFFECTIVE POROSITY)[2]
	U	A	U	A	U	A	U	A	U	A		
"Shallow" (Riverbed Sands)	33	33	2,620	2,620	$7.0x10^{-5}$	$6.0x10^{-5}$	21	21	524	524	35%	28%
"Deep" (Vincentown)	123	-	9,880	-	$1.2x10^{-4}$	-	5	-	124	-	41-42%	29-32%
Upper Raritan	-	186 to 435		15,000 to 35,000	-	1.2 to 1.3×10^{-4}	-	8.2 to 35.9	-	200 to 880	40%	35%

(1) Based on aquifer test data: U = unadjusted for barometric and tidal effects.
A = adjusted for barometric and tidal effects.

(2) Based on sieve analyses.

(3) Calculations based on theis non-leaky artesian aquifer type curve: S vs r^2 on Log-Log paper.

TABLE 2.4-11

WATER QUALITY OF THE RIVERBED SANDS,
VINCENTOWN AND MOUNT LAUREL AND WENONAH AQUIFERS

				ALKALINITY	ANIONS in mg/l				CATIONS in mg/l							OTHER PARAMETERS				
Aquifer	Wells	Date (1974)	Remarks (**)	Carbonates	Bicarbonates	Chloride	Sulfate	Nitrite	Nitrate	Sodium	Potassium	Calcium	Magnesium	Total Iron	Manganese	Silica	Specific Conductance	pH	TDS	Turbidity as TU	Total Hardness	Carbonate Hardness
Quaternary river bed sands (shallow)	302	3-22	-	0	363	2700	215	0.001	5.5	1340	58	100	380	24	3.5	56	11000	6.1	6722	26	1520	396
	302	3-23	B.P.	0	401	2670	215	0.001	0.036	1340	50	100	360	13	3.5	56	10800	6.1	6562	125	1520	440
	302	3-29	A.P.	0	273	2580	255	0.001	0.076	1600	50	160	370	41	3.5	57	10900	5.6	6890	46	1650	311
	312	3-23	B.P.	0	142	1940	20	0.001	0.064	1080	42	160	285	123	3.0	56	8400	5.7	5314	22	1340	180
	312	3-26	A.P.	0	914	1930	4.5	0.44	0.015	1080	42	100	285	46	2.0	51	7800	6.8	4330	26	1250	1270
	313	3-24	B.P.	0	1050	2070	129	0.051	0.011	920	50	160	320	70	3.0	52	8300	6.7	4550	29	1380	112
	313	3-29	A.P.	0	227	2000	123	0.001	0.012	1080	42	160	310	54	3.5	56	8400	5.6	5174	44	1420	256
	323	3-24	B.P.	0	1050	1120	1080	0.36	0.01	520	42	300	320	220	11	41	6400	6.9	4030	68	1750	113
	323	3-26	A.P.	0	1110	987	1070	0.14	0.009	520	33	300	285	55	11	47	6300	6.8	3770	26	1740	1216
	502	3-25	B.P.	0	506	2750	114	0.001	0.11	1340	67	100	370	89	3.0	29	11100	6.1	6412	55	1490	542
	502	3-26	I	0	1080	2930	41	0.51	0.025	1340	67	100	330	70	0.25	17	11000	6.8	6106	23	1350	1160
	502	4-5	A.P.	0	1290	2528	156	0	—	1313	85.0	158	349	5.58	—	—	>8500	7.0	6375	1050	1850	—
Vincentown (deep)	[illegible]	4-1	I	0	—	3610	—	—	—	—	—	—	—	82.80	—	—	>10000	2.3	>7500	—	—	—
		4-5	A.P.	0	170	3820	63	0	—	1525	37.5	569	117	18.95	—	—	>10000	6.5	>7500	720	1890	—
	[illegible]	3-28	B.P.	0	0	4640	198	0.012	0	1740	17	1410	140	48	1.5	47	19200	2.1	6110	7.9	3260	0
	301	4-1	I	0	—	5100	—	—	—	—	—	—	—	47.10	—	—	<10000	2.4	<7500	—	—	—
	301	4-5	A.P.	0	230	4660	135	0	—	1550	26/5	1250	82	4.49	—	—	< 1000	6.7	7500	500	3490	—
	311	3-26	B.P.	0	400	3780	149	0.001	0.25	1600	67	660	360	267	0.25	32	13800	6.2	9096	87	2720	454
	311	3-26	B.P.	0	474	3390	119	0.44	0.008	1480	67	340	330	53	0.2	19	11800	6.9	6760	12	1700	506
	311	4-5	A.P.	0	300	2790	80	0	—	1210	62.3	148	216	3.28	—	—	8000	7.2	6000	620	1280	—
	314	3-27	B.P.	0	556	3930	153	0.3	0	2000	25	200	310	48	0.5	31	12500	7.5	7436	6.5	1600	620
	314	4-5	A.P.	0	590	4120	111	0	—	1950	55.0	228	285	1.22	—	—	<10000	7.0	<7500	150	1760	—
	321	3-14	B.P.	0	80.5	3939	266	0.011	0.035	1410	37	1000	45	2.1	0.30	24	11400	7.3	7648	200	2530	99
	322	3-21	B.P.	0	108	3660	137	0.001	0.018	1740	8	40	10	140	0.5	31	13800	5.7	8820	44	2560	131
	322	3-26	I	0	324	3320	110	0.51	0.008	1340	15	420	200	112	0.5	33	10900	6.7	6610	26	1660	354
	322	4-5	A.P.	0	340	3410	91	0	—	1250	24.3	399	168	2.19	—	—	10000	6.8	7500	380	1700	—
	501	3-28	B.P.	0	0	4370	135	0.007	0	2140	16	500	190	18	0.5	42	15700	2.5	9068	1.4	1910	0
	501	4-4	A.P.	0	460	4030	106	0	—	1650	25.5	466	18	0.85	—	—	<10000	6.8	<7500	147	1840	—
	Dewatering well Salem	3-19	B.P.	0	281	3660	329	-.053	0.037	1880	42	340	200	4	0.5	40	11800	6.8	7510	45	1580	291
Mount Laurel and Wenonah	401	3-19	B.P.	0	79	903	2000	0.26	0.19	520	16	410	285	40	32	25	5900	6.6	4350	6.9	2220	100
	401	3-26	B.P.	0	246	2690	35	0.11	0.001	920	33	480	90	18	0.5	18	9000	7.3	5610	65	1660	258
	401	4-5	A.P.	0	340	5970	26	0	—	2200	66.5	1139	103	1.38	—	—	<10000	6.7	<7500	160	3280	—
	402	4-1	B.P.	-	—	1980	—	—	—	—	—	—	—	2.19	—	—	<10000	1.8	7500	—	—	—
	402	4-5	A.P.	0	470	4750	212	0	—	1720	57.5	619	213	1.55	—	—	<10000	6.8	<7500	273	2440	—
	404	3-28	B.P.	0	382	7060	185	0.44	0.008	3888	50	660	54	195	0.10	26	12000	7.2	7780	18	1840	478.0
	404	4-5	A.P.	0	430	4270	156	0	—	1718	65.0	661	99	3.18	—	—	<10000	6.9	<7500	168	2070	—

(**) See following page.

TABLE 2.4-11 (Continued)

Aquifer	Wells	Date (1974)	Remarks (**)	ALKALINITY: Carbonates	ALKALINITY: Bicarbonates	ANIONS in mg/l: Chloride	ANIONS in mg/l: Sulfate	ANIONS in mg/l: Nitrite	ANIONS in mg/l: Nitrate	CATIONS in mg/l: Sodium	CATIONS in mg/l: Potassium	CATIONS in mg/l: Calcium	CATIONS in mg/l: Magnesium	CATIONS in mg/l: Total Iron	CATIONS in mg/l: Manganese	CATIONS in mg/l: Silica	OTHER PARAMETERS: Specific Conductance	OTHER PARAMETERS: pH	OTHER PARAMETERS: TDS	OTHER PARAMETERS: Turbidity as TU	OTHER PARAMETERS: Total Hardness	OTHER PARAMETERS: Carbonate Hardness
Mount Laurel and Wenonah	C	4-3	I	0	240	160	<10	10	—	122	17.2	37	9	0.77	—	—	925	7.3	694	125	200	—
	D	4-3	I	0	160	178	<10	5	—	108	15.0	33	19	0.20	—	—	810	7.6	608	49	164	—
	PW-1	3-22	I	0	0	38	25	0.001	0	29	4.0	100	4.5	2	0.05	15	6500	2.3	370	0.14	328	0
	PW-2	3-22	I	0	133	60	0	0.52	0	40	3.6	150	5.0	3	0.05	15	7200	6.5	404	2.8	298	126
	PW-3	3-22	I	0	0	29	16	0.001	0.01	40	3.2	135	8.6	3	0.05	14	6800	2.1	316	0.24	217	0
	PW-4	3-28	B.P.	0	161	739	25.1	0.31	0.008	120	25	200	52	4	0.5	15	2800	7.1	1916	15	795	172
	PW-4	4-5	A.P.	-	160	624	14	0	—	128	31.5	201	65	0.58	—	—	2100	7.8	1575	140	770	—

(**) B.P. = before pumping
A.P. = after pumping
I = intermediate
C = contaminated
N = sample container pre-treated with nitric acid to stabilize metals in solution
M = sample container pre-treated with mercuric chloride to stabilize nitrogen in solution

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TABLE 2.4-12

WATER QUALITY IN SALEM PRODUCTION WELL NO. 5
(UPPER RARITAN FORMATION)

CONSTITUENTS		ppm as	7/11/77	10/20/77	1/16/78	7/17/78	10/15/80	1/15/81	4/15/81	10/15/81
CATIONS										
Calcium	(Ca^{++})	$CaCO_3$	6.0	4.0	6.0	5.0	88.0	203.0	200.0	7.0
Magnesium	(Mg^{++})	$CaCO_3$	0.0	3.0	1.0	1.0	62.0	151.0	156.0	4.0
Sodium	(Na^{+})	$CaCO_3$	166.0	169.0	172.0	169.0	140.0	133.0	137.0	189.0
Potassium	(K^{+})	$CaCO_3$	15.0	4.0	4.0	4.0				
TOTAL CATIONS			187.0	180.0	182.0	179.0	290.0	487.0	493.0	200.0
ANIONS										
Bicarbonate	(HCO_3)	$CaCO_3$	155.0	155.0	157.0	153.0	157.0	157.0	160.0	156.0
Carbonate	(CO_3)	$CaCO_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydroxide	(OH)	$CaCO_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sulfate	(SO_4)	$CaCO_3$	5.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0
Chloride	(Cl)	$CaCO_3$	23.0	23.0	23.0	24.0	124.0	318.0	323.0	37.0
Phosphate (Total)	(PO_4)	$CaCO_3$	2.45	2.45	2.5	1.72	0.93	0.17	0.05	1.65
Nitrate	(NO_3)	$CaCO_3$	1.1	0.0	0.0	0.7	2.5	4.8	1.6	0.1
TOTAL ANIONS		$CaCO_3$	187.0	100.0	182.0	179.0	290.0	487.0	493.0	200.0
Total Hardness(1)		$CaCO_3$	6.0	7.0	7.0	6.0	150.0	354.0	356.0	11.0
Methyl Orange Alkalinity		$CaCO_3$	155.0	155.0	157.0	153.0	157.0	157.0	160.0	156.0
Phenolphthalein Alkalinity		$CaCO_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carbon Dioxide, Free		CO_2	2.0	3.0	11.0	2.0	3.0	5.0	5.0	6.0
pH (as pH)		-	7.95	7.0	7.25	8.05	8.0	7.0	7.95	7.7
Iron, Total		Fe	8.11	0.13	0.02	0.11	0.49	0.49	0.02	0.22
Manganese		Mn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
Silica		SiO_2	0.7	0.0	10.0	9.0	11.2	12.7	12.9	9.6
Turbidity after Shaking (Ntu's)			1.4	0.0	0.1	0.5	6.5	4.7		
Conductivity, (umhos)			325.0			320.0	490.0	910.0	1,000.0	333.0

(1) Hardness in grains per U.S. gallon as $CaCO_3$ (1 gallon = 3.71 liters).

M P82 148/11 1-jk

TABLE 2.4-13

WATER QUALITY OF HOPE CREEK PRODUCTION WELLS (1 & 2)
IN THE UPPER RARITAN FORMATION

CONSTITUENT	DATE															
	8/29/77	8/31/78	10/5/78	2/1/79	5/30/79	8/3/79	8/6/79	11/1/79	2/4/80	5/5/80	5/5/80	2/12/81	5/21/81	8/7/81	11/6/81	1/7/82
Chloride (ppm)	-	-	-	-	-	-	-	-	14.18	8.84	7.54	1.1	0.92	8.62	9.06	8.76
Fluoride (ppm)	0.94	0.69	0.74	1.1	0.84	0.82	-	0.83	<0.1	<0.1	0.1	1.2	1.1	0.1	0.1	0.1
Nitrate (ppm)	<0.1	<0.1	<0.12	0.44	<0.1	<0.1	-	0.21	0.05	0.02	0.02	0.01	<0.1	0.03	0.04	0.03
pH (as pH)	-	-	-	-	-	-	-	-	8.01	7.98	8.0	7.95	7.85	7.5	8.3	7.6
Sulfate (ppm)	-	-	-	-	-	-	-	-	<0.01	<0.01	0.01	0.03	0.11	0.01	0.01	0.01
Total Coliform Colonies, #/100 ml	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-
Turbidity, NTU	2.9	0.77	0.13	0.33	0.77	0.18	-	0.12	0.47	1.15	-	-	-	-	-	-
Trace Metals:																
Arsenic (ppm)	<0.002	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01	0.01	0.01
Barium (ppm)	<0.05	<0.1	<1	<1	<0.1	<1	-	<1	<0.1	<0.1	0.1	0.1	0.5	0.1	0.1	0.1
Cadmium (ppm)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.01	<0.01	0.001	0.001	0.001	0.001	0.001	0.001
Chromium (ppm)	<0.005	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
Lead (ppm)	<0.025	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02	<0.02	<0.02	-	0.02	0.02	0.02	0.02	0.02
Mercury (ppm)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	<0.002	<0.002	<0.002	0.002	0.001	<0.001	0.001	0.001	0.001
Selenium (ppm)	<0.01	<0.005	<0.005	<0.005	<0.01	<0.005	-	<0.005	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01
Silver (ppm)	<0.005	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01
Pesticides, Herbicides:																
Endrin (ppm)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002	<0.0002	<0.0002	0.0002	0.0002	<0.0002	0.0002	0.0002	0.0002
Lindane (ppm)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-	<0.004	<0.004	<0.004	0.004	0.004	<0.004	0.004	0.004	0.004
Methoxychlor (ppm)	<0.1	<0.1	-	<0.01	<0.1	<0.1	-	<0.1	<0.1	<0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Toxaphene (ppm)	<0.005	<0.005	-	<0.005	<0.005	<0.005	-	<0.005	<0.005	<0.005	0.005	0.005	<0.009	0.005	0.005	0.005
2,4-D (ppm)	<0.1	<0.1	-	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Silvex (ppm)	<0.01	<0.01	-	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01

TABLE 2.4-14

PUBLIC WATER SUPPLIES IN THE SITE REGION

DISTANCE kilometers	DISTANCE miles	TOWN	POPULATION SERVED	AVERAGE OUTPUT mld	AVERAGE OUTPUT mgd	SOURCE OF WATER
14.5	9	Salem, New Jersey	9,000	6.4	1.7	About 2/3 of water consumed is surface water pumped from the Quinton pumping station about three miles east of town and nine miles northeast of the site. Remainder is obtained from four wells, ranging in depth from 80 to 168 feet, located east of Salem[1].
22.5	14	Pennsville, New Jersey	10,500		-	Four wells ranging in depth from 105 to 240 feet. The wells are probably completed in the Magothy Formation.
27.4	17	Penns Grove, New Jersey	8,000		-	Two wells, 292 and 360 feet deep. The water probably comes from the Potomac Group.
27.4	17	Woodstown, New Jersey	3,000		-	Eight wells; six are about 100 feet deep and the others are about 300 and 350 feet deep.
35.4	22	Elmer, New Jersey	2,500		-	Three wells; two are 80 feet deep and the third is 500 feet deep. The shallow wells probably tap the Mount Laurel -Wenonah Formation.
25.7	16	Bridgeton, New Jersey	22,000		-	A total of 12 wells, some of which are no longer in use, range in depth from 75 feet to 129 feet. They are completed in the Cohonsey Sand.
17.7	11	Smyrna, Delaware	-	1.0	0.27	Two wells, 20 feet and 95 feet deep, supply the town. The shallower well is used for standby purposes.
20.9	13	Clayton, Delaware	825	4.5	1.2	One well, 272 feet deep, is the source of water supply.
16.1	10	Middletown, Delaware	2,000	0.8	0.2	Three wells, having depths of 100 feet, 200 feet and 500 feet, supply the town.
14.5	9	Delaware City, Delaware	1,500		-	Two wells, one 26 feet deep in the Wenonah Formation and the other in the Magothy Formation, supply the town.
22.5	14	New Castle, Delaware	-		-	The town obtains water from a shallow infiltration gallery system located in Pleistocene deposits.

[1] One foot = 0.3043 meter; one mile = 1.609 kilometrs.

TABLE 2.4-15 (Page 1 of 2)

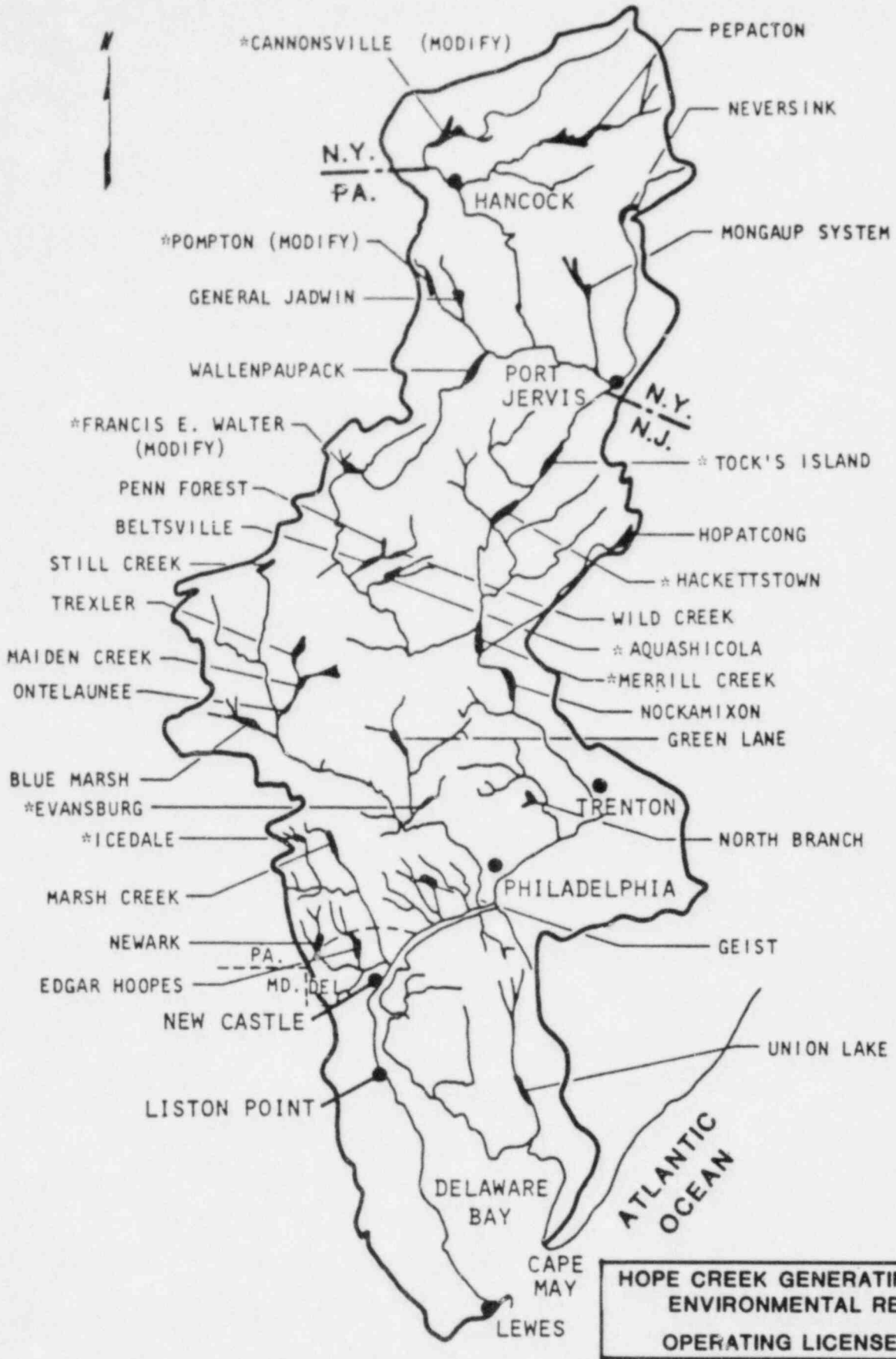
PRIVATE WATER WELLS IN VICINITY OF THE SITE[1]

WELL NO.	OWNER'S NAME	TOTAL DEPTH		DIAMETER		CASING LENGTH		STATIC WATER LEVEL		YIELD		REMARKS
		Meters	Feet	Centi-meters	Inches	Meters	Feet	Meters	Feet	Liters/ second	gpm	
1	Aloes Marina	77	252	5	2	67	220	1.1	3-1/2	-	-	-
2	Dr. Devlin	77	252	5	2	64	210	1.5	5	-	-	-
3	Dr. Devlin	77	252	5	2	70	230	1.1	3-1/2	-	-	-
4	Dr. Devlin	77	252	5	2	65	212	1.2	4	-	-	-
5	Mr. Henchman	77	252	5	2	66	218	1.8	6	-	-	-
6	C. Harbeson	5	15	107	42		-		-	-	-	Dug Well
7	C. Harbeson	5	15	107	42		-		-	-	-	Dug Well
8	F. Harris	4	12	91	36		-	2.4+	8+	-	-	Four wells, deepest 52m (32 ft)
9	F. Shimp	27	90		-	18+	60+	3.7-3.9	12-13	-	-	-
10	T. Hillird	27	90	15	6	18+	60+	3.7-3.9	12-13	-	-	-
11	Mr. Snideker	3	10	91	36		-	2.1-2.4	7-8	-	-	-
12	Mr. Snideker	27	90	10	4		-		-	-	-	-
13	W. Ashlock	77	252	5	2	70	231	2.4	8	-	-	-
14	F. Senrier	27	90	10	4	18	60	3.7-3.9	12-13	-	-	-
15	B. Hendman	27	89	5	2	26	84	4.6	15	-	-	-
16	B. Hendman		-		-		-		-	-	-	Well filled in
17	State of N.J.	27	89	5	2	26	84	3.7	12	-	-	-
18	-		-	5	2		-		-	-	-	-
19	T. Dixon	48	156	5	2	45	147	0.9	3	-	-	-
20	-		-		-		-		-	-	-	Well abandoned
21	T. Dixon	27	90	5	2		-	3.7	12	-	-	Well abandoned
22	D. Harris	10	32	5	2	10	32		-	Flowing		Well abandoned
23	Mr. McCray	5	17	5	2	5	17		-	Flowing		Water is salty
24	Mr. McCray	50	165	5	2	45	147	1.5	5	-	-	-
25	J. Pancast	35	115	5	2		-	1.5-1.8	5-6	-	-	-
26	J. Pancast	27	89	5	2	25	82	1.2	4	-	-	-
27	R. Davis	4	14	91	36		-	1.8	6	-	-	Dug well
28	W. Hancock	27	90	10	4	15	50	3.0-3.7	10-12	-	-	Iron, bad water
29	Mr. Ingersol	27	90	10	4	15	50	3.0	10-12	-	-	-
30	L. Ponderbank	31	100	5	2	26	86	0.9	3	-	-	-
31	O. Ayars	60	199	5	2	58	189	2.1	7	-	-	-
32	Stony Point	96+	315+		-		-		-	-	-	Well abandoned
33	-	122+	400+		-		-		-	-	-	-
34	-	274+	900+		-		-		-	-	-	-
35	-		-		-		-		-	-	-	-
36	-	50	165	5	2	27	90		-	-	-	-
37	Eagle Island Gun Club	34	110	5	2	31	103	1.8	6	-	-	-
38	J. Dilkes		-	5	2	40	131	2.4	8	-	-	-
39	Public Service (Salem G.S. Production Well #3)	91	298	41	16	74	243	6.1	20	12.6	200	-
40	Public Service (Salem G.S. Production Well #4)	87	284	41	16	64	210	-	-	12.6	200	Sealed and abandoned
41	Public Service (Salem G.S. Production Well #1)	91	300	25	10	76	250	-	-	12.6	200	Intermittent use for construction
42	Public Service (Salem G.S. Production Well #2)	87	286	40.6	16	61	200	5.6	18.5	-	-	Not in use
43	Public Service (Salem G.S. Production Well #5)	91	300	45.7	18	233	765	10.7	35	50.5	800	-
44	Public Service (Salem G.S. Production Well #6)	335	1100		-	-	-	-	-	37.9	600	-

TABLE 2.4-15 (Continued)

WELL NO.	OWNER'S NAME	TOTAL DEPTH		DIAMETER		CASING LENGTH		STATIC WATER LEVEL		YIELD		REMARKS
		Meters	Feet	Centi-meters	Inches	Meters	Feet	Meters	Feet	Liters/ second	gpm	
45	State of New Jersey	19	61	-	-	-	-	-	-	-	-	-
46	Lower Alloways Creek Township	79	260	10	4	70	231	2	5	6.3	100	For the Fire Department
47	P. Tucker	15	252	5	2		40	3	10	-	-	-
48	B. Coleman	70	252	5	2	70	230	-	-	-	-	-
49	R. Counsler	70	15	5	2	70	230	-	-	-	-	-
50	J. Horne	61	15	5	2	61	200	-	-	-	-	-
51	C. Hart	70	12	5	2	70	230	-	-	-	-	-
52	W. Parks	70		5	2	70	230	-	-	-	-	-
53	R. Fleckenstein	70		5	2	70	230	-	-	-	-	-
54	J. Pancoast	70	90	5	2	70	230	-	-	-	-	-
55	R. Saul	70	90	5	2	70	230	-	-	-	-	-
56	J. Farnkolf	61	10	5	2	61	200	-	-	-	-	-
57	Lower Alloways Creek Township	76	250	5	2	76	250	-	-	-	-	For the Municipal Bldg.
58	Lower Alloways Creek Township	76	250	10	4	76	250	-	-	-	-	Irrigation Well
59	C. Kennedy	70	230	5	2	70	230	-	-	-	-	-
60	T. Warren	61	200	5	2	61	200	-	-	-	-	-
61	R. Pancoast	61	200	5	2	61	200	-	-	-	-	-
62	Meth. Church	70	230	5	2	70	230	-	-	-	-	-
63	R. Heibel	70	230	5	2	70	230	-	-	-	-	-
64	P. Kernan	61	200	5	2	61	200	-	-	-	-	-
65	H. Fisher	70	230	5	2	70	230	-	-	-	-	-
66	V. Sheets	70	230	5	2	70	230	-	-	-	-	-
67	E. Plummer	73	240	5	2							
68	R. Levick	61	200	5	2	61	200	-	-	-	-	-
69	W. Baker	70	230	5	2	70	230	-	-	-	-	-
70	E. Pancoast	70	230	5	2	70	230	-	-	-	-	-
71	G. Elmer	61	200	5	2	61	200	-	-	-	-	-
72	J. Ayars	70	230	5	2	70	230	-	-	-	-	-
73	T. Smith	70	230	5	2	70	230	-	-	-	-	-
74	J. Wolfe	70	230	5	2	70	230	-	-	-	-	-
75	R. Beyers	70	231	5	2							
76	P. Kates	61	200	5	2	61	200	-	-	-	-	-
77	Wm. Mahan	61	200	5	2	61	200	-	-	-	-	-
78	E. Wilson	61	200	5	2	61	200	-	-	-	-	-
79	D. Hichman	76	250	5	2	76	250	-	-	-	-	-
80	A. Thompson	8	25	10	4	8	25	-	-	-	-	-

(1) Inventory included wells within a 8 kilometer (5 mile) radius of the site in New Jersey. Total depth of well equals length of casing plus length of screen. Screen is at bottom of well below casing. Static water level is the distance to the water level in the well measured from the top of the well casing.



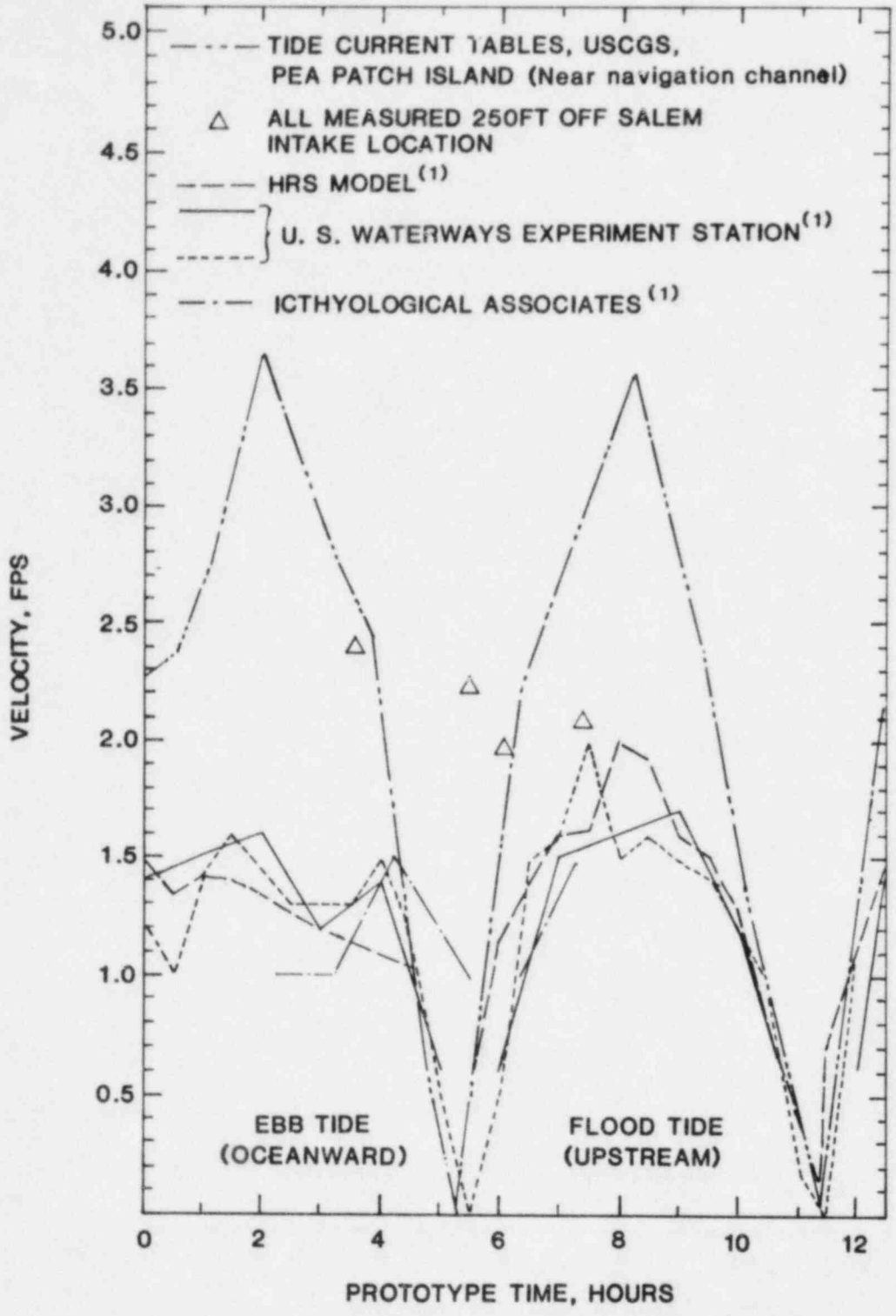
* PROPOSED FACILITIES IN COMPREHENSIVE PLAN OF DRBC.

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

LOCATIONS OF MAJOR IMPOUNDMENTS IN THE DELAWARE RIVER BASIN

FIGURE 2.4 - 1



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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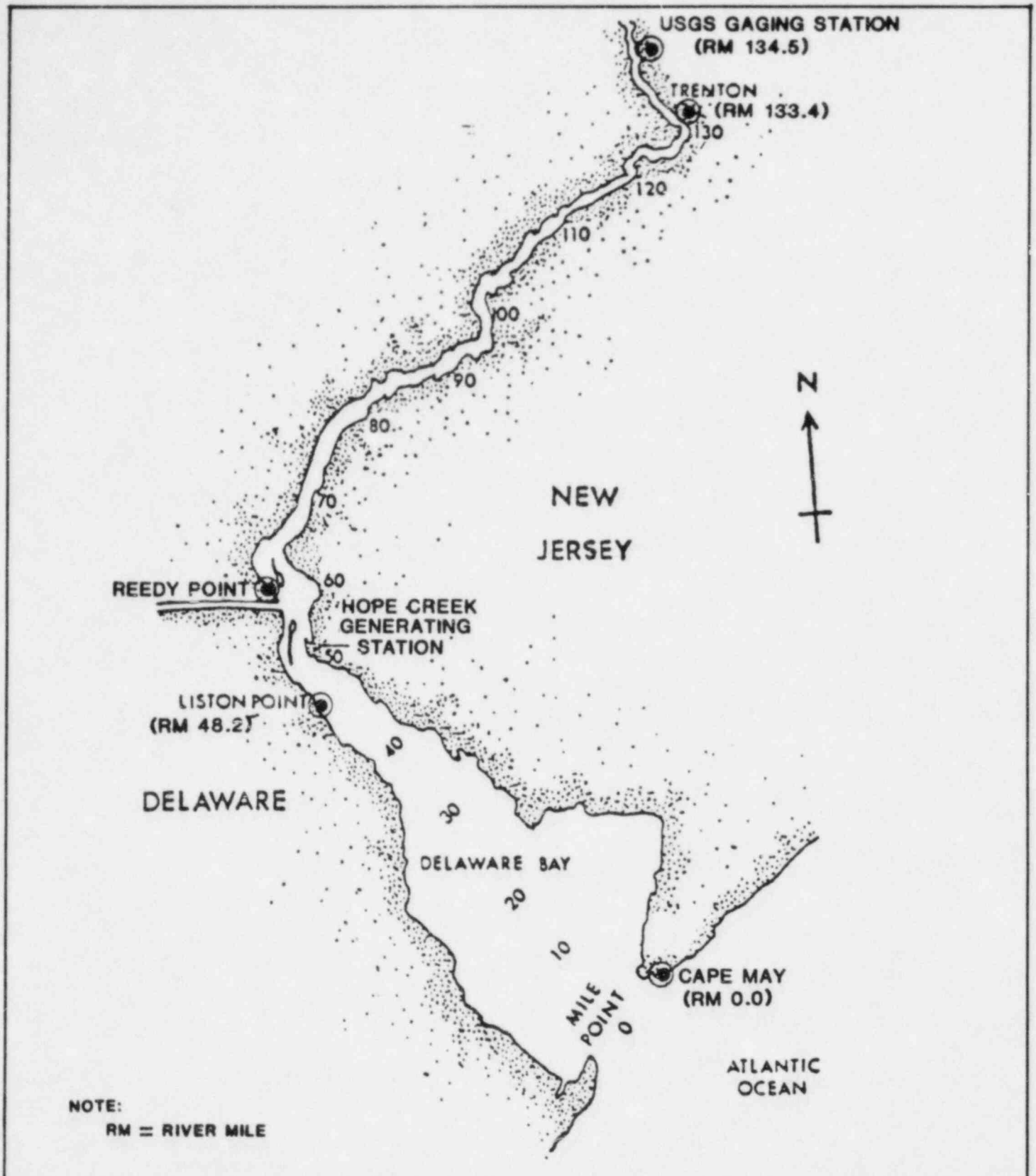
DELAWARE RIVER
FLOW VELOCITY

FIGURE 2.4 - 2

(1) 30.5 METERS (100FT) OFF SALEM INTAKE LOCATION



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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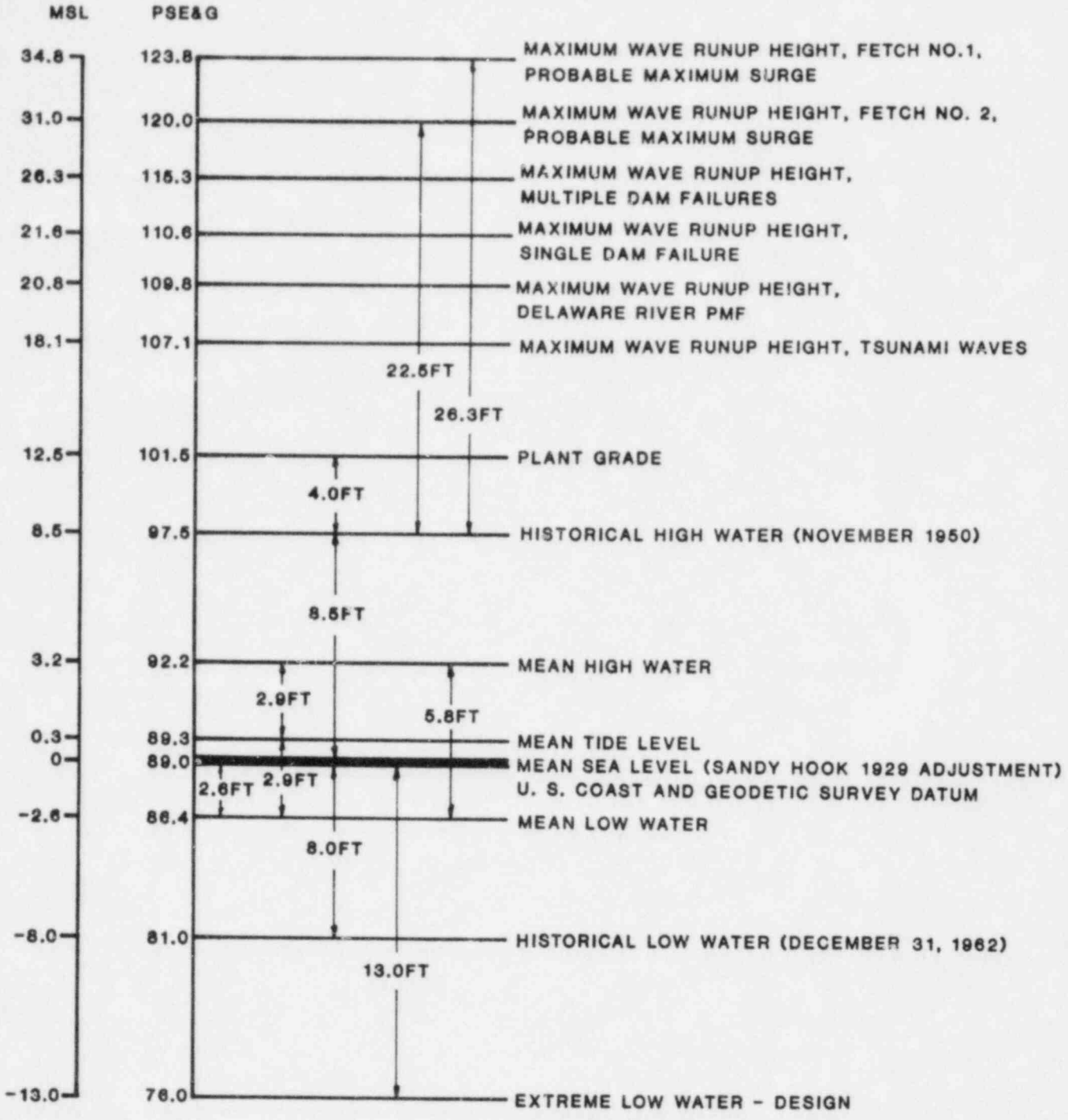
HOPE CREEK GENERATING STATION
REGIONAL LOCATION MAP

FIGURE 2.4 - 3

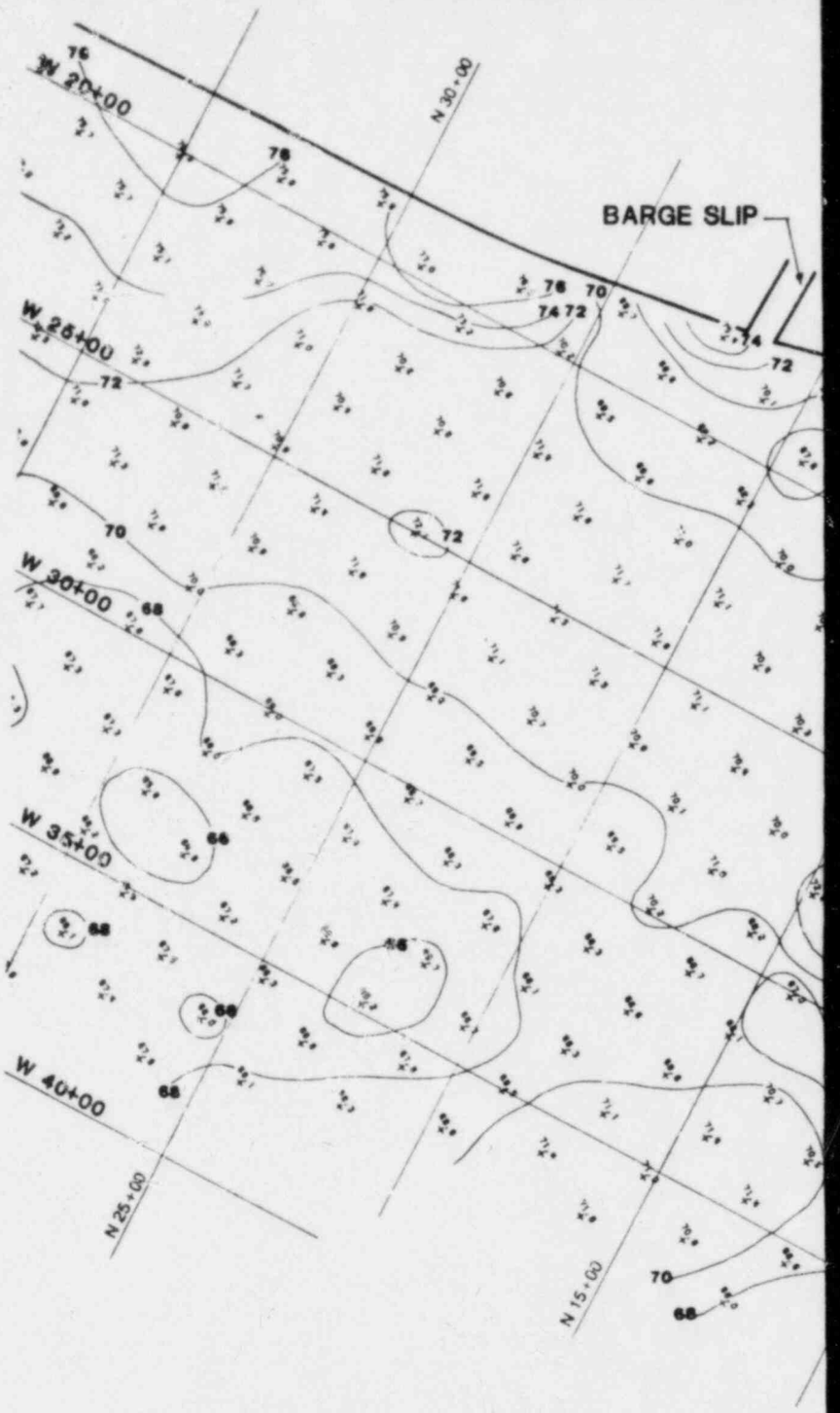


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

DATUM AND WATER LEVEL RELATIONSHIP

FIGURE 2.4 - 4



PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

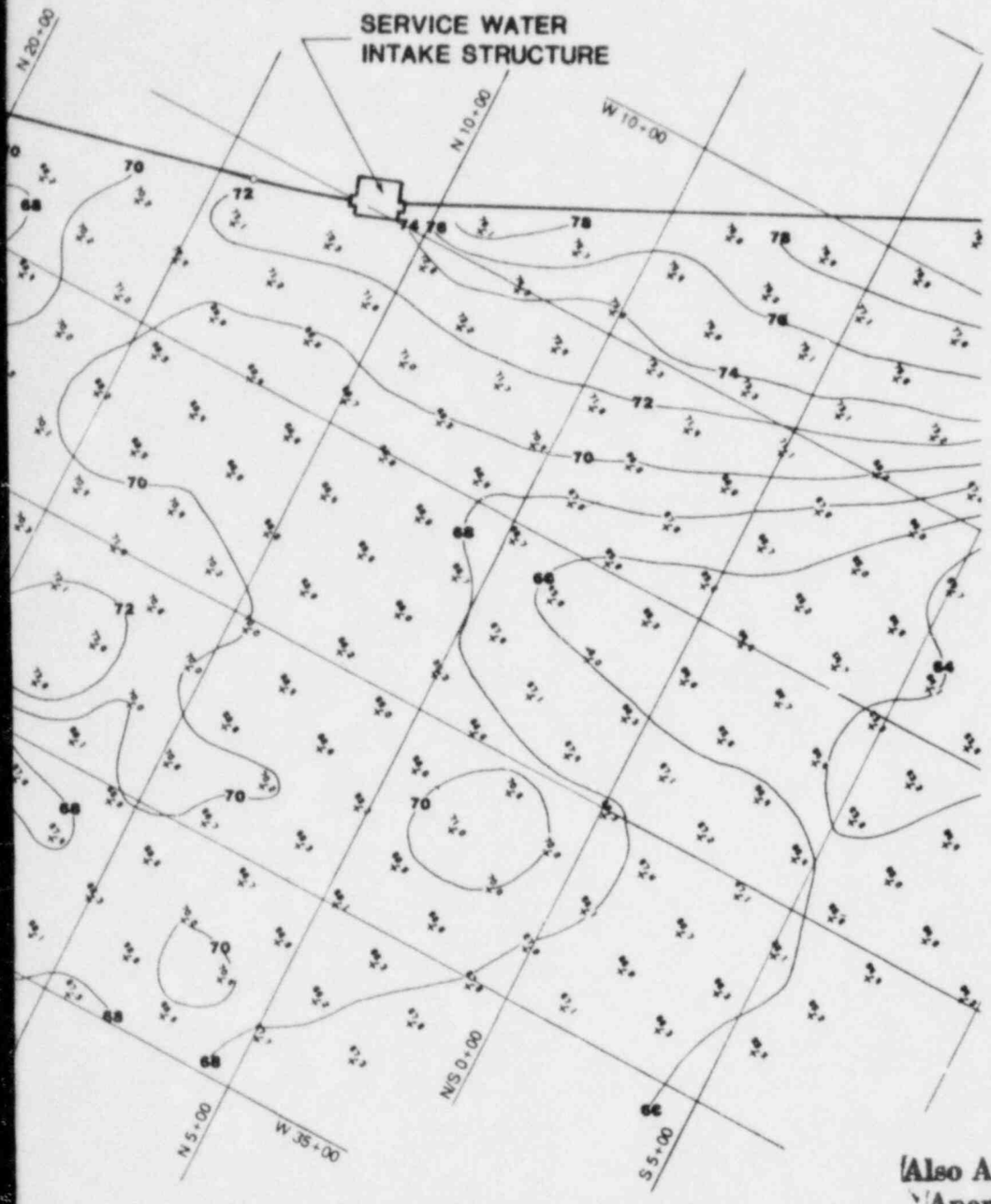
NOTE: 1. BOTTOM ELEVATIONS (PSD)

2. CONTOUR INTERVAL: 2 FEET
3. THIS MAP IS NOT FOR NAVIGATIONAL USE

HOPE CREEK GENERATING STATION

AUXILIARY BUILDING

REACTOR BUILDING



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NORTH

61 0 122
Scale in meters

200 100 50 0 100 200 400 600
SCALE IN FEET

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

BATHYMETRY - GENERAL STUDY AREA
SURVEY 24: 29 SEPTEMBER 1980

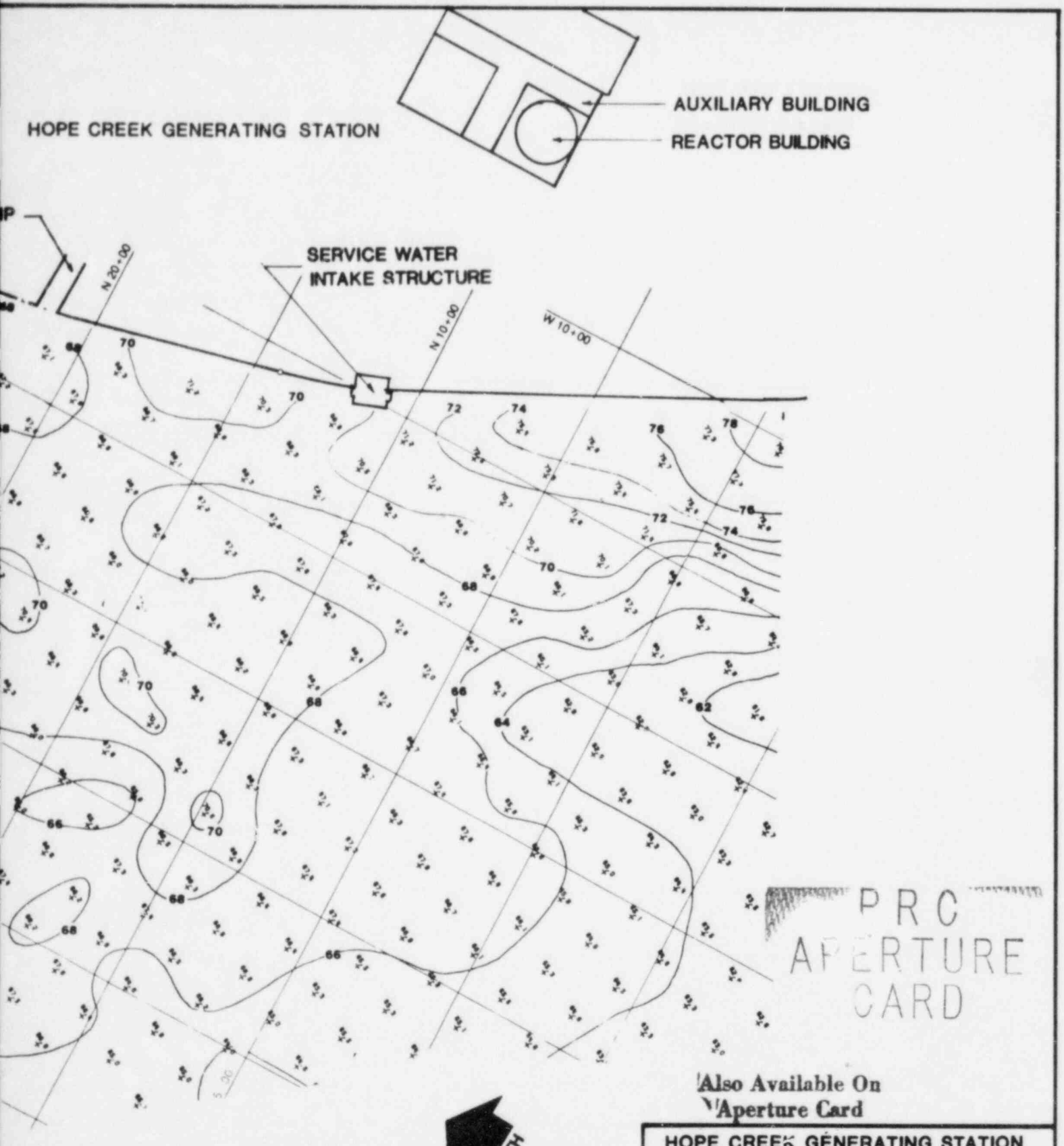
FIGURE 2.4 - 5

8306290435 - 31

PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

NOTE: 1. BOTTOM ELEVATIONS (PSD)

2. CONTOUR INTERVAL: 2 FEET
3. THIS MAP IS NOT FOR NAVIGATIONAL USE



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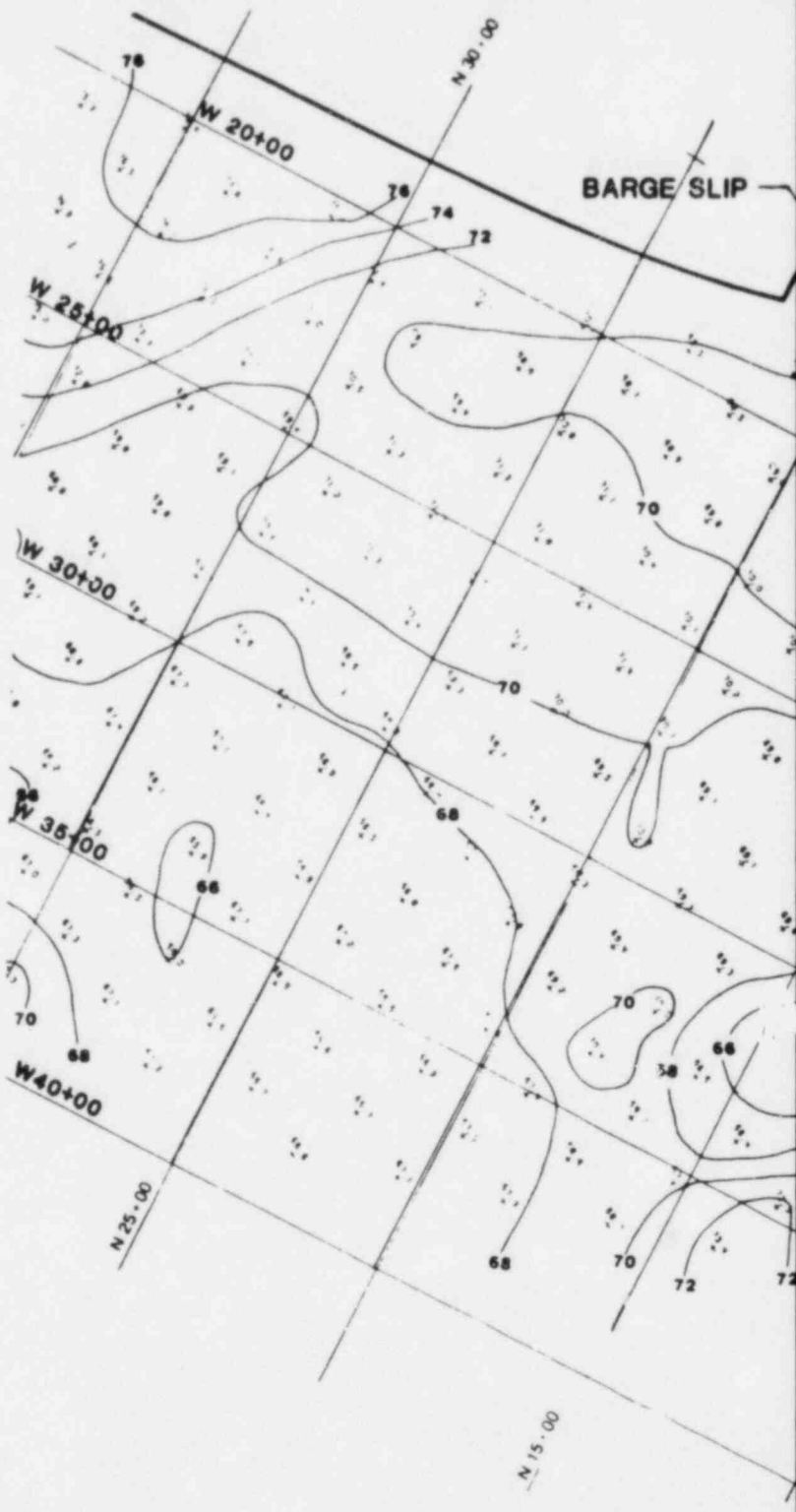
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

BATHYMETRY - GENERAL STUDY AREA
SURVEY 27: 22 MARCH 1981

FIGURE 2.4 - 6

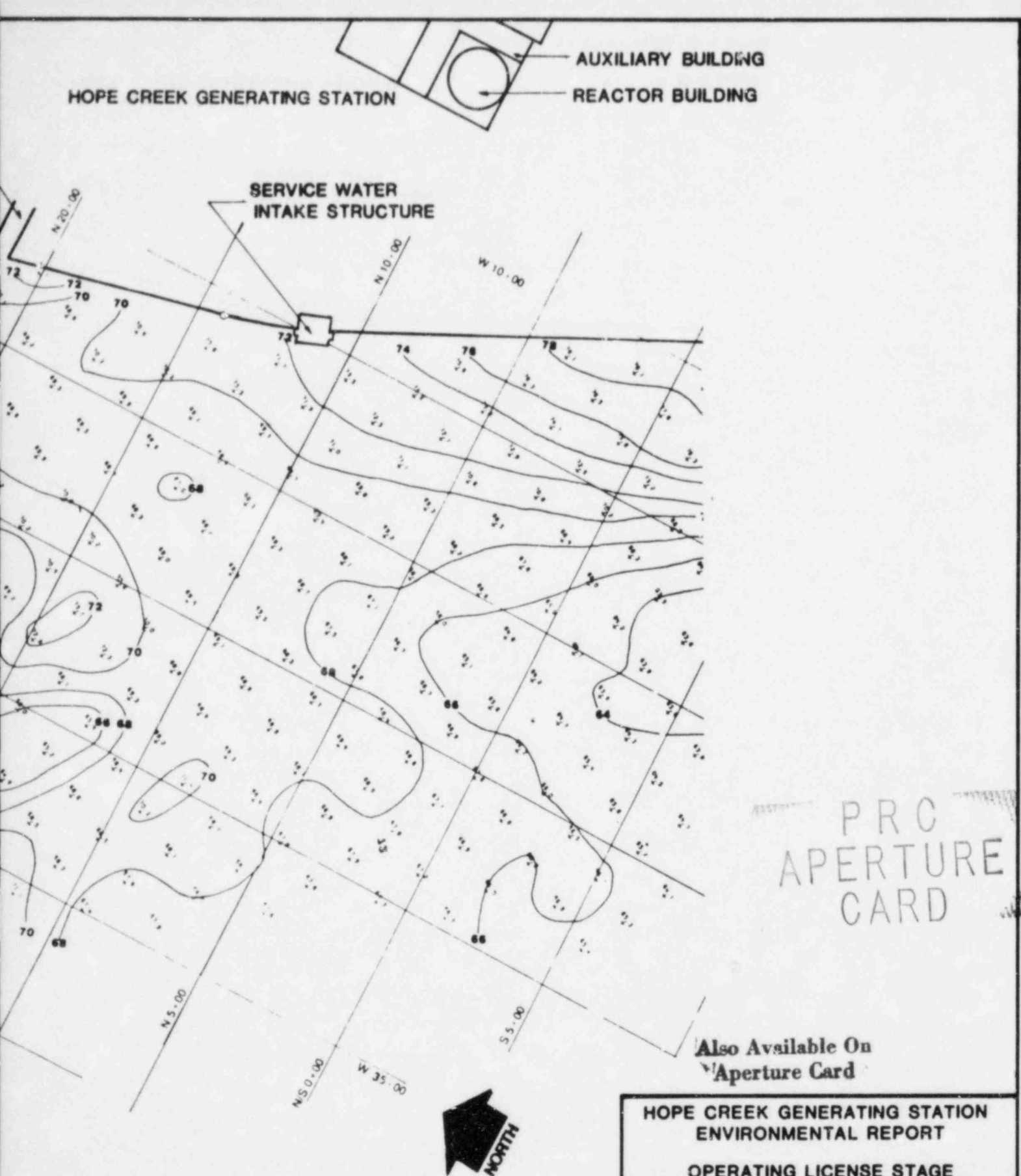
8306290435 - 32



PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

NOTE: 1. BOTTOM ELEVATIONS (PSD)

2. CONTOUR INTERVAL: 2 FEET
3. THIS MAP IS NOT FOR NAVIGATIONAL USE



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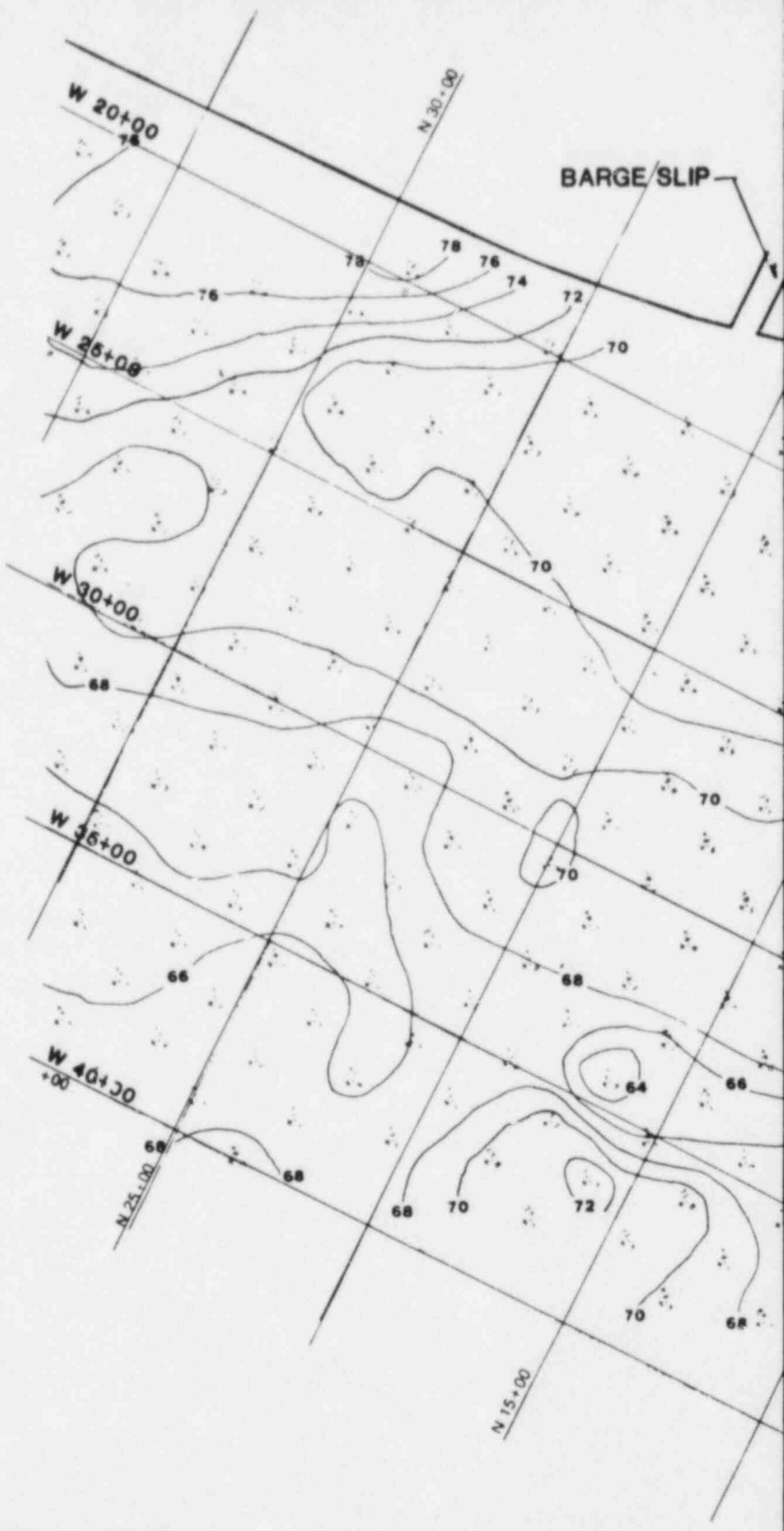
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

BATHYMETRY - GENERAL STUDY AREA
SURVEY 30: 26 SEPTEMBER 1981

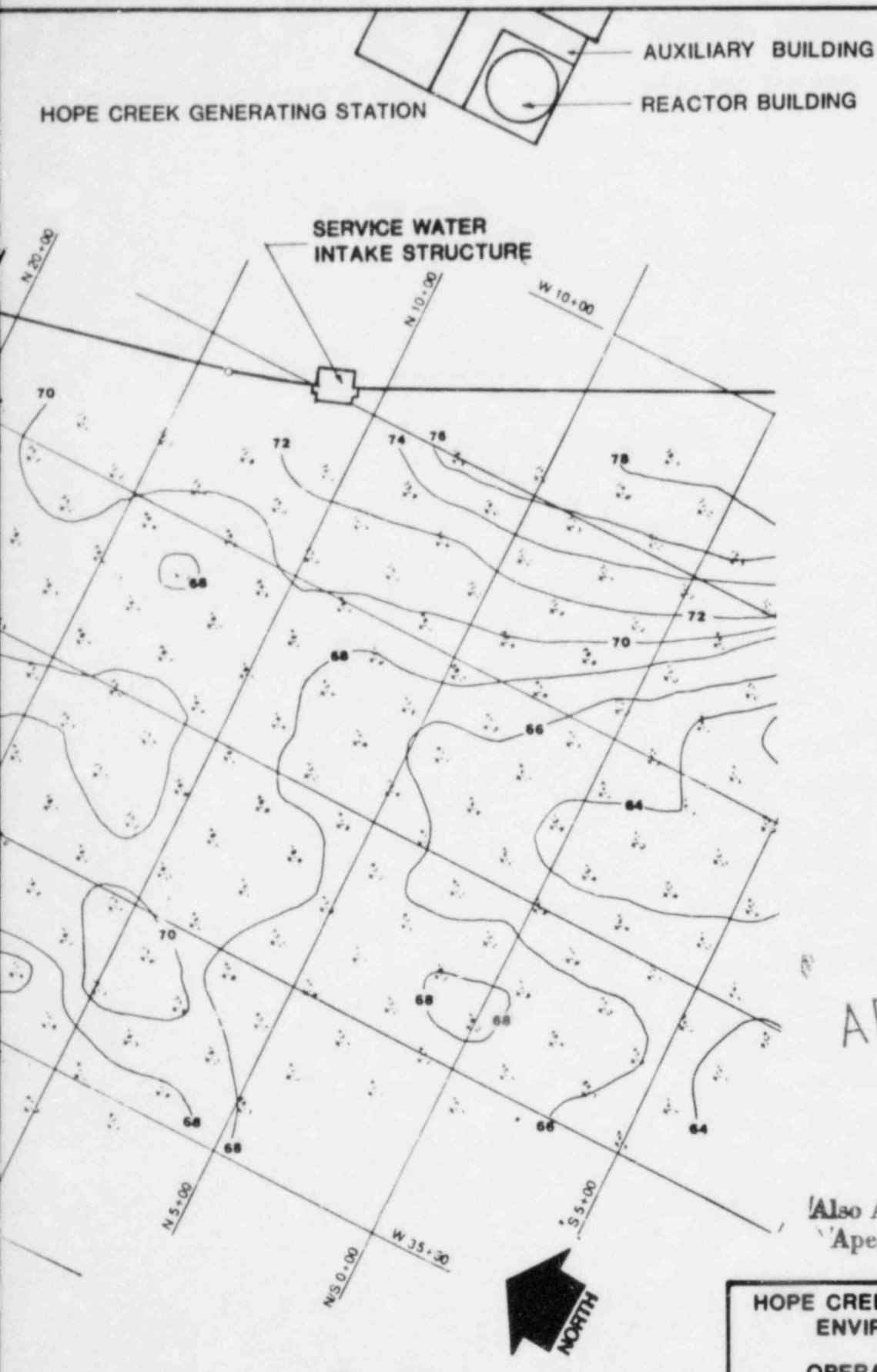
FIGURE 2.4 - 7



PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

NOTE: 1. BOTTOM ELEVATIONS (PSD)

2. CONTOUR INTERVAL: 2 FEET
3. THIS MAP IS NOT FOR NAVIGATIONAL USE



PRC
APERTURE
CARD

Also Available On
Aperture Card

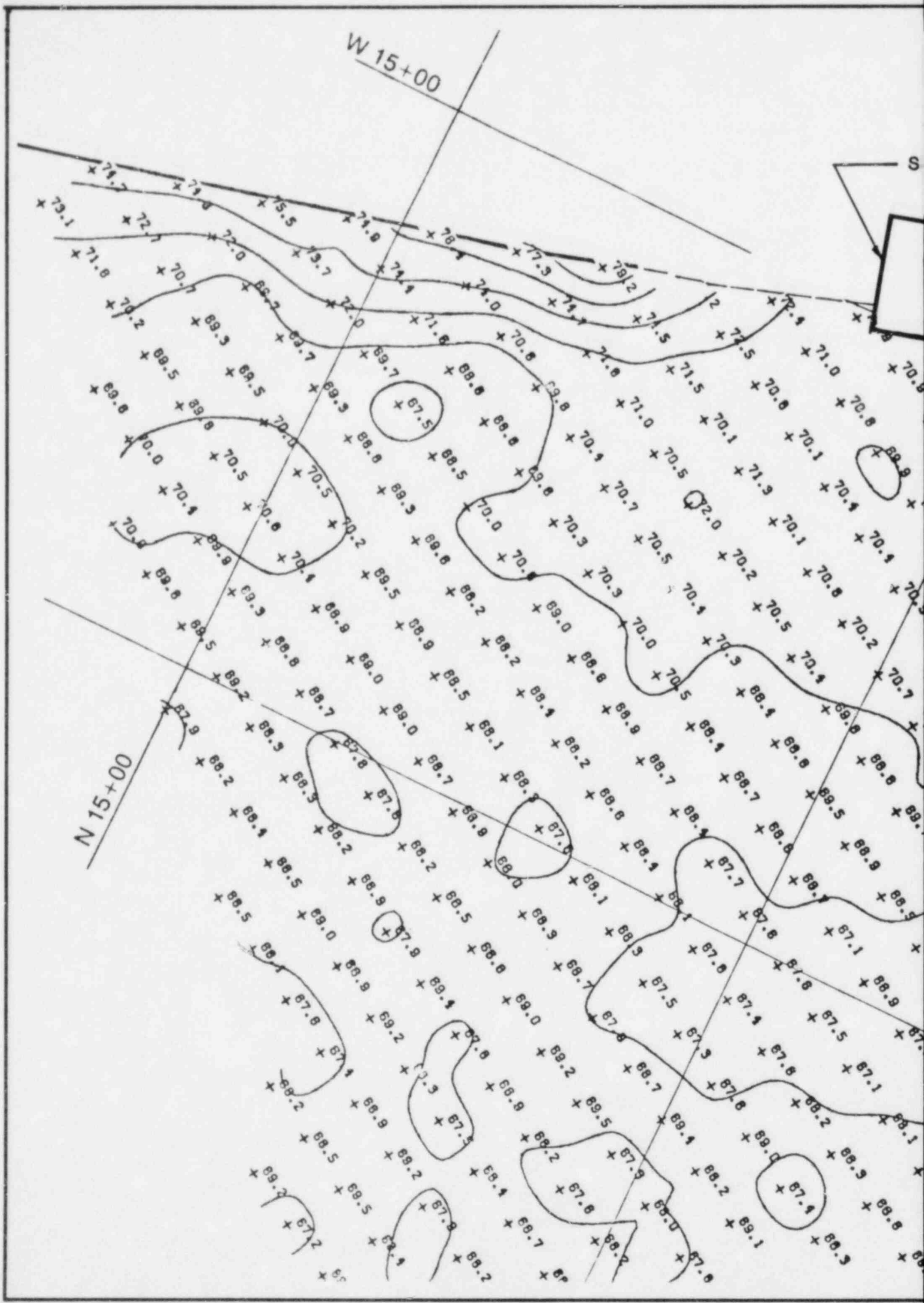
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

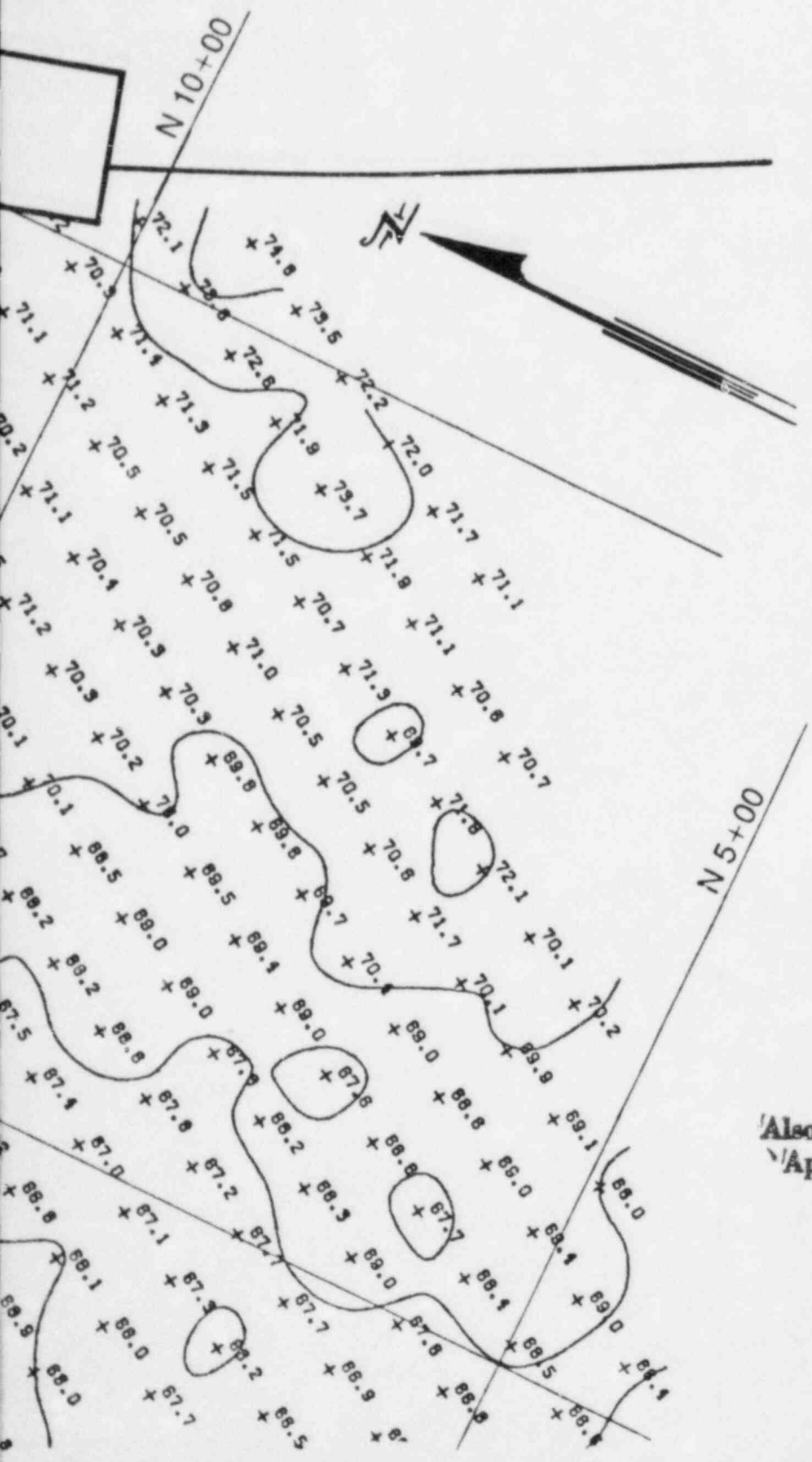
BATHYMETRY GENERAL STUDY AREA
SURVEY 33: 30 AND 31 MARCH 1982

FIGURE 2.4 - 8

8306290435 - 34


W 15+00
N 15+00

ERVICE WATER INTAKE STRUCTURE



PUBLIC SERVICE DATUM (PSD)
89.0FT = 0.0MSL

NOTE:

1. BOTTOM ELEVATION IN PSD
2. CONTOUR INTERVAL: 2 FEET

PRC
APERTURE
CARD

SCALE IN METERS

0 30.5 61.0

SCALE IN FEET

100 50 0 100

(1 INCH = 100 FEET)

Also Available On
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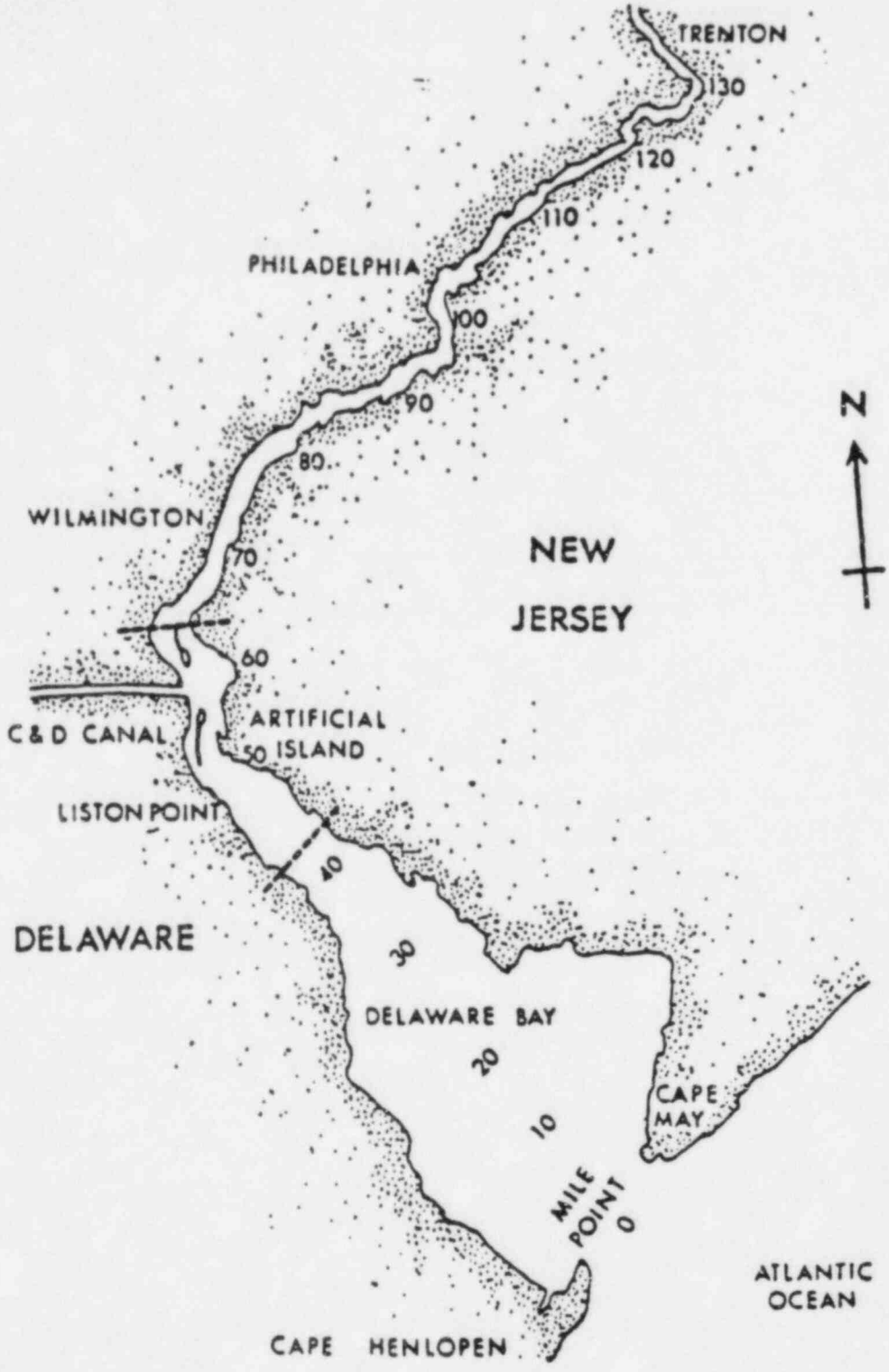
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

BATHYMETRIC SURVEY
NEAR SERVICE WATER
INTAKE STRUCTURE
25 SEPTEMBER 1982

FIGURE 2.4 - 9

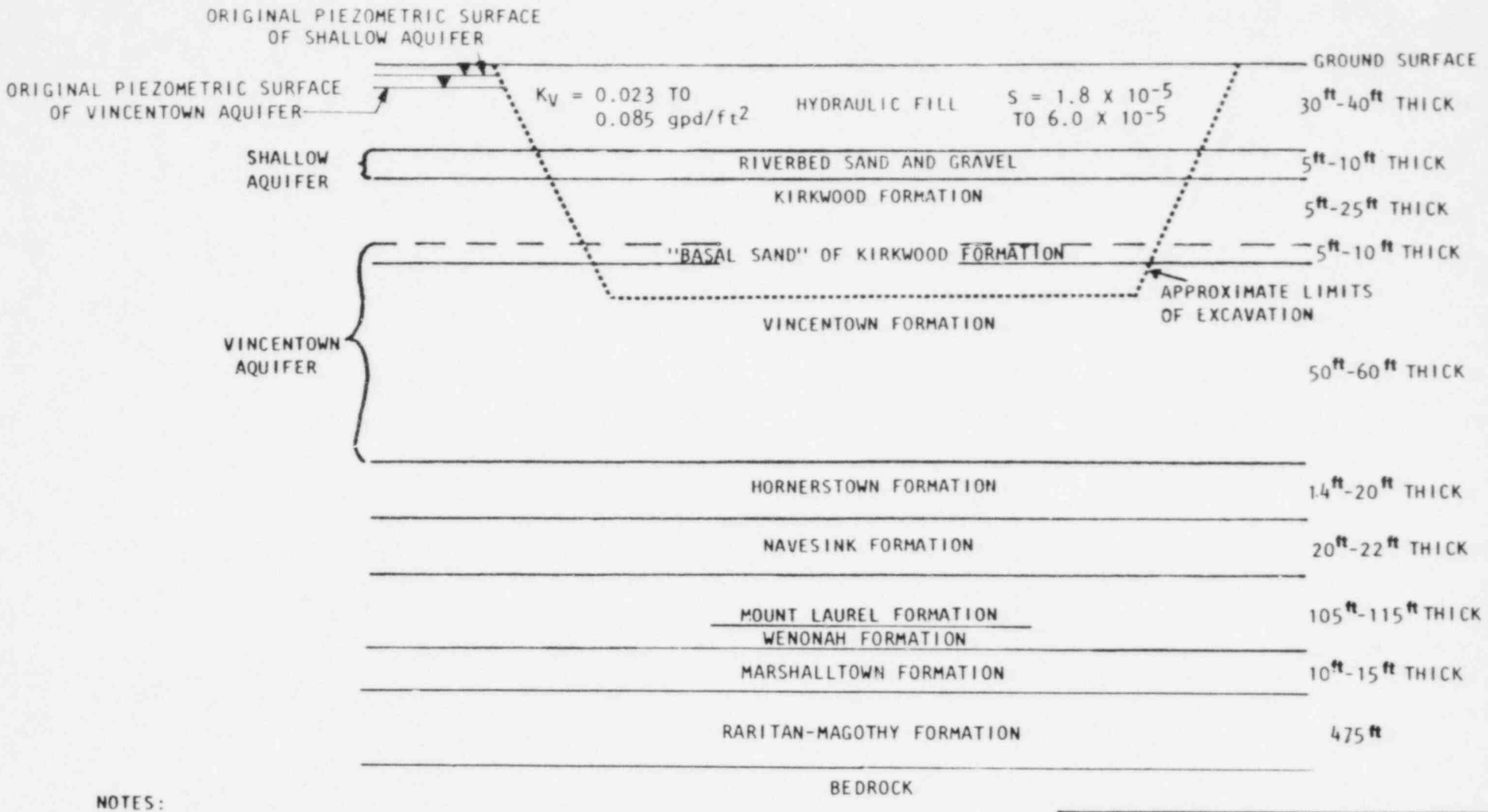


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

THE DELAWARE RIVER ESTUARY
AND LOCATION OF
THE STUDY AREA

FIGURE 2.4 - 10



NOTES:

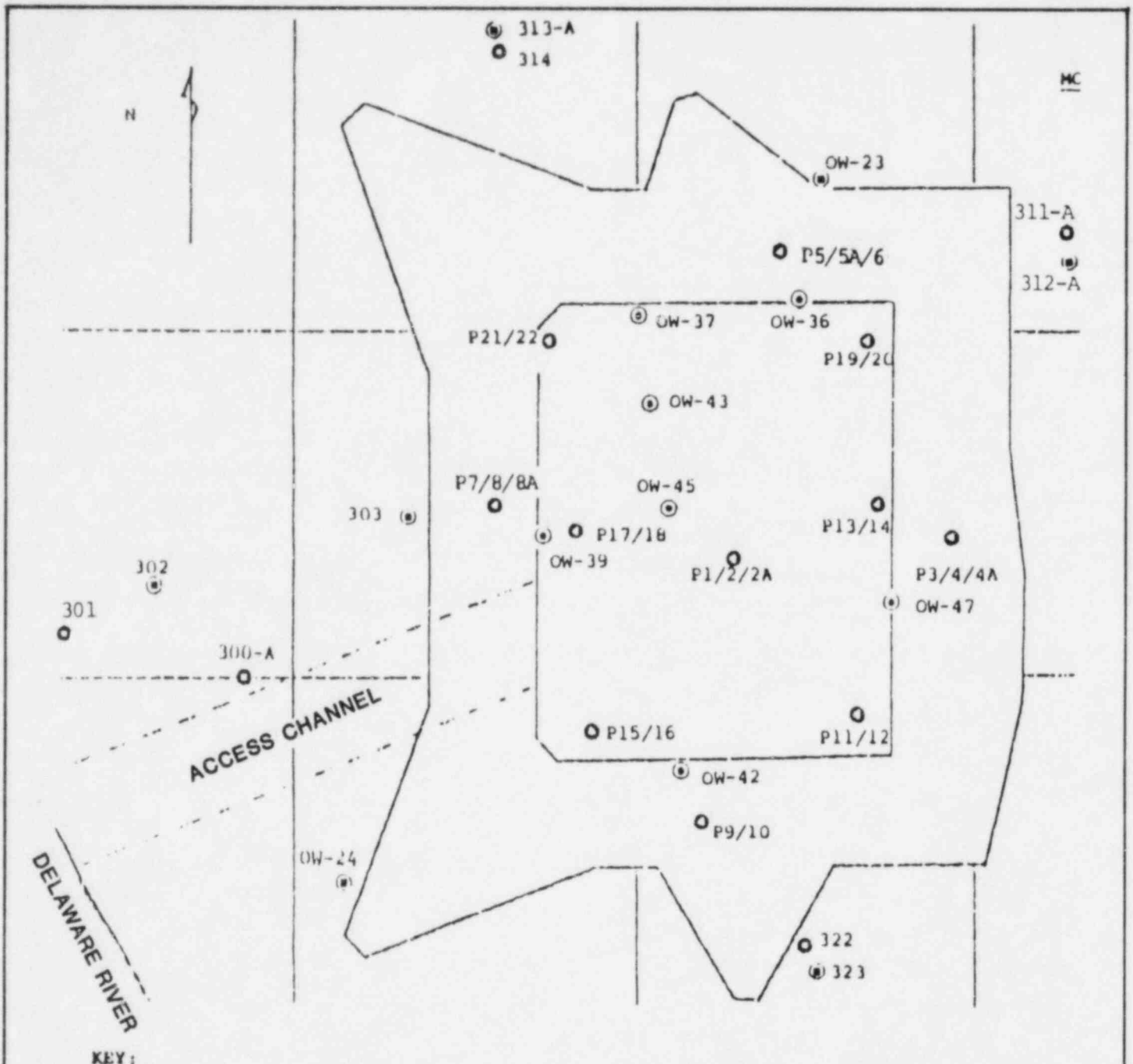
1. This figure is not drawn to scale and should not be used for any purpose other than providing a generalized picture of the site stratigraphy.
2. Some deviation in the stratigraphy can be expected.
3. Feet X 0.305 = Meters

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

GENERALIZED GEOLOGICAL CROSS SECTION OF THE HOPE CREEK SITE

FIGURE 2.4 - 11



KEY:

- Deep Observation Well
- Shallow Observation Well
- Pressure Cell Piezometer
- Other Observation Well

0 100 200 300
Scale in Feet

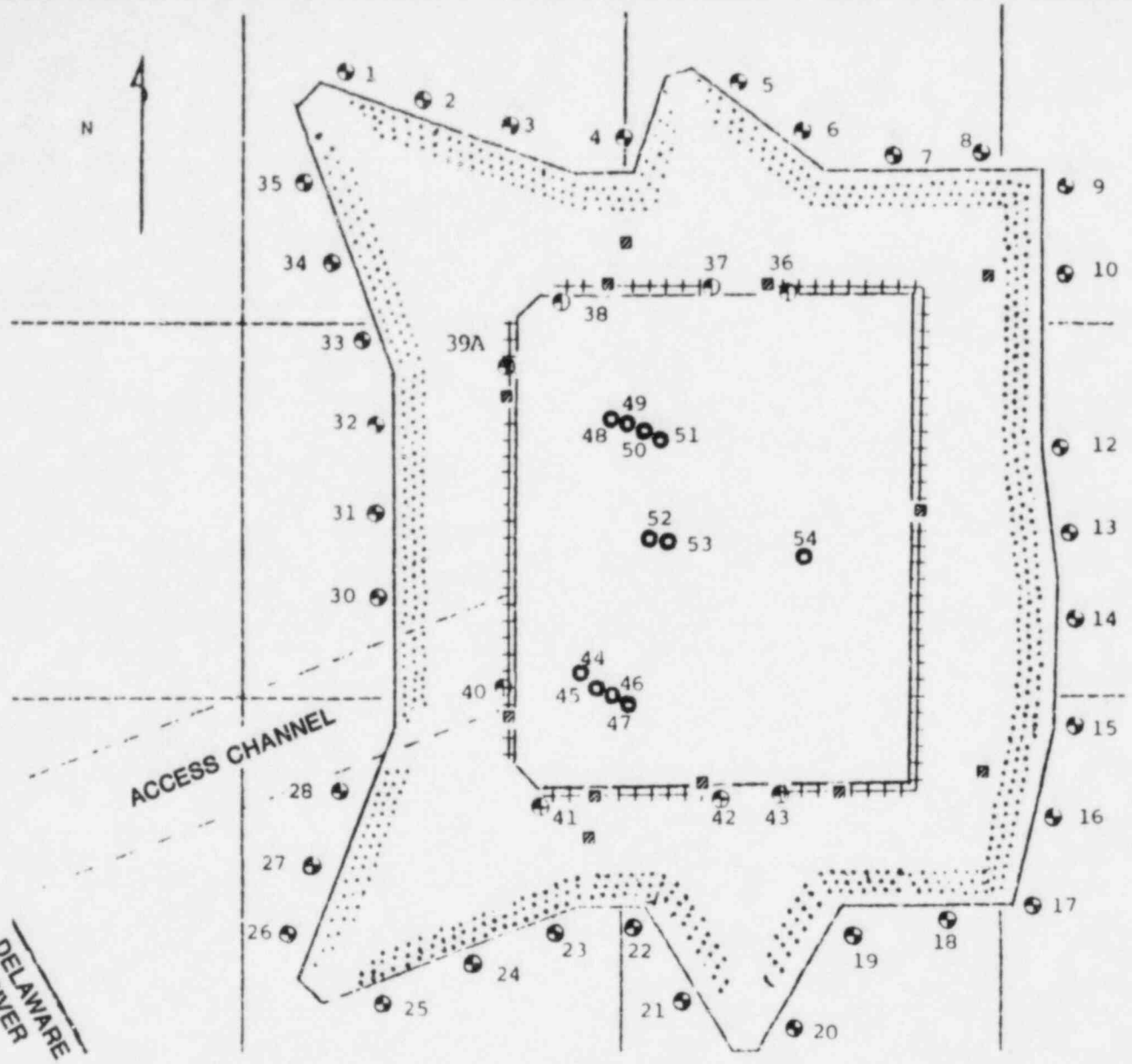
0 30.5 61 91.5
SCALE
(in meters)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SCHEMATIC MONITORING SYSTEM PLAN

FIGURE 2.4 - 12



KEY:

- Deep Dewatering Well (DDW)
- Temporary Deep Dewatering Well
- Supplementary Deep Dewatering Well for Pits and Trenches
- Sand Drains
- Well Point System
- Surface Water Sump

NOTE: DDW 3 was not put into production

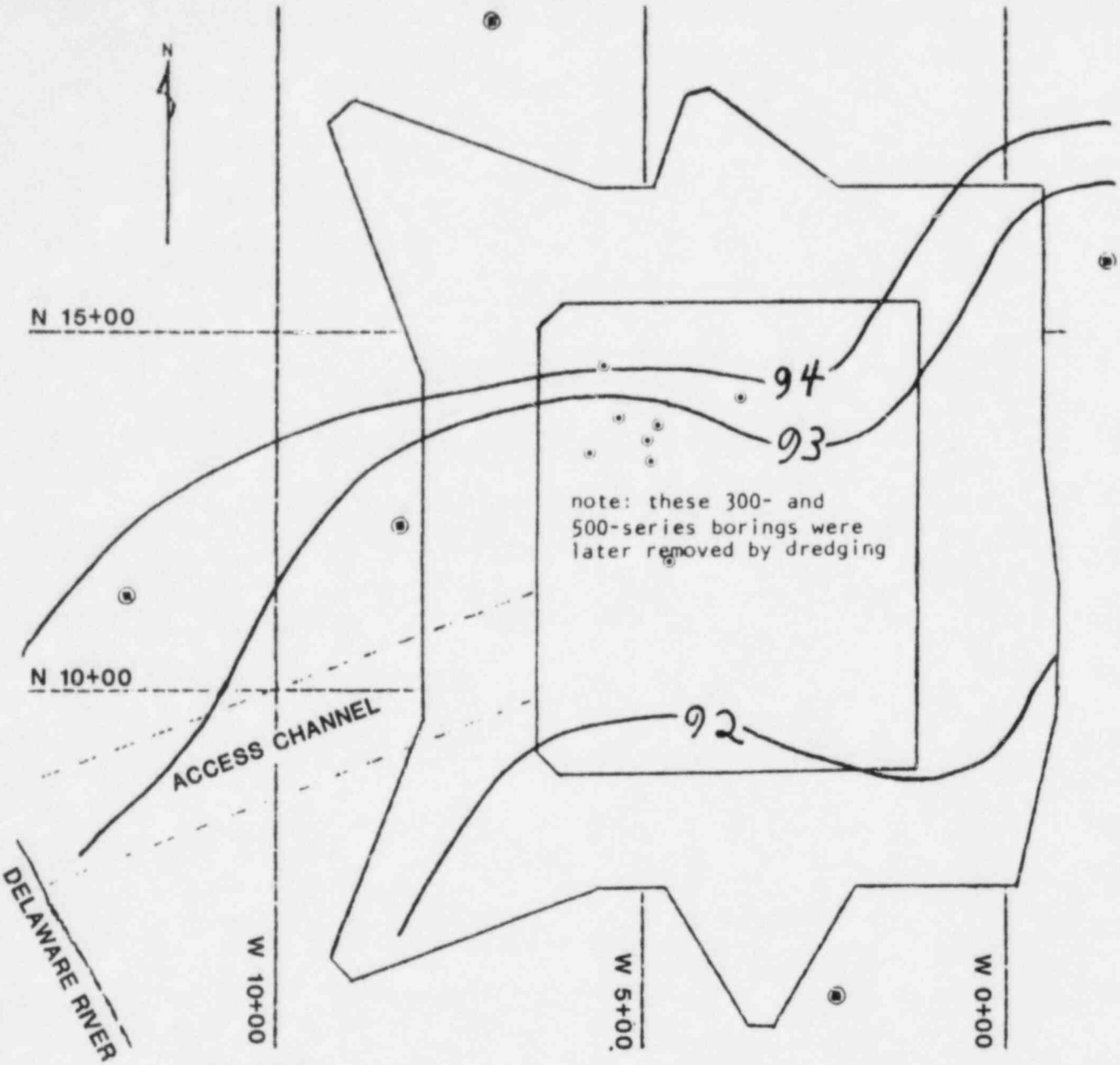
0 100 200 300
Scale in Feet

0 30.5 61 91.5
SCALE
(In meters)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

SCHEMATIC DEWATERING SYSTEM PLAN

FIGURE 2.4 - 13



EXPLANATION:

DATE January 16, 1976

◉ Shallow Observation Well

⊙ Other Observation Well

90

Piezometric Surface Contour Line (Elevation in ft. PSD) estimated from water level measurements in the depicted wells

PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

0 100 200 300
SCALE
(in feet)

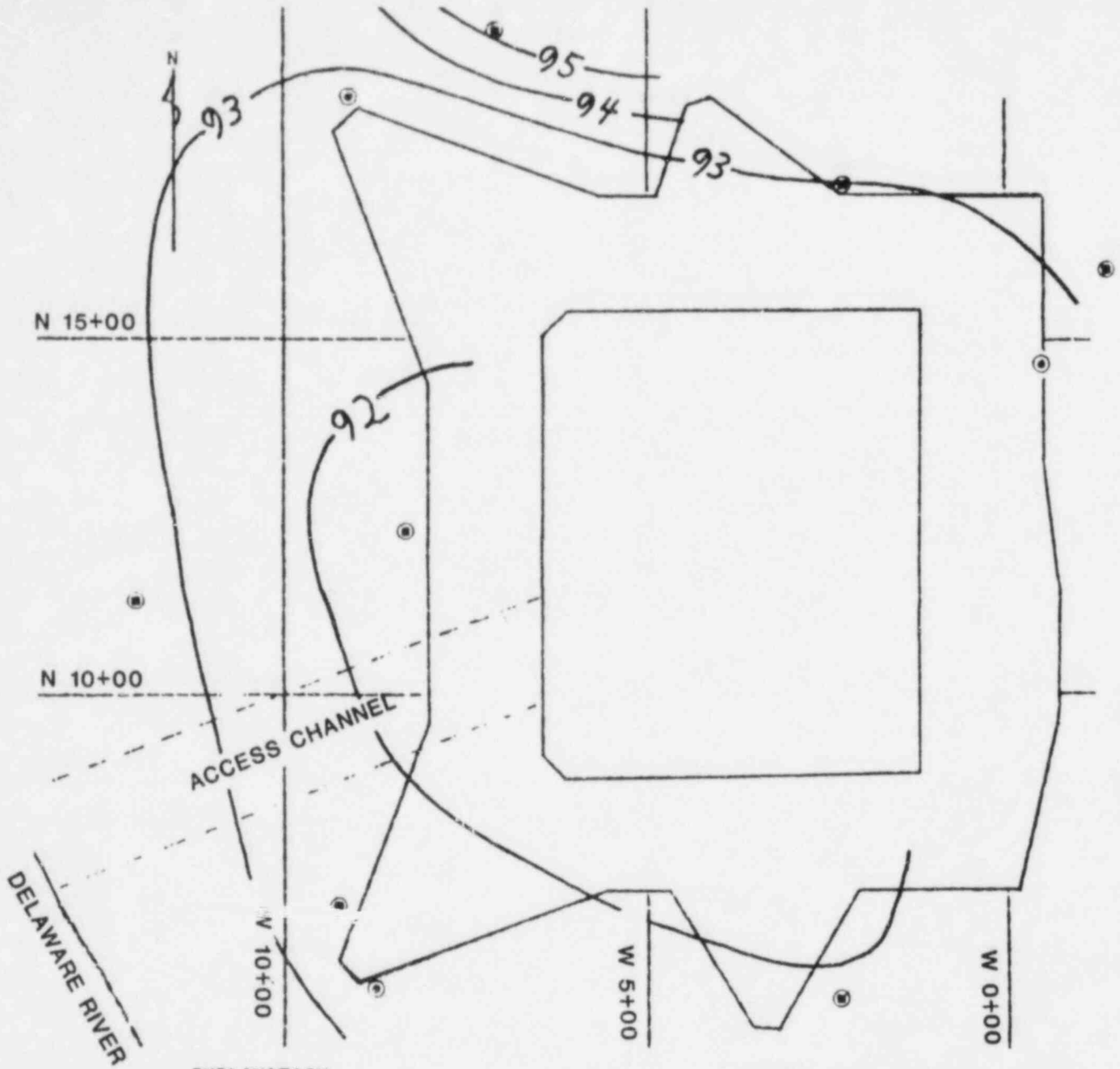
0 30.5 61 91.5
SCALE
(in meters)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SHALLOW AQUIFER
PIEZOMETRIC LEVELS

FIGURE 2.4 - 14



EXPLANATION:

DATE August 24, 1976

Shallow Observation Well

Other Observation Well

90

Piezometric Surface Contour Line (Elevation in ft. PSD) estimated from water level measurements in the depicted wells

0 30.5 61 91.5

SCALE

(in meters)

0 100 200 300

SCALE

(in feet)

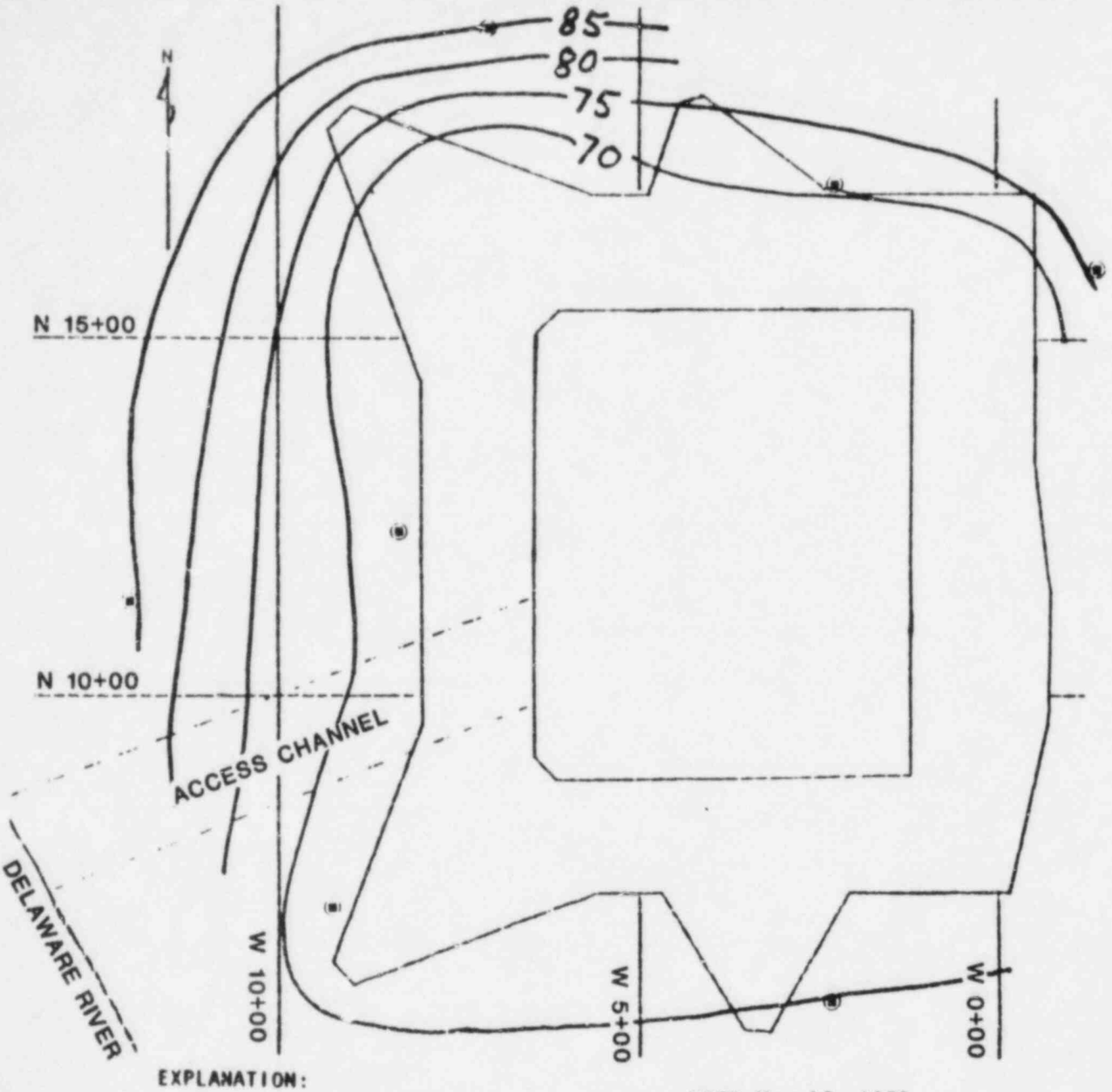
PUBLIC SERVICE DATUM (PSD) 89.0FT= 0.0MSL

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SHALLOW AQUIFER
PIEZOMETRIC LEVELS

FIGURE 2.4 - 15



EXPLANATION:

● Shallow Observation Well

DATE May 17, 1978

90

Piezometric Surface Contour Line (Elevation in ft. PSD) estimated from water level measurements in the depicted wells

PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

0 30.5 61 91.5

SCALE
(in meters)

0 100 200 300

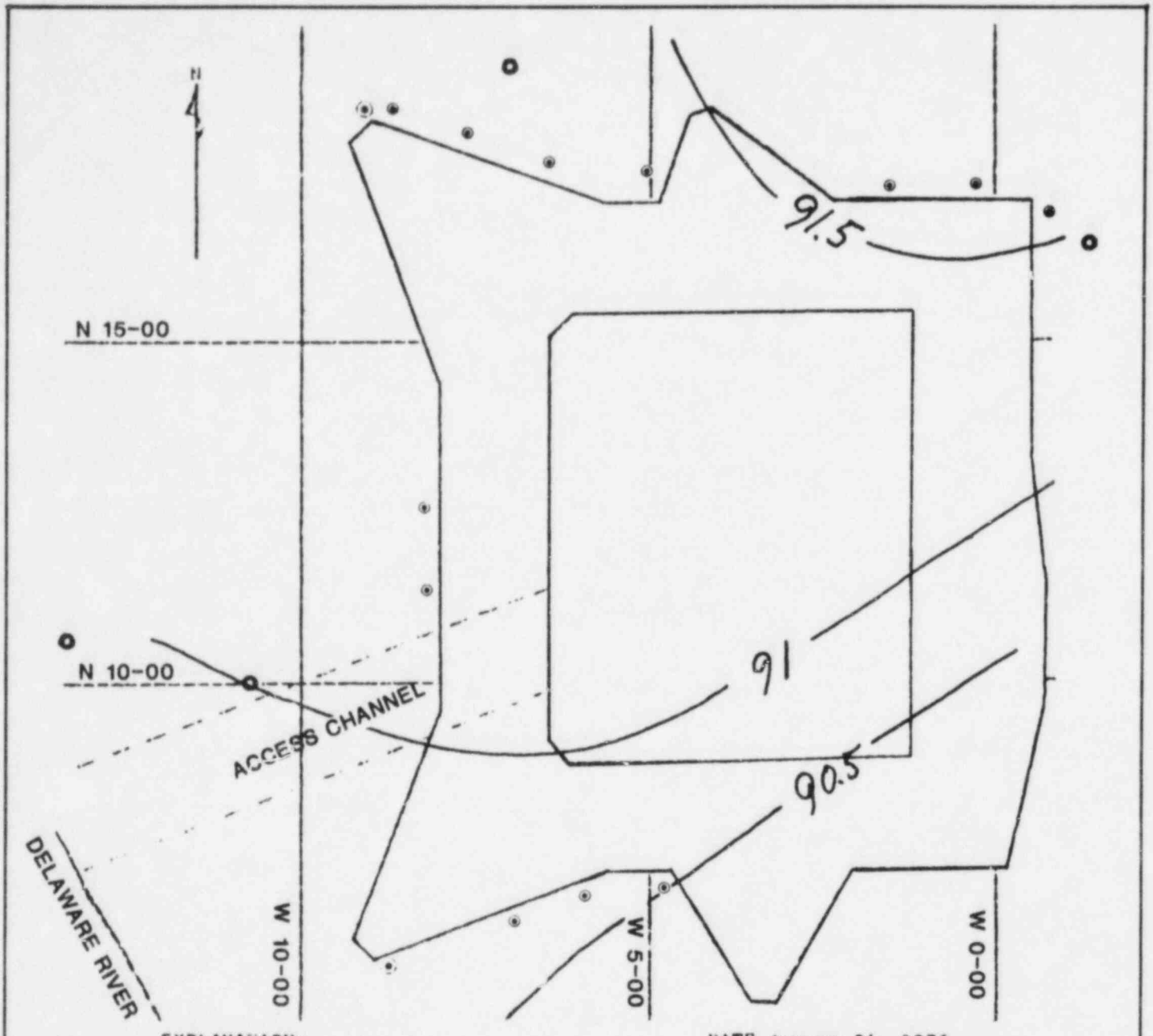
SCALE
(in feet)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SHALLOW AQUIFER
PIEZOMETRIC LEVELS

FIGURE 2.4 - 16



EXPLANATION:

DATE August 24, 1976

- Deep Observation Well
- Hydrostatic Pressure Cell Piezometer
- Point Piezometer
- Other Observation Well

55

Piezometric Surface Contour Line (Elevation in ft. PSD) estimated from water level measurements in the depicted wells and piezometers.

PUBLIC SERVICE DATUM (PSD) 89FT = 0 MSL

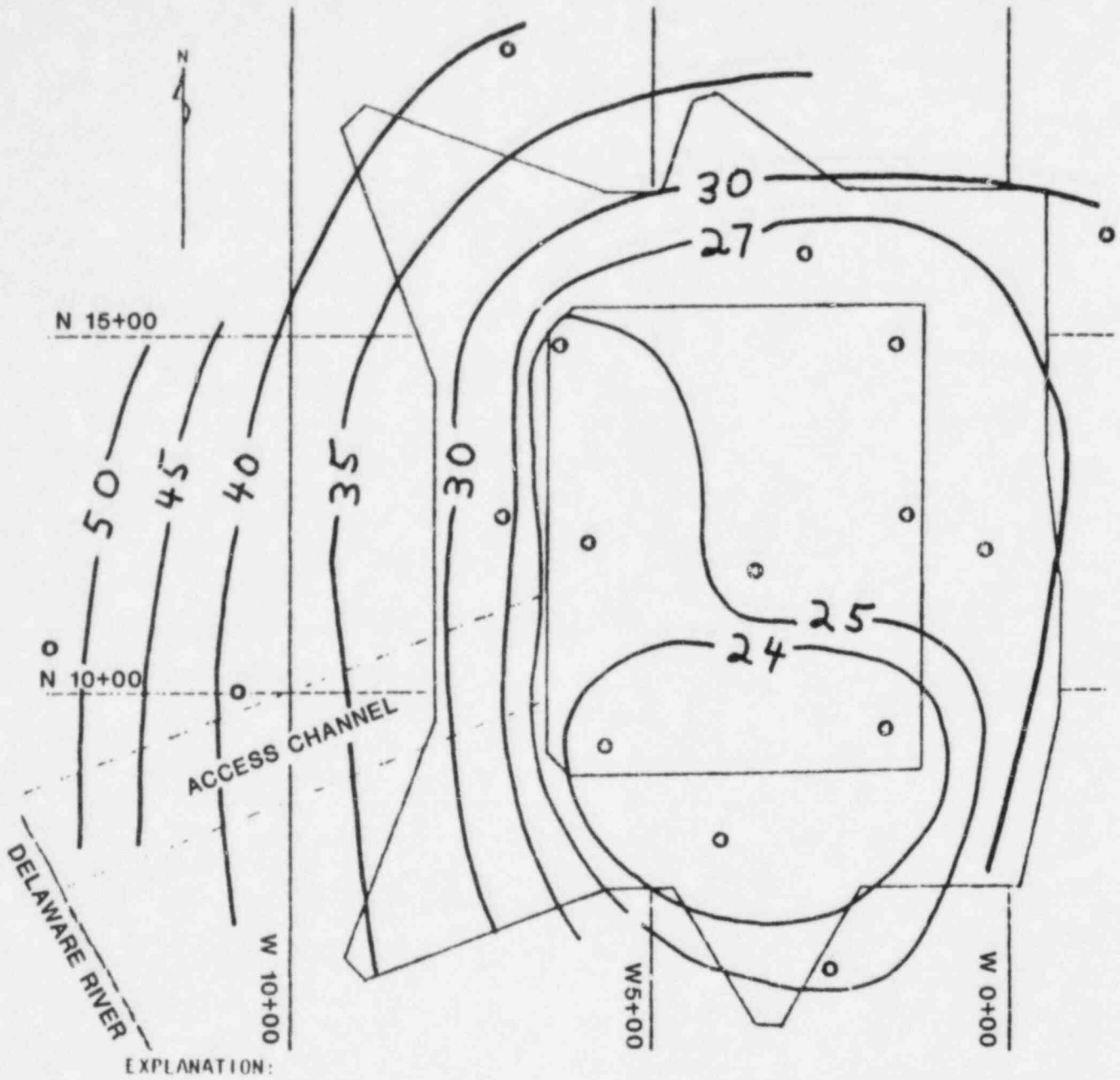
0 100 200 800
SCALE (in feet)

0 30.5 61 91.5
SCALE (in meters)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

VINCENTOWN AQUIFER
PIEZOMETRIC LEVELS

FIGURE 2.4 - 17



EXPLANATION:

DATE May 17, 1978

- Deep Observation Well
- Hydrostatic Pressure Cell Piezometer

PUBLIC SERVICE DATUM (PSD) 89.0FT = 0.0MSL

55

Piezometric Surface Contour Line (Elevation in ft. PSD) estimated from water level measurements in the depicted wells and piezometers.

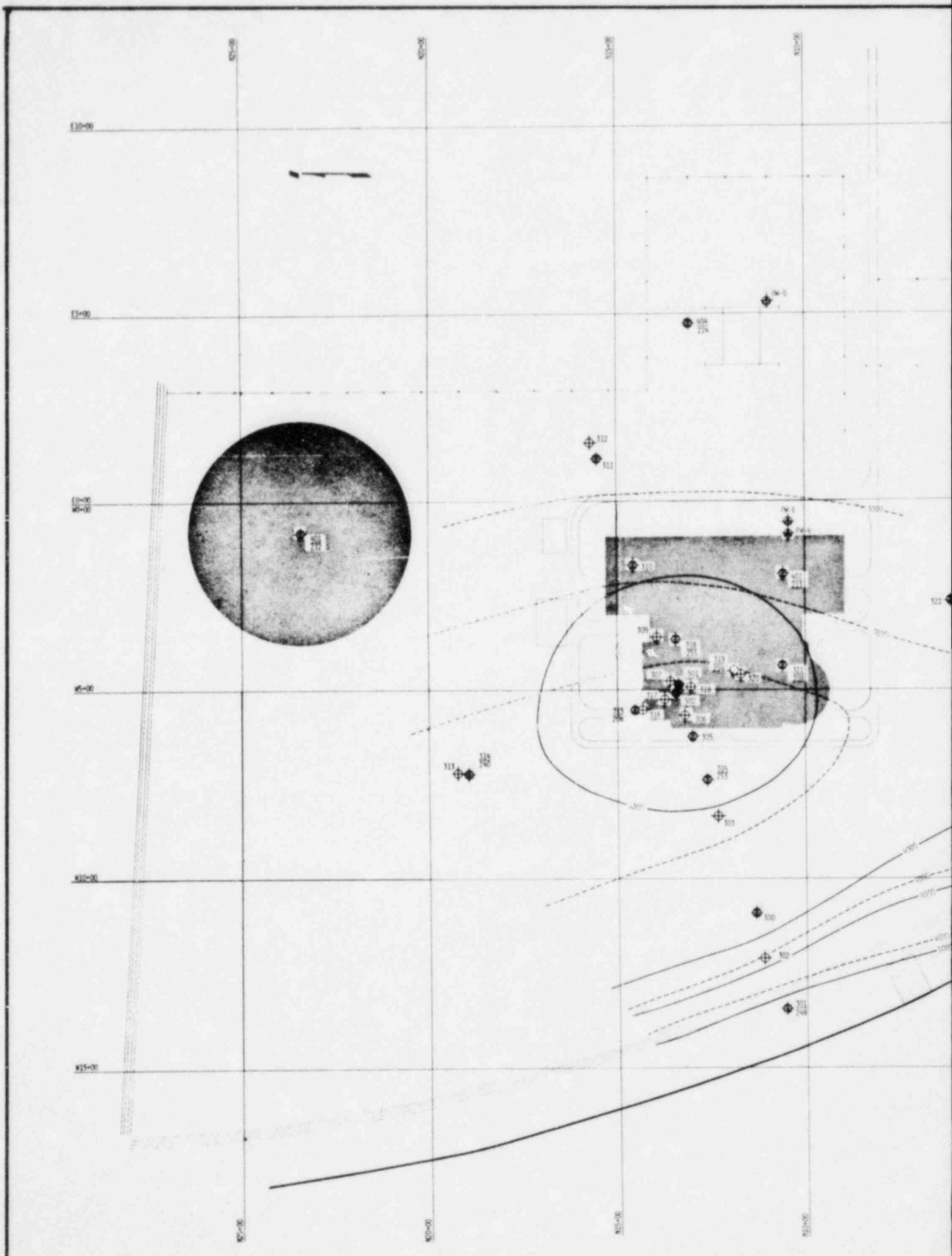
0 100 200 300
SCALE
(in feet)

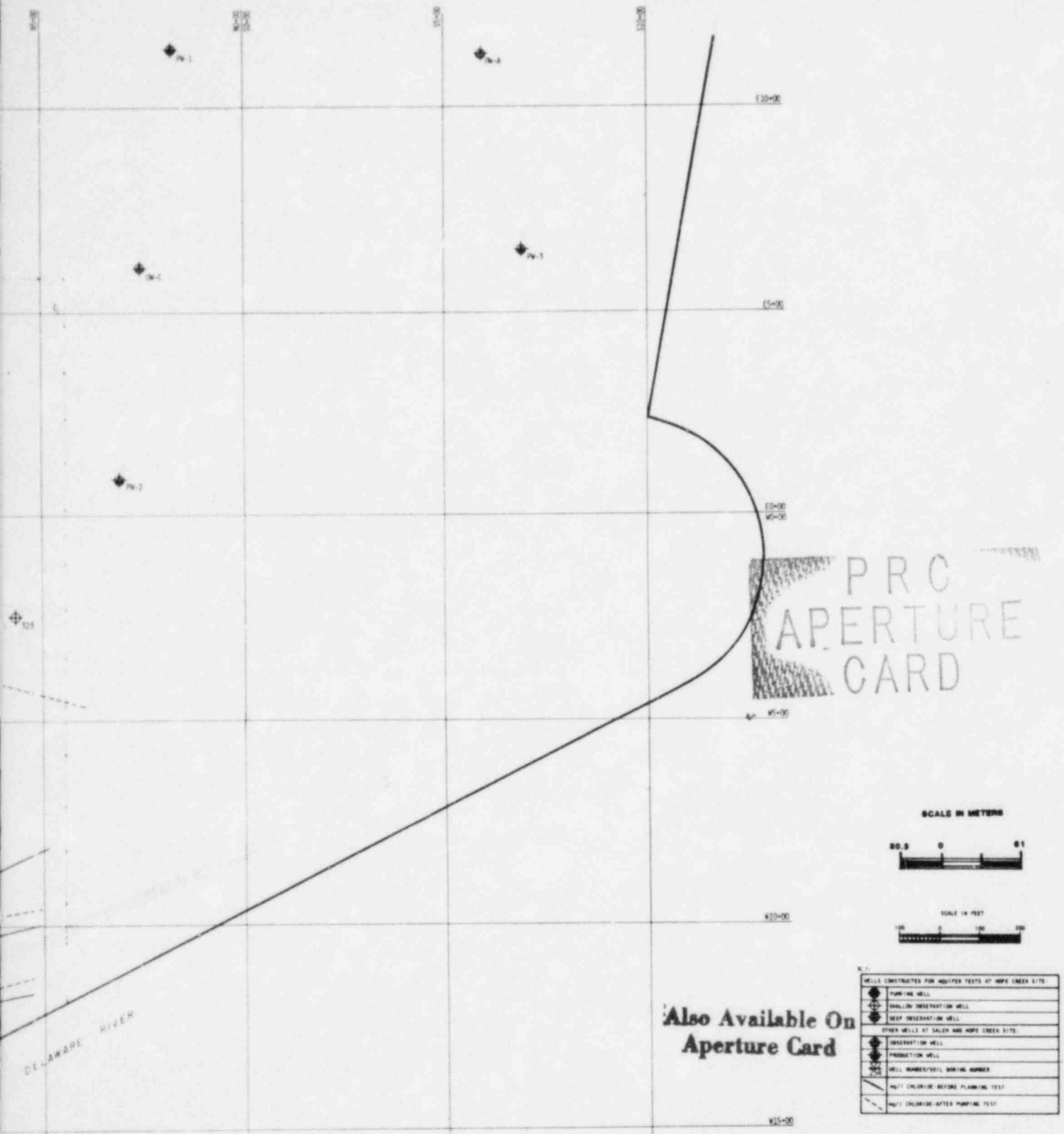
0 30.5 61 91.5
SCALE
(in meters)

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

VINCENTOWN AQUIFER
PIEZOMETRIC LEVELS

FIGURE 2.4 - 18


E10+00
E5+00
E0+00
W0+00
W5+00
W10+00
W15+00
N25+00
N20+00
N15+00
N10+00
312
311
322
313
300
302



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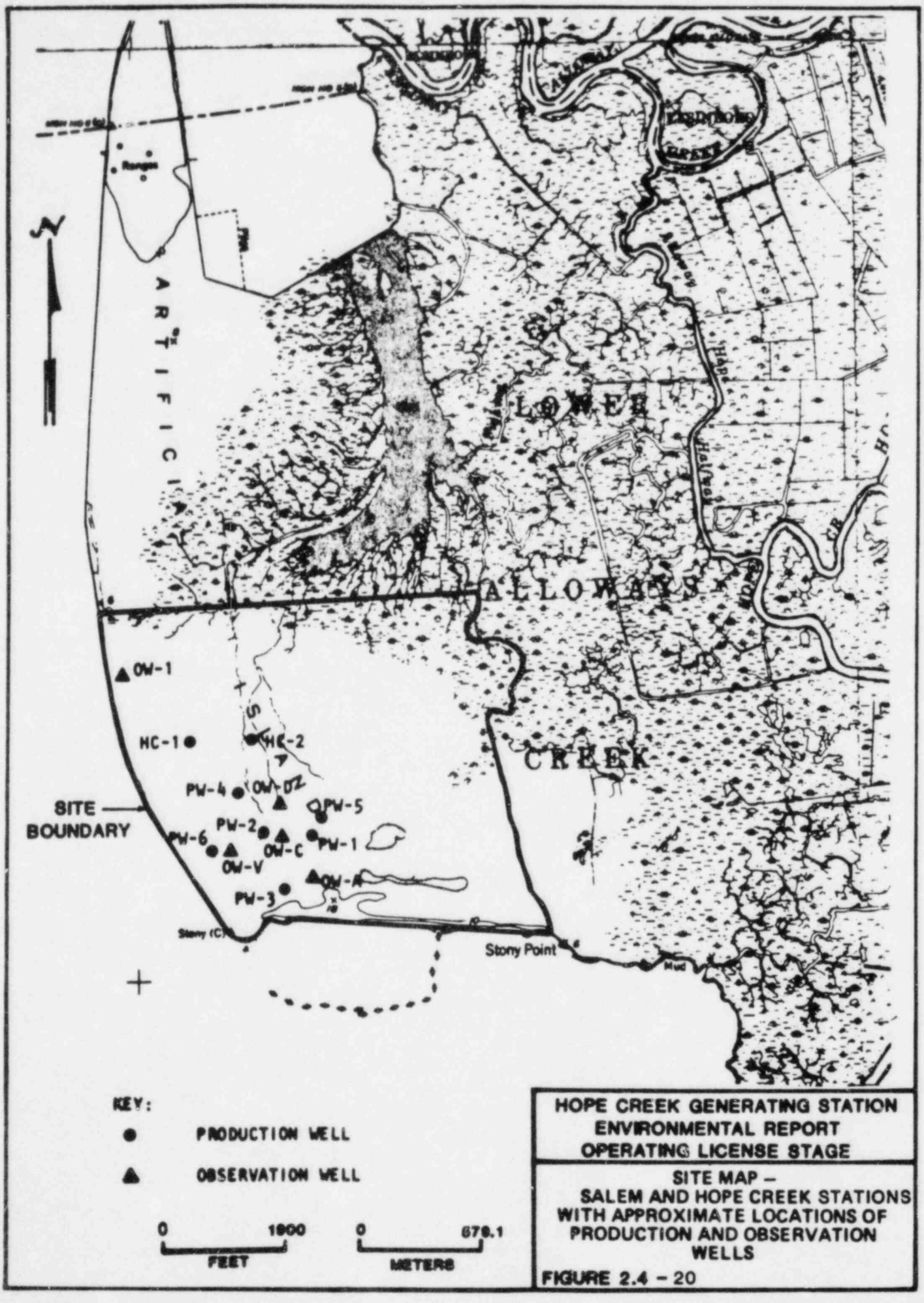
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

GROUNDWATER QUALITY MAP
FOR THE VINCENTOWN FORMATION
contour lines of
(equal chloride concentration)

FIGURE 2.4 - 19

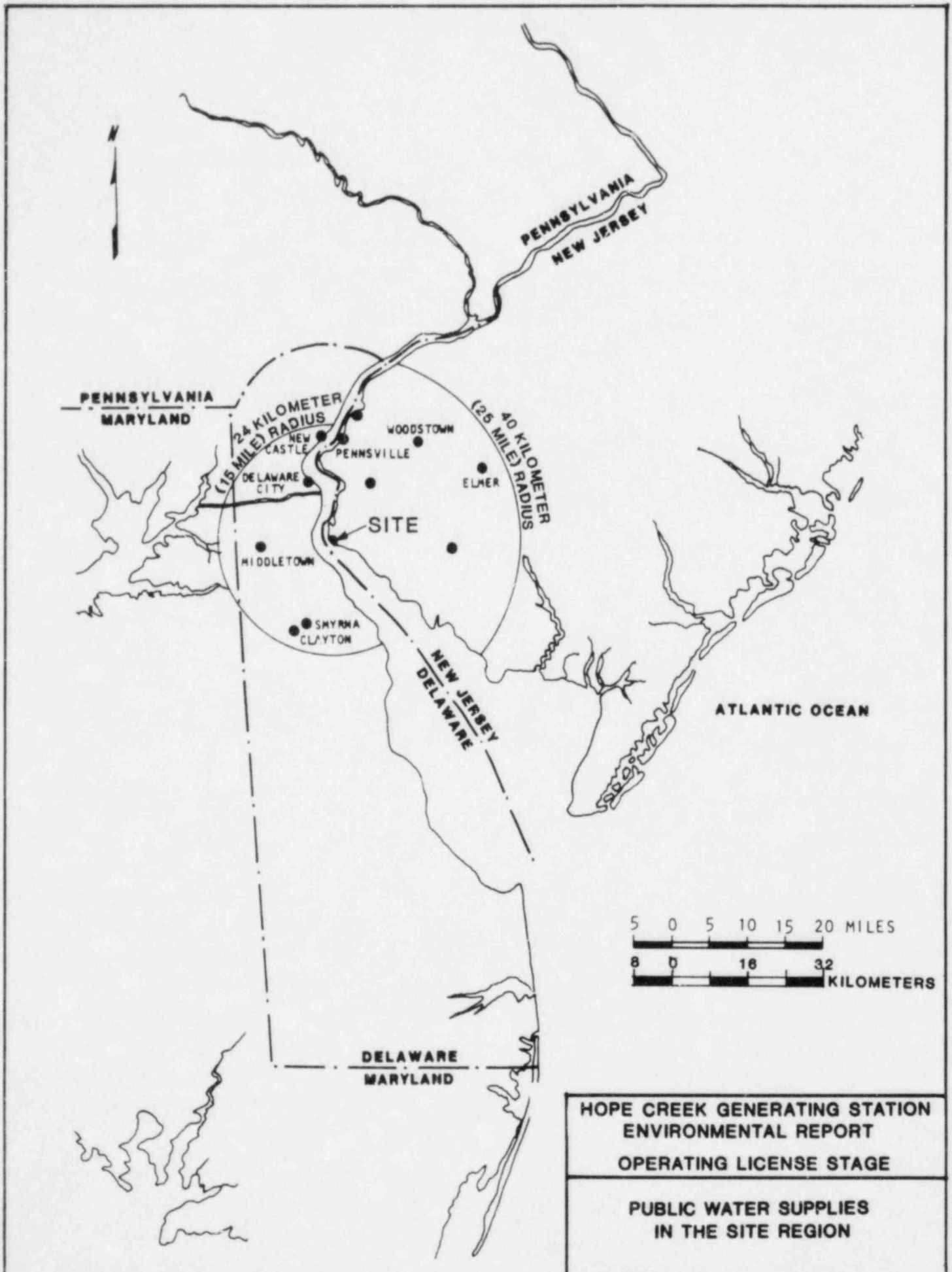
8306290435 - 36



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

SITE MAP –
SALEM AND HOPE CREEK STATIONS WITH APPROXIMATE LOCATIONS OF PRODUCTION AND OBSERVATION WELLS

FIGURE 2.4 – 20

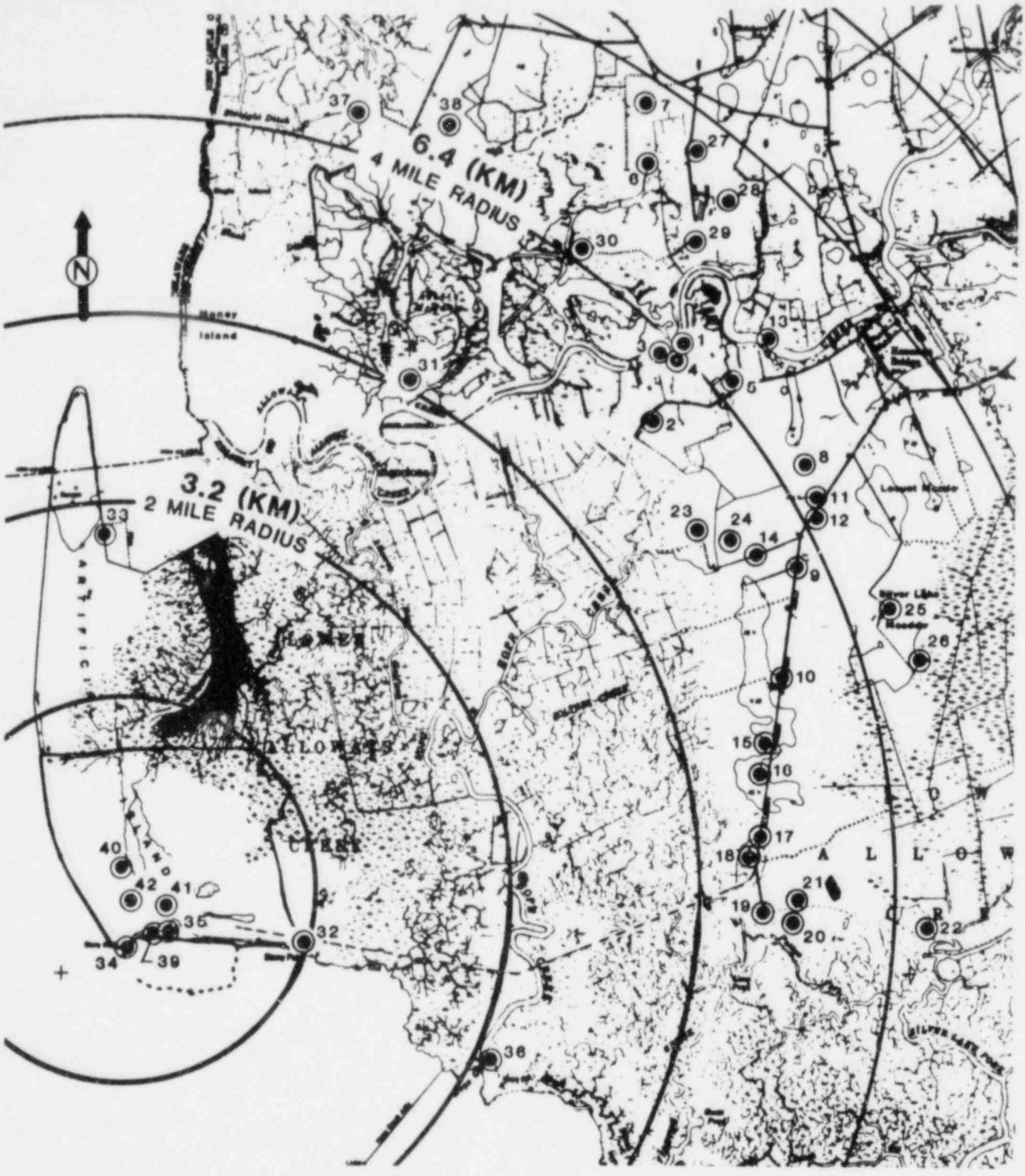


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

PUBLIC WATER SUPPLIES
IN THE SITE REGION

FIGURE 2.4 - 21



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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MAP OF AREA

KNOWN WATER WELLS IN
NEW JERSEY IN VICINITY OF SITE

FIGURE 2.4 - 22

2.5 GEOLOGY

During the Construction Permit stage, PSE&G described the geology of the HCGS vicinity. The geology of the HCGS vicinity was also described in the FES. Section 2.5 contains a combination of this material, in addition to updated information.

This section describes the geologic conditions at the HCGS site; it provides information concerning the site geology, including physiography, stratigraphy, structure, and engineering geology. Other topics discussed include surface faulting, stability of subsurface materials and foundations, and groundwater conditions. The information summarized in this section is derived from the results of several geologic and geotechnical investigations conducted at the site, using subsurface exploration with borings, geophysical surveys, and detailed mapping of excavations. PSE&G has presented detailed discussions of these investigations in a series of reports previously submitted to the Nuclear Regulatory Commission (NRC) (References 2.5-5, 2.5-6, 2.5-7, 2.5-8). Section 2.5 of the FSAR contains additional maps, boring logs, diagrams, etc., pertaining to geological conditions at the site.

2.5.1 SITE GEOLOGY

2.5.1.1 Physiography

The HCGS site is located in Salem County, New Jersey, approximately 29 kilometers (18 miles) south of Wilmington, Delaware (Figure 2.1-2). It is situated on Artificial Island along the east shore of the Delaware River estuary. The extent and elevation of the original river bar which occupied this location was increased by the emplacement of hydraulic fill derived from the adjacent river channel.

The site is located within the Atlantic Coastal Plain Physiographic Province. It is situated approximately 29 kilometers (18 miles) southeast of the Fall Line, which separates it from the Piedmont Physiographic Province.

The morphology of the site is typical of locations within the Coastal Plain. The Delaware River borders the site to the west and south. Most areas immediately north and east of the site consist of marine tidal marshes dissected by shallow stream channels.

The northern end of the island is covered with marsh grass in many places. A low-lying dike, constructed from soil fill, runs parallel to the shoreline on the south and west. The top of this dike ranges in elevation from about 16 to 19 feet above MSL.

The site surface is relatively flat, and generally ranges in elevation from 6 to 30 feet above MSL. The highest terrain is in the area north of the reactor. This area forms a nearly rectangular bench about two to three meters (six to 10 feet) higher in elevation than the central area, where the reactor and turbine buildings are situated. A broad, very shallow trough extends southward from the cooling tower location, and then continues westward from the turbine building to the western edge of the site. This depression is a minor erosional feature that drains the higher elevations in the northern portion of the site.

2.5.1.2 Stratigraphy

The HCGS site is underlain by a thick sequence of terrestrial and marine strata deposited on a precretaceous basement surface. This stratigraphic sequence is about 457 meters (1500 feet) thick, and the sediments vary from Early Cretaceous to Holocene in age. Figure 2.5-1 illustrates the sequence and configuration of the stratigraphic units at the site.

Pre-Upper Cretaceous Strata

The lowermost sedimentary units underlying the site consist of Early Cretaceous strata which are non-marine in origin; these strata unconformably overlie the basement rocks. A series of stratigraphic units referred to as the Potomac Group represents the Early Cretaceous sediments. This stratigraphic group consists of discontinuous beds of sand, clay and silt, deposited as continental fluvial and deltaic detrital sediments. The clastic wedge of sediments is estimated to be about 366±61 meters (1200±200 feet) thick beneath the HCGS site (Reference 2.5-2).

Upper Cretaceous Strata

The Upper Cretaceous strata consist of a sequence of formations which record the change from non-marine deposition. The marine formations of the sequence reflect deposition during three marine transgressions and two regressions. These stratigraphic units are the Raritan and Magothy Formations, as well as the formations of the Matawan and Monmouth Groups (Figure 2.5-1).

a. Raritan and Magothy Formations

The Raritan Formation is predominantly of non-marine origin, and mostly consists of light-colored, interbedded sand and clay.

The Magothy Formation (Figure 2.5-1) disconformably overlies the Raritan Formation; it is differentiated on the basis of increasing clay content. The lithologic character of the Magothy Formation indicates that it is a coastal deposit, representing the initial marine transgression in Late Cretaceous time.

b. The Matawan Group

The Matawan Group is represented by the Merchantville, Woodbury, Englishtown, Marshalltown and Wenonah Formations (Figure 2.5-1). With the exception of the Englishtown Formation, these stratigraphic units are massive shelf and inner shelf sediments accumulated during both transgressive and regressive phases of marine deposition. The Englishtown Formation consists of near-shore coastal sediments deposited during the regressive phase of the Late Cretaceous marine incursion.

The Merchantville Formation disconformably overlies the Magothy Formation, and is the oldest glauconitic unit in the New Jersey Coastal Plain (Reference 2.5-2). The Merchantville sediments represent massive shelf deposits of a marine transgression. The Woodbury Formation conformably overlies the Merchantville Formation, and grades upward indistinguishably into the Englishtown Formation (Figure 2.5-2). These strata are marine regressive inner-shelf and near-shore sediments, respectively. Samples taken from the Englishtown Formation consist mostly of finer-grained particles, which are not easily distinguishable from the clayey silts of the underlying Woodbury Formation (Reference 2.5-6). Samples obtained from these sediments contained gray-to-black clay, silty clay and clayey silt, with trace quantities of very fine, uniformly disseminated mica. Most samples taken near the top of the Englishtown Formation contained fine, thin, calcareous shell fragments with fine sand partings.

The Marshalltown Formation conformably overlies the Englishtown Formation (Figure 2.5-1). Typically, the Wenonah Formation conformably overlies the

Marshalltown Formation. Both units are comprised of sediments indicative of a shelf depositional environment; however, the lower unit was deposited during a transgressive phase, and the Wenonah Formation represents a marine regression. The lithologic similarities of the Marshalltown and Wenonah Formations at the site make differentiation of these two units difficult (Reference 2.5-6).

The Marshalltown-Wenonah Unit is about 12 meters (40 feet) thick. Owens and Minard (Reference 2.5-3) state that the Marshalltown Formation is consistently three to five meters (10 to 15 feet) thick throughout the New Jersey Coastal Plain; therefore, it is interpreted that the Wenonah Formation comprises the upper eight to nine meters (25 to 30 feet) of this lithologic unit at the site (Reference 2.5-6). Samples from within this unit consisted of gray clayey silt and fine sand with trace quantities of glauconite and mica.

c. Monmouth Group

At the site only the two oldest formations of the Monmouth Group are present (Reference 2.5-6). These are the Mount Laurel and Navesink Formations (Figures 2.5-1 and 2.5-2). The Mount Laurel sand was deposited in a relatively near-shore environment during a marine regression, while the overlying Navesink Formation was deposited in the deeper water shelf environment during a successive transgressional phase. The Red Bank, New Egypt and Tinton Formations, which compose the upper strata of the Monmouth Group elsewhere on the coastal plain, are not present at the site (Reference 2.5-6).

A large number of borings at the site encountered the Mount Laurel Formation (References 2.5-4, 2.5-5 and 2.5-6). In these borings, the formation varied from 33 to 32 meters (109 to 104 feet) thick. The top of the Mount Laurel Formation is generally encountered between elevations 64 and 76 feet below MSL. The upper surface of the Mount Laurel Formation locally slopes toward the southeast, between 8 and 11 meters per kilometer (25 and 35 feet per mile).

Within the upper three to five meters (10 to 15 feet) of the Mount Laurel Formation, the sand fraction consists of equal quantities of fine-to-coarse, subangular-to-subrounded quartz sand and glauconite

sand. The silt fraction makes up about 35 to 50 percent of the entire sediment, with only trace quantities of clay and few shall fragments. A zone between elevations 80 and 90 feet below MSL usually contains semi-consolidated layers of nodules. Several of these nodules consist of highly-weathered, cemented shell fragments. The sand-silt ratio at elevation 90 feet below MSL is similar to the top of the formation, but the percentage of quartz in the sand fraction increases to 70 percent, with glauconite decreasing to 30 percent. Shell fragments remain in trace quantities. The quartz-to-glauconite ratio continues to change with depth. At elevation 100 feet below MSL this ratio is 90 to 100 percent, with glauconite decreasing rapidly to trace quantities below elevation 110 feet below MSL. Below elevation 110 feet below MSL the silt content decreases abruptly, and cleaner sands with finer grain size begin to appear.

The Navesink Formation conformably overlies the Mount Laurel sands (Figure 2.5-2), and is readily identified by its unique mineralogy (Reference 2.5-6). The thickness of this formation ranges from six to seven meters (20 to 22 feet) at the site. Borings penetrated its upper contact at approximately elevation 50 feet below MSL; the Navesink Formation generally slopes toward the southeast, at approximately nine meters per kilometer (30 feet per mile). The sand fraction in the upper strata of the Navesink Formation contains about 90 percent fine-to-medium, subangular quartz sand. Many borings encountered numerous pelecypod fragments near the upper contact. The base of the Navesink Formation is characterized by a one to two meter (four to six foot) thick zone, where the glauconite content comprises more than 95 percent of the sand-size fraction.

Tertiary Strata

The Tertiary strata at the site consist of the Hornerstown, Vincentown and Kirkwood Formations (Figure 2.5-1). The Hornerstown and Vincentown stratigraphic units consist predominantly of glauconite sand deposited in an inner and mid-shelf marine environment. The Hornerstown Formation appears to be transgressive in character, while the Vincentown was deposited during a marine regression (Reference 2.5-1). These units are unconformably overlain by the near-shore marine regressive sand and clay of the Kirkwood Formation.

The Hornerstown Formation unconformably overlies the Navesink sands. The thickness of this formation, below the site, ranges from four to six meters (14 to 20 feet); the formation is generally encountered at elevation 25 feet below MSL. The Hornerstown Formation consists of fine-to-medium sand and 25 to 40 percent silt. The sand fraction in the upper portion of the formation is predominantly fine-to-medium, subangular-to-subrounded quartz, with 15 to 20 percent fine-to-medium, subround and botryoidal glauconite. Fine shell fragments comprise approximately five percent of the sand. The relative percentage of quartz to glauconite changes with depth. Quartz sand grains decrease to 30 percent, whereas the glauconite content correspondingly increases to approximately 60 to 70 percent, of the sand fraction. Shell content remains in trace quantities; however, the basal sands of the Hornerstown Formation are usually characterized by large, angular pelecypod fragments, up to 0.4 centimeter (one inch long). The upper contact of the Hornerstown Formation was determined by noting an increase in silt, a rapid increase in size and quantity of glauconite, and a corresponding decrease in shell fragments (Reference 2.5-6); however, the above characteristics vary somewhat between borings due to the gradational nature of the Vincentown-Hornerstown contact.

The Vincentown Formation conformably overlies the Hornerstown sands. Because of the erosional relief on its upper surface, both the thickness of the Vincentown Formation and the elevation of its upper contact is somewhat variable.

The Vincentown Formation is a relatively homogeneous stratigraphic unit, predominantly composed of greenish-gray, fine-to-medium grained sand above elevation 10 feet above MSL, and fine sand below elevation 10 feet above MSL. The sand fraction of the sediments is composed of calcium carbonate fragments (including shells, bryozoa, echinoid spines and foraminifera), detrital quartz and glaconite. The ratio of detrital quartz to shell fragments is not predictable at any given depth. Glauconite usually represents less than 10 percent of the sand fraction; however, it can range to nearly 20 percent in concentrated zones. Both the Hornerstown and Vincentown sands contain numerous thin, hard layers, which resist penetration by sampling spoons due to cementation of the sand grains by calcium carbonate. PSE&G conducted detailed petrographic studies to investigate the character of cementation (References 2.5-6, 2.5-7, 2.5-8). The cemented layers usually range in thickness between several inches and one foot (up to 0.3 meter). The upper six to nine meters (30 to 40 feet) of the Vincentown Formation generally consists of quite strongly cemented rock lenses interspersed with partially cemented silty sands, while the lower portion of the Formation is more variable, ranging from slightly cemented sands to rock (Reference 2.5-5).

The Vincentown Formation is the foundation stratum for HCGS. The composite of this sandstone unit is calcareous, glauconitic, variably-cemented, fine-to-medium grained quartz sand. The sandstone is not divisible into refined stratigraphic units; however, three lithologically distinct layers were exposed to the walls of the foundation excavations (Reference 2.5-8). These layers are, from lowermost to uppermost:

a. Layer one - grayish-green, calcareous, glauconitic sandstone.

b. Layer two - oxidized yellow to reddish-brown weathered sand and sandstone.

c. Layer three - unweathered dark green, clayey, glauconitic sand.

Figure 2.5-3 shows a plot plan of the main excavation.

The Kirkwood Formation unconformably overlies the glauconitic sand unit. These sediments vary considerably in thickness because of the irregular configuration of the upper and lower Kirkwood contacts. The upper surface of the Kirkwood Formation is usually encountered between elevations 56 and 64 feet below MSL. Based on information from borings and excavation mapping, the Kirkwood strata are subdivided into two lithologically distinct subunits consisting of a 0.6 to 1.8 meter (2 to 6 foot) thick basal sand layer overlain by a thicker gray micaceous silty organic clay. The Kirkwood Formation identification of the two subunits is based upon their similarity to lithologies described within the Kirkwood unit stratigraphic position, and results of micropalentologic analysis (Reference 2.5-8).

The basal sand unit is composed of numerous beds of silt, sand, gravel and cobbles. The overlying organic clay layer is composed of a lower woody peat, and a peaty and clayey silt, that grade upward into a silty organic clay.

The contact between the organic clay and basal sand appears to be both unconformable and conformable in the excavation. The nature of the contact is interpreted to indicate that the two subunits are of similar age, but represent depositions from two laterally varying, adjacent but sharply different, sedimentary environments (Reference 2.5-8). An initial fluvial environment appears to have been slowly replaced by a freshwater marsh environment.

Quaternary Strata

The Kirkwood Formation is overlain by three lithologic units of Quaternary age. The lowest of these is a non-organic clay unit which directly overlies the organic clay of the Kirkwood Formation. The non-organic clay unit was distinguished from the Kirkwood clay on the basis of its texture, composition and micropaleontologic content (Reference 2.5-8). The non-organic clay unit varies in thickness from approximately 1.5 to 6 meters (5 to 20 feet). In general, it is thickest in the southern portion of the excavation, and thins to the north. The Quaternary age of this unit is based on mineralogic and micropaleontologic analyses (Reference 2.5-8).

The non-organic clay unit is overlain by coarse sands and gravels that formerly comprised the bed of the Delaware River. The thicknesses of these strata vary across the site from 0.5 to 4 meters (2 to 12 feet), and they consist of gray, fine-to coarse, subround-to-round gravel, with a trace of mica and glauconite. The uppermost and very recent unit consists of hydraulic fill, composed of irregular discontinuous lenses of gray, micaceous, clayey silt, fine silty sands and organic clays varying from 9 to 14 meters (30 to 45 feet) in thickness.

2.5.1.3 Structural Geology

The structural geology of the HCGS site has been investigated using an extensive boring program, seismic refraction surveys, and detailed examination and mapping of the foundation excavations. The results of these investigations are presented in detail in previously docketed reports (References 2.5-6, 2.5-7, 2.5-8); therefore, this section consists of a summary of the conclusions based on the results of earlier site investigations.

It is concluded from the site geological studies that the structure of the sedimentary strata below the site is limited to a sequence of uniformly dipping strata. The investigators detected no folds, shear zones, abrupt changes in stratigraphic elevations or anomalous sequences of strata (Reference 2.5-6). The structure of the strata at the site conforms with the regional character of the Atlantic Coastal Plain. It consists of a gently southeastward dipping homocline composed of a southeastward thickening wedge of sedimentary strata deposited on the pre-Cretaceous age basement complex.

Specific information regarding the geologic structure at the site is limited to the upper 137 meters (450 feet) of strata

(Reference 2.5-6). The depth to the basement surface in the site vicinity is approximately 457 meters (1500 feet) (Reference 2.5-9).

The slope of the basement surface is variable along the continental shelf; however, below the site it appears to slope uniformly to the southeast at approximately 23 to 30 meters per kilometer (75 to 100 feet per mile). Overlying this surface is a thick sequence of post-Jurassic terrestrial and marine sediment, which strikes northeast, and dips gently to the southeast. The dip of these strata appears to decrease up through the sequence as a result of the eastward thickening of the stratigraphic section.

Continuity of the stratigraphic units within 61 meters (200 feet) of the surface was established with information obtained by subsurface exploration with borings, and confirmed using geophysical techniques (Reference 2.5-6). Beneath the unconformity developed on the top of the Vincentown Formation, the strata maintain relatively uniform stratigraphic thicknesses, and dip to the southeast at approximately nine meters per kilometer (30 feet per mile). The conformable contact between the Mount Laurel Formation and the overlying Navesink Formation is a particularly distinct horizon beneath the site. This contact clearly represents a uniform surface below the site that exhibits minor undulations but lacks any discontinuities or abrupt changes in elevations.

The unconformable contact between the basal sands of the Kirkwood Formation and the underlying Vincentown Formation is an undulation displaying as much as six meters (20 feet) of relief. Subaerial exposure and fluvial erosion of the upper Vincentown unit is evident from the character of samples from borings and the examination of exposures in foundation excavations. The thickness of the Kirkwood Formation changes considerably at the site; however, these variations directly correspond to the relief observed on the underlying Vincentown unit (Reference 2.5-6).

Three stratigraphic contacts were mapped in detail as part of the examination of the foundation excavations. The three horizons are the upper and lower contact of the Kirkwood Formation basal sand and the top of the Kirkwood organic clay (Section 2.5.1.2).

Across the site in general, the top of the Vincentown Formation represents a surface of subaerial exposure and terrestrial erosion, as indicated by its relief and the zone oxidation. The elevation of the contact ranges from approximately 16 meters (51 feet) in the northeast area of the excavation to

nine meters (31 feet) in the southwest area. Several small channels, or shallow depressions, contribute to the undulatory character of this surface (References 2.5-6, 2.5-8).

In the northeast corner of the excavation, the slope of the upper contact of the Vincentown is interrupted by a minor, but abrupt, relief feature. Careful examination of the feature indicated that it is of erosional origin. The overlying upper contact of the basal sand, as well as intermediate bedding planes, cross this feature with no evidence of disruption.

The top of the Kirkwood basal sand unit in the northeast and eastern portion of the excavation suggests that this contact represents an erosional unconformity; however, this was not consistently observed, and in the southwest portion of the excavations the contact is more gradational and apparently conformable (Reference 2.5-8). In places, a transition facies, between the lower organic clay unit and the underlying basal sands, indicates continued deposition throughout a gradual change or shift in depositional environment.

The upper contact of the Kirkwood basal sand undulates gently across the site with a maximum topographic relief of three meters (11 feet). The trace of this contact appears almost flatlying to gently south-dipping along the east and west walls. Elsewhere, the contact trace undulates gently, and the depressions are filled with dark gray silty peat.

The uppermost stratigraphic contact mapped at the site separates the Quaternary non-organic clay unit from the underlying Kirkwood Formation organic clay unit. This contact is commonly marked by a persistent thin gravel layer. The contact appears to be a relatively conformable surface which represents a brief hiatus between varying depositional environments (Reference 2.5-8). The trace of this contact on the east and west excavation slopes has a gently apparent dip to the south. It merges with the underlying upper contact of the basal sand in the northeast portion of the excavation where the lower clay unit appears to pinch out.

The detailed mapping of the aforementioned stratigraphic contacts precludes the presence of faults, shear zones or folds within the Tertiary and Quaternary sediments exposed in the site excavations; however, several kinds of smaller structures were observed in the excavations (Reference 2.5-8). Of these structures, clay seams were the only features not obviously related to construction activities; however, their occurrence at shallow depth with respect to the dredge-cut surface, as well as their general morphology, suggest that the seams are

filled tensional fractures created by the excavation procedures (Reference 2.5-8). The common technique of undercutting the dredge banks to include large-scale slumping, as part of dredging, could well create such tensional fractures in small local areas. These seams were all located within the topographically higher oxidized Vincentown Formation in the northeast corner of the excavation; no exposures of similar features were observed within the approved foundation strata or in the overlying strata.

2.5.1.4 Site Engineering Geology

The engineering geology of the HCGS site has been investigated by extensive boring and laboratory testing programs, seismic refraction surveys, and detailed examination and mapping of the foundation excavations. Previously docketed reports contain detailed data and results of the site geotechnical investigations (References 2.5-5, 2.5-6, 2.5-7, 2.5-8).

Sections 2.5.1.2 and 2.5.1.3 describe the geologic conditions underlying the principal structures of the site. Section 2.5.3 discusses the static and dynamic engineering properties of the site foundation strata.

Section 2.5.1.3 summarizes the results of thorough examination and mapping of the site excavations. No deformational zones, such as shears, joints, fractures and folds, or combinations of these features, were identified at the site.

As a result of these investigations, it is concluded that there are no geologic deformational zones within the excavations which might have an adverse impact on the site foundations.

Investigators detected zones of alteration and weathering in the Vincentown Formation at the site. The lower portion of the Vincentown has undergone various degrees of cementation by normal diagenetic processes. PSE&G has investigated cementation of the Vincentown Formation using petrologic analysis (Reference 2.5-8). In addition, it was found to be suitable for foundation purposes on the basis of extensive testing programs. Sections 2.5.1.2 and 2.5.3 summarize the results of these investigations. The upper portion of the Vincentown Formation displayed a zone of weathering of variable thickness. This weathered zone was not considered suitable for the site foundations (Section 2.5.3), and was removed from the area of the main excavation (Reference 2.5-8).

Investigators detected no soils at the site that might be unstable because of their mineralogy or physical and chemical properties. Section 2.5.1.2 describes the site stratigraphy, and Section 2.5.3 provides information concerning the static and dynamic properties of the site foundation materials.

The conclusions of site geologic and geotechnical investigations indicate that no adverse conditions are expected to affect the site as a result of landsliding, subsidence or karst conditions.

2.5.2 SURFACE FAULTING

There is no known occurrence of surface faulting at or within eight kilometers (five miles) of the HCGS site. PSE&G conducted subsurface exploration and detailed mapping of excavations at the site to detect any evidence of surface faulting. Section 2.5.1 summarizes the results of these investigations, which were presented in previously docketed reports (References 2.5-6, 2.5-8). The conclusions reached as a result of these investigations provide that there is no evidence of surface faulting at the site proper.

2.5.2.1 Evidence of Fault Offset

There is no evidence of fault offset of the sedimentary strata comprising the Coastal Plain stratigraphic sequence at or near the site. Analysis of marker horizons using information from subsurface exploration (Section 2.5.1.2) (Reference 2.5-6) indicates that there is no fault offset of the principal stratigraphic contacts within the Late Cretaceous and Early Tertiary age strata which underlie the site; furthermore, investigators detected no evidence of fault offset within the sediments during detailed mapping of the foundation excavations (Section 2.5.1.3).

2.5.3 STABILITY OF SUBSURFACE MATERIALS AND FOUNDATIONS

2.5.3.1 Geologic Features

Section 2.5.1 discusses in detail the geologic features of the site, which are summarized below as they relate to engineering properties. A comprehensive field investigation program, including borings, trenches and geophysical surveys, was undertaken to determine the subsurface features at the site and their relevance to site stability.

The site lies within the Atlantic Coastal Plain Physiographic Province. The unconsolidated sediments of the Coastal Plain

comprise a stratigraphic sequence of interbedded sands, silts and clays, which generally dips toward the southeast. The surface of the crystalline bedrock is between 457 and 610 meters (1500 and 2000 feet) below the site.

The Coastal Plain sediments, which overlie the basement rocks, consist of a non-marine sequence of Lower Cretaceous strata and Upper Cretaceous-Tertiary marine deposits. Three formations of Tertiary age are present at the site. The lower Tertiary Hornerstown Formation lies unconformably on the Cretaceous age Navesink Formation, and consists of olive green to green quartz and glauconite sand. This formation grades into the overlying Vincentown sands, which consist of gray-green fine shell and quartz sand. The western half of the site contains an elongated shallow trough in the surface of the Vincentown, which may have been scoured to its present depth by streams which drained into the retreating sea.

The basal sands and overlying clays of the Miocene Kirkwood Formation lie on a thick sequence of the calcareous Vincentown sands. Pleistocene sand and gravel, which formerly comprised the bed of the Delaware River estuary, cover the top of the Kirkwood clays. Hydraulic fill was subsequently placed over these deposits, and now forms the surface of Artificial Island. A brief description of the Vincentown and overlying strata, which are the formations most directly affecting site stability, appears below; References 2.5-4 and 2.5-6 describe these strata in detail.

The hydraulic fill extends to a depth of about nine meters (30 feet) below the ground surface. This fill deposit is of man-made origin, having been deposited on the site as a result of channel maintenance in nearby areas. It is similar in gradation and texture to soils of recent deposits that underlie the fill. The composition of the fill ranges from irregular and sometimes discontinuous layers of micaceous silty clays, to clayey silts, to silty sands, with organics in some places. Between depths of three and five meters (10 and 15 feet) there are sporadic 0.6 to 1.5 meter (2 to 4 foot) thick sand lenses throughout the site. These lenses consist of fine-to-medium sand, usually with less than 15 percent silt. The hydraulic fill is generally loose or soft in consistency, and the fine-grained portions are highly plastic. Blow counts are low, generally between 2 and 100 blows per foot, with a maximum of 15 blows per foot.

Below the hydraulic fill is a gray sandy and gravelly material that formerly comprised the bed of the Delaware River. This layer varies in thickness from 0.5 to 2 meters (2 to 8

feet), and is composed of fine-to-coarse sand, little fine-to-coarse gravel and a trace of silt. The fines content is less than 20 percent, and D50 (grain size which is larger than 50 percent of particles in sample) varies from 0.2 to 0.75 millimeter. The blow counts from standard penetration tests generally vary from 20 to 85 blows per foot.

Below the old river bottom sand, the soils of the Kirkwood Formation extend to depths varying from 50 to 75 feet below the ground surface. The Kirkwood Formation consists of medium-stiff to stiff clayey soils ranging from high plastic organic clays near the surface of this formation to silty clays and clayey silts. The layer averages about six meters (20 feet) in thickness, generally grading slightly thicker to the south and west. At the northern end of the site, the clays of the Kirkwood Formation grade to clayey fine sand.

The basal sands of the Kirkwood Formation are approximately 0.6 to 2 meters (2 to 6 feet) thick. They are reddish-brown micaceous fine to medium sands, with a silt content of about 30 percent in the upper portion of the layer, generally grading coarse with depth, and becoming gravelly at the bottom of the layer. Blow counts from standard penetration tests vary generally between 20 and 70 blows per foot. The D50 size varies from approximately 0.07 to 0.3 millimeter.

Below the reddish-brown basal sands, the greenish-gray silt sands of the Vincentown Formation were typically found at a depth of about 20 meters (65 feet), elevation 35 feet below MSL; however, the elevation of the top of the Vincentown Formation ranges from about 7 to 15 meters (23 to 50 feet) below surface level. Beyond the main station area, to the northeast and east, the surface of the formation is relatively higher. A bright yellow-brown color of the soil, and composition of about 30 percent fines with a trace of shells, characterize these higher areas. This color is most likely a result of oxidation during exposure to air. Typically, the upper portion of this zone was found to be less dense than the lower zone. Investigators noted deeper-oxidized zones and shallow unweathered zones, indicating that the process was not a function of depth. In general, the Vincentown sands range from silty sands in the upper zone to poorly graded sands in the middle, to silty sands near the bottom of the formation.

Varying degrees of calcite cementation exist throughout the Vincentown Formation. PSE&G performed a petrographic study to evaluate the nature, degree and distribution of the cementation (Reference 2.5-7). Results of this study indicate that the effects of cementation are not always readily apparent to

the touch; some samples classified visually as uncemented are found to contain calcite cement when examined in thin sections. The cementation varies on a small scale (within a thin section or sample), but also on a larger scale, over the entire stratigraphic interval of the Vincentown Formation of HCGS. The upper portion of the formation, extending from about elevation 30 feet above MSL down to elevation zero, has been cemented to a greater degree than that portion of the formation below elevation zero. Although completely cemented (rock) lenses are present throughout the formation beneath the site, the intervening less-cemented lenses between elevations 30 feet and zero generally contain significantly higher percentages of calcite cement than do many of those lenses below elevation zero.

The effects of four main diagenetic processes are apparent in the Vincentown soils. These processes consist of subaerial weathering, solution of calcium carbonate, precipitation of calcite cement, and compaction of the Vincentown sediments. Solution and cementation are the most significant processes to have affected the Vincentown sediments since their disposition approximately 60 million years ago. Evidence points to the termination of significant alteration of the Vincentown sediments at some time during or slightly before Miocene time, about 25 million years ago. The rock lenses appear to represent the final stage of the cementation process, while the less-cemented samples represent intermediate stages in incomplete cycles of cementation.

The conclusion of the petrographic study is that the Vincentown Formation is a relatively strong and rigid structural unit whose behavior under static and dynamic loads cannot be evaluated by traditional methods of soil mechanics because of the cemented nature of the formation.

The soils below the Vincentown Formation, extending to the depths investigated, are generally silty sands, with variable amounts of silt. These soils are dense, and therefore are considered essentially incompressible under the small stresses induced by the construction.

Investigators observed no areas of actual or potential subsidence, uplift or collapse at the site.

2.5.4 GROUNDWATER CONDITIONS

As mentioned previously, the site lies within the Atlantic Coastal Plain, about 29 kilometers (18 miles) south of the Fall Zone. Interbedded aquifers and aquicludes (some of the strata may be more accurately described as aquitards rather

than aquicludes) of Cretaceous, Tertiary and Quaternary ages underlie the Coastal Plain. River bed sand and gravel compose the first aquifer encountered, which is called the "shallow" aquifer. Grayish-brown clay belonging to the Kirkwood Formation underlies the river bed sand and gravel.

The Kirkwood clay is underlain by a second aquifer, composed of the basal sand of the Kirkwood Formation, all of the Vincentown Formation, and the upper sands of the Hornerstown Formation.

A direct hydraulic connection exists from one sand layer to the next; therefore, for analytical purposes, the combination of these three sand units is referred to as the Vincentown (or "deep") Aquifer.

The Mount Laurel and Wenonah sands, referred to herein as the Mount Laurel-Wenonah aquifer, are separated from the overlying Vincentown Formation by a 12 meter (40 foot) thick aquitard, consisting of the Hornerstown and Navesink Formations.

Underlying the Mount Laurel-Wenonah aquifer are the Marshalltown Formation; the Englishtown sand, the Woodbury clay; the Merchantville clay; and the Raritan and Magothy Formations. From this group, only the Raritan and Magothy Formations constitute a significant aquifer at the site. The remaining formations are aquitards and aquicludes. See Section 2.4, for details.

In the strictest sense of the word, all of the soil formations underlying the HCGS site are hydraulically connected with each other, as none of the confining layers which separate the aquifers is completely impermeable. Whereas permeabilities are about 21 cubic meters per day per square meter (524 gallons per day per square foot) for the shallow aquifer, five cubic meters per day per square meter (124 gallons per day per square foot) for the Vincentown aquifer, and 4 cubic meters per day per square meter (100 gallons per day per square foot) for the Mount Laurel-Wenonah aquifer, the permeabilities of the confining beds are significantly less. The estimated vertical permeability for the Hornerstown and Navesink Formations is 0.02 cubic meter per day per square meter (0.4 gallon per day per square foot), and the Kirkwood clay is estimated at less than 0.2 cubic meter per day per square meter (5 gallons per day per square foot). Thus, the confining beds act as aquitards, and allow some leakage to occur between aquifers whenever there is a vertical hydraulic gradient between adjacent aquifers separated by an aquitard.

Section 2.4 gives a brief description of the major aquifers encountered at the site.

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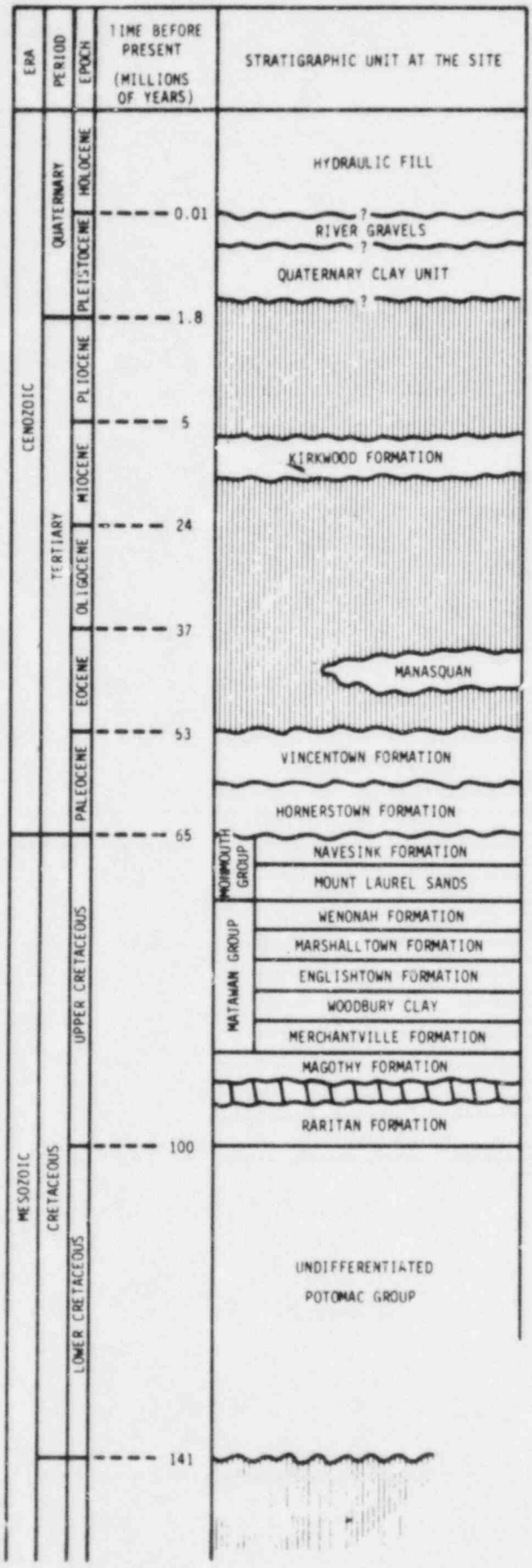
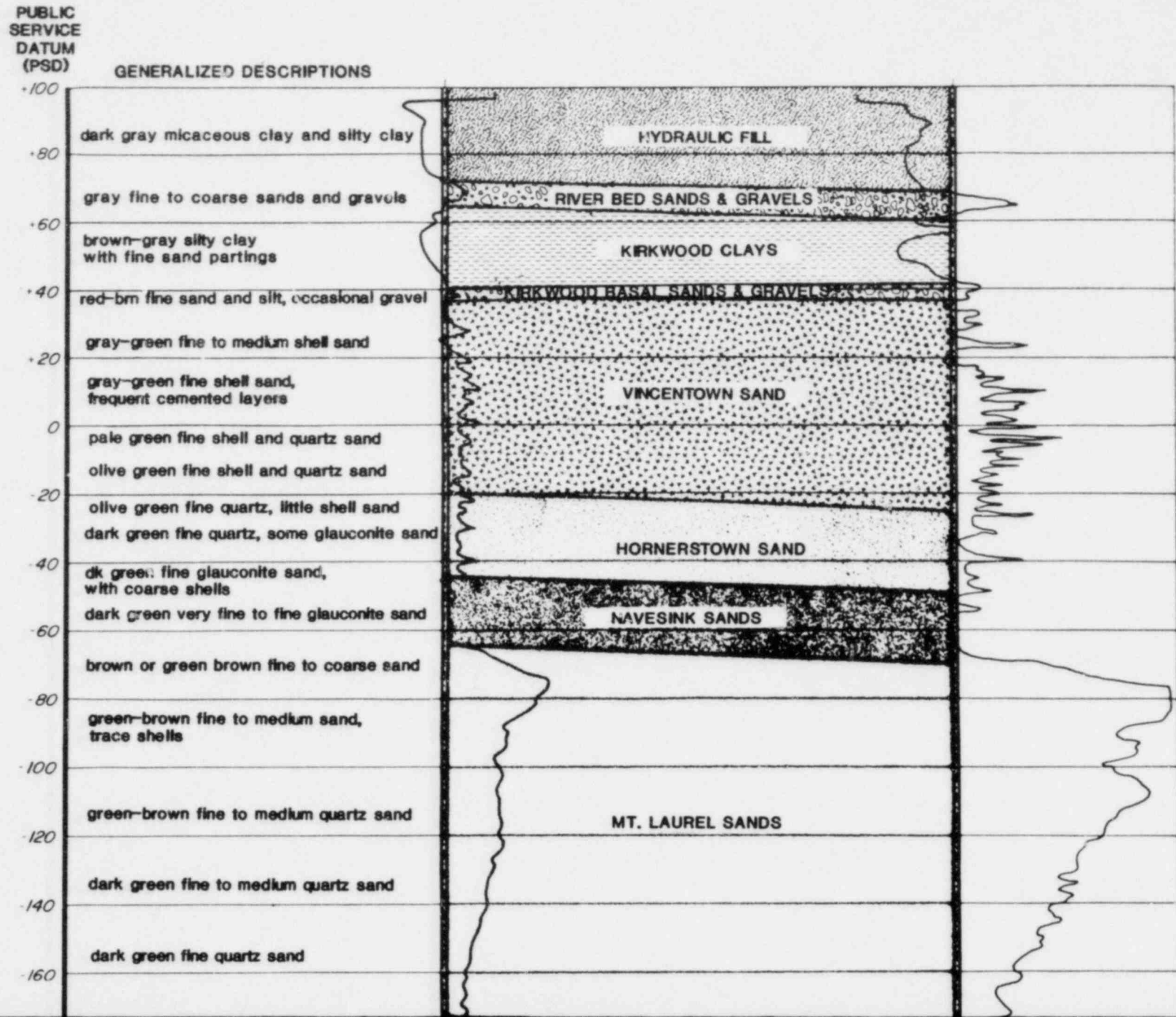


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SITE STRATIGRAPHIC RELATIONSHIPS

FIGURE 2.5 - 1


PUBLIC SERVICE DATUM (PSD)
GENERALIZED DESCRIPTIONS
+100
+80
+60
+40
+20
0
-20
-40
-60
-80
-100
-120
-140
-160
dark gray micaceous clay and silty clay
gray fine to coarse sands and gravels
brown-gray silty clay with fine sand partings
red-brn fine sand and silt, occasional gravel
gray-green fine to medium shell sand
gray-green fine shell sand, frequent cemented layers
pale green fine shell and quartz sand
olive green fine shell and quartz sand
olive green fine quartz, little shell sand
dark green fine quartz, some glauconite sand
dk green fine glauconite sand, with coarse shells
dark green very fine to fine glauconite sand
brown or green brown fine to coarse sand
green-brown fine to medium sand, trace shells
green-brown fine to medium quartz sand
dark green fine to medium quartz sand
dark green fine quartz sand
HYDRAULIC FILL
RIVER BED SANDS & GRAVELS
KIRKWOOD CLAYS
KIRKWOOD BASAL SANDS & GRAVELS
VINCENTOWN SAND
HORNERSTOWN SAND
NAVESINK SANDS
MT. LAUREL SANDS

PRC APERTURE CARD

NOTES:

PUBLIC SERVICE DATUM (PSD)
PSD 89.0FT = 0.0MSL

SINGLE POINT RESISTANCE LOG

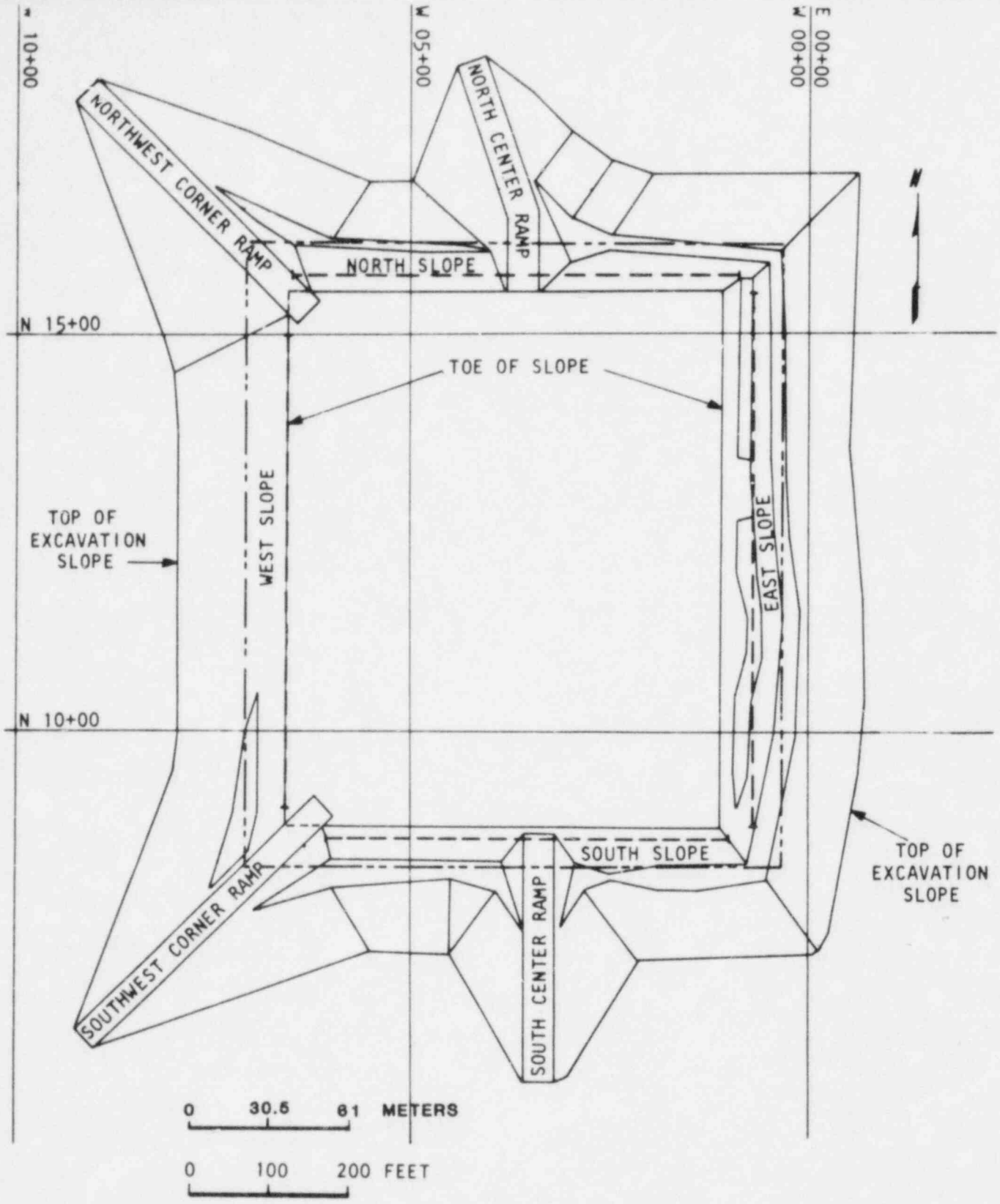
Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

STRATIGRAPHY OF
DEEP TEST BORINGS

FIGURE 2.5 - 2



LEGEND:

⊢– – –⊣ LOCATION OF EXCAVATION SLOPE PROFILES

—– – – LIMIT OF AREA INCLUDED IN STRUCTURAL CONTOUR MAPS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

PLOT PLAN OF MAIN EXCAVATION

FIGURE 2.5 - 3

2.6 REGIONAL HISTORIC, ARCHAEOLOGICAL, ARCHITECTURAL, SCENIC, CULTURAL AND NATURAL FEATURES

HCGS is located in an area which is rich in history. Both Salem County, New Jersey and New Castle County, Delaware were among the first regions in the country to be settled. Although a considerable amount of cultural resource survey data are available for New Castle County (References 2.6-1 and 2.6-2), less is available for Salem County (Reference 2.6-3). A Stage I Cultural Resource Survey for Fort Mott, located approximately 16 kilometers (10 miles) north of HCGS in Lower Pennsville, New Jersey, was completed in 1979 (Reference 2.6-4). A recently released report concerns the restoration of Fort Mott (Reference 2.6-5). An archaeological excavation undertaken in the city of Salem uncovered no cultural resources (Reference 2.6-6). The plant site is located on Artificial Island, which was created early in the twentieth century from the deposition of dredge material by the U. S. Army Corps of Engineers; therefore, the site property holds no archeological significance.

Salem County's original inhabitants were the semi-nomadic, agriculturally oriented Lenni-Lenape indian tribe. Since there was no established settlement in the vicinity of the site, traces of their existence are limited to artifacts.

John Fenwick, a Quaker who purchased the land from Lord Berkeley, one of New Jersey's first proprietors, founded the city of Salem in 1675 (Reference 2.6-7). It was once a bustling port area, whose economy centered around the Delaware River and the fertile farmland. Caspar Wistak of Philadelphia introduced the first glassworks to the area in 1738; this industry has continued to be prominent to this day.

The Salem area was of significance during the Revolutionary War. General George Washington dispatched General "Mad Anthony" Wayne to Salem (Fenwick's Colony) to obtain food for the starving Continental Army at Valley Forge. The local residents were extremely generous in supplying the troops with the needed provisions. The British retaliated by sending troops into the Salem County area to quell local resistance. The Tory troops captured a contingent of local patriots and massacred all but two of them in the William Hancock House (Reference 2.6-8).

Of historical interest are the twenty-nine remaining eighteenth-century brick dwellings and meeting houses with patterned or decorated gable ends (Reference 2.6-9). Nearest to the site is the Chambless House, located on the east side of Alloways Creek Neck Road, approximately 6.2 kilometers (3.9 miles) from the station. Built in 1730, it is one of the oldest examples of this architectural style (Reference 2.6-10). The Chambless House is not presently lived in or maintained. The Hancock House in Hancocks's Bridge, which is listed on the National Register of Historic Places, is said to have been patterned after the Chambless House.

Pursuant to the National Historic Preservation Act of 1966, the National Park Service annually lists properties on the the National Register of Historic Places. Listed properties have met the criteria for inclusion on the Register. Additional properties, determined by the Advisory Council on Historic Preservation to be eligible for inclusion in the Register, are also listed annually by the National Park Service. Many of these properties are already listed on state registers.

Table 2.6-1 contains properties, listed on the National Register of Historic Places, that are located within a 16 kilometer (10 mile) radius of HCGS (References 2.6-11 and 2.6-12). For the locations of these properties, see Figure 2.6-1.

The following districts in New Castle County, Delaware, are listed as eligible for inclusion on the National Register of Historic Places (Reference 2.6-12):

a. Delaware City Historic District
b. St. Georges Historic District
c. Townsend Historic District

There are no sites in New Jersey within a 16 kilometer (10 mile) radius of HCGS that are listed as eligible for the National Register of Historic Places (Reference 2.6-3). However, the Broadway Historic District in Salem City is pending nomination to the State and National Registers of Historic Places (Reference 2.6-13).

Table 2.6-2 identifies historic sites listed on the National Register of Historic Places within 2 kilometers (1.2 miles) of either side of the Salem - New Freedom portion of the Salem - Deans transmission line (see Figure 3.9-3). There are no sites classified as eligible for inclusion on the Register (Reference 2.6-3).

The National Park Service also maintains the National Natural Landmarks Program, whose purpose is to identify and preserve areas that illustrate the ecological and geological character of the United States. At present, there are no listed sites within a 16 kilometer (10 mile) radius of HCGS or within 2 kilometers (1.2 miles) of either side of the Salem - New Freedom portion of the Salem - Deans transmission line. Section 2.1.3 lists wildlife management areas, state parks and other open space categories.

Section 5.6 discusses the visual effects of the station and transmission lines on the historic sites previously mentioned.

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2.6-10 David Culver, Quote from the "Islander" Newspaper, December, 1981.

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TABLE 2.6-1

HISTORIC PROPERTIES LISTED ON THE
NATIONAL REGISTER OF HISTORIC PLACES AS OF NOVEMBER, 1982
WITHIN 16 KILOMETERS (10 MILES) OF HCGS

LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
SALEM COUNTY, NEW JERSEY	
Elsinboro Township	
1. HOLMELAND (Benjamin Holme's House), Fort Elfsborg Hancocks Bridge Road	08/31/78
2. SAMUEL AND SARAH NICHOLSON HOUSE (1752), Amwellbury Road	02/24/75
Lower Alloways Creek	
3. HANCOCK HOUSE (1734) Hancocks Bridge, Locust Island Road	12/18/70
Pennsville Township	
4. FINN'S POINT REAR RANGE LIGHT (1876) Intersection of Fort Mott and Lighthouse Roads	08/30/78
5. FORT MOTT AND FINN'S POINT NATIONAL CEMETERY DISTRICT (1865) On the Delaware River at Finn's Point	08/31/78
Salem City	
6. MARKET STREET HISTORIC DISTRICT (18-19th Century) Area includes 9-119 Market Street, and East Broadway	04/10/75
CUMBERLAND COUNTY, NEW JERSEY	
Greenwich Township	

TABLE 2.6-1 (Continued)

	LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
7.	THOMAS MASKEL HOUSE (1698, 1725) Bacon's Neck Road	06/10/75
	NEWCASTLE COUNTY, DELAWARE	
	Blackbird Crossroads	
8.	OLD UNION METHODIST CHURCH 0.3 kilometers (0.2 miles) north of Blackbird Crossroads on U.S. 13	01/18/73
	Delaware City	
9.	CHELSEA HOUSE	04/08/82
10.	EASTERN LOCK OF THE CHESAPEAKE AND DELAWARE CANAL Battery Park	04/21/75
	Delaware City Vicinity	
11.	FAIRVIEW 0.8 Kilometers (0.5 miles) west on DE 411	04/08/82
12.	FORT DELAWARE ON PEA PATCH ISLAND Pea Patch Island in the Delaware River	12/16/71
	Middletown	
13.	GREENLAWN (OUTTEN DAVIS HOUSE; WILLIAM BRADY HOUSE) North Broad St.	04/24/73
14.	MIDDLETOWN ACADEMY 218 North Broad St.	12/05/72
15.	MIDDLETOWN HISTORIC DISTRICT roughly bounded by Redding, Scott , Lockwood and Catherine Sts.	10/04/78

TABLE 2.6-1 (Continued)

LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
16. PHILIP READING TANNERY 201 East Main St.	04/26/78
17. ST. JOSEPH'S CHURCH, 15 West Cochran St.	02/17/78
Middletown Vicinity	
18. ARNOLD S. NAUDAIN HOUSE South of Middletown on DE 71	04/24/73
19. NOXONTOWN South of Middletown off DE 896	07/02/73
20. OLD ST. ANNE'S CHURCH South of Middletown off DE 71	03/07/73
21. ACHMESTER North of Middletown on SR 429	12/28/79
Odessa	
22. APPOQUINIMINK FRIENDS MEETINGHOUSE Main St.	12/04/72
23. CORBIT-SHARP HOUSE Southwest corner of Main and 2nd Sts.	12/24/67
24. ODESSA HISTORIC DISTRICT Bounded roughly by Appoquinimink Creek on southeast, High St. on northeast, 4th St. on northwest and Main St. on southwest	06/21/71
25. OLD DRAWYERS CHURCH U.S. 13	02/06/73
Odessa Vicinity	
26. DUNCAN BEARD SITE	12/18/73

TABLE 2.6-1 (Continued)

	LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
27.	HELL ISLAND SITE South of Odessa	04/13/77
28.	COMDR. THOMAS MACDONOUGH HOUSE North of Odessa on U.S. 13	12/12/78
29.	SERECK SHALLCROSS HOUSE (OAKLAND) West of Odessa off U.S. 13	04/03/73
30.	WILLIAMS HOUSE 1.9 kilometers (1.2 miles) northwest of Odessa on Mar Pit Rd.	06/04/73
31.	MONTEREY North of Odessa on Bayview Rd.	12/05/80
	Port Penn	
32.	PORT PENN HISTORIC DISTRICT DE 9	11/20/73
	Port Penn Vicinity	
33.	ASHTON HISTORIC DISTRICT North of Port Penn on Thormton Rd.	11/15/78
34.	AUGUSTINE BEACH HOTEL South of Port Penn on DE 9	04/03/73
35.	DILWORTH HOUSE Off DE 9	11/27/73
36.	HAZEL GLEN West of Port Penn on DE 420	11/20/78
37.	LISTON RANGE REAR LIGHT STATION West of Port Penn on DE 2	11/15/78
38.	JOHN B. NELSON HOUSE West of Port Penn off U.S. 13	12/08/78

TABLE 2.6-1 (Continued)

	LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
	Smyrna Vicinity	
39.	BRICK STORE East of Smyrna on DE 488	08/14/73
40.	CLEARFIELD FARM North of Smyrna on DE 485	03/20/73
41.	FLEMING HOUSE Northeast of Smyrna on DE 9	01/31/80
	St. Georges	
42.	BLOOMFIELD	04/08/82
43.	ROY HOUSE	04/08/82
44.	SUTTON HOUSE Broad and Delaware Sts.	04/24/73
	St. Georges Vicinity	
45.	BIDDLE HOUSE South of St. George on U.S. 13	12/08/78
46.	DRAGON RUN FARM 1.9 kilometers (1.2 miles) west on DE 407	04/08/82
47.	LINDEN HILL 0.8 kilometers (0.5 miles) north on U.S. 13	04/08/82
48.	MCCOY HOUSE 2.2 kilometers (1.4 miles) west on DE 407	04/08/82
49.	ST. GEORGE'S CEMETERY AND CARETAKER'S HOUSE 1.3 kilometers (0.8 miles) west on DE 409	04/08/82

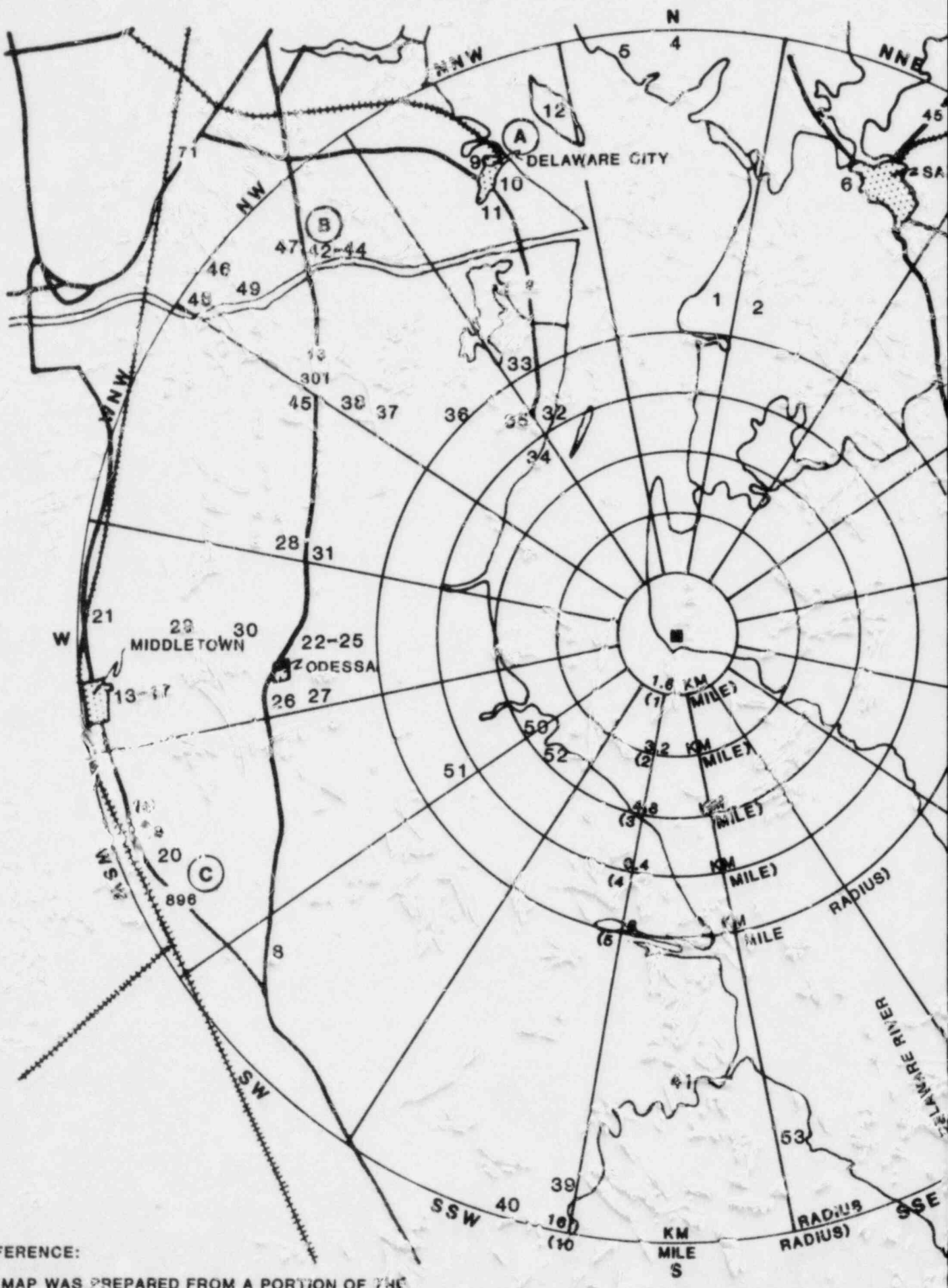
TABLE 2.6-1 (Continued)

LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
Taylors Bridge Vicinity	
50. HART HOUSE East of Taylors Bridge on DE 453	03/20/73
51. HUGUENOT HOUSE (HOMESTEAD FARM, NAUDAIN HOUSE) West of Taylors Bridge on DE 9	03/20/73
52. LISTON HOUSE East of Taylors Bridge on DE 453	03/26/73
KENT COUNTY, DELAWARE	
Woodland Beach Vicinity	
53. THOMAS SUTTON HOUSE (NEWBERRY) DE 79 Within Woodland Beach Wildlife Area	04/11/73

TABLE 2.6-2

HISTORIC PROPERTIES LISTED ON THE
NATIONAL REGISTER OF HISTORIC PLACES AS OF NOVEMBER, 1982
ALONG THE SALEM - NEW FREEDOM PORTION OF
THE SALEM-DEANS TRANSMISSION LINE

LOCATION	DATE ADOPTED TO NATIONAL REGISTER OF HISTORIC PLACES
SALEM COUNTY	
Hancocks Bridge	
1. HANCOCK HOUSE (1734) Locust Island Road	12/18/70
Upper Pittsgrove Township	
2. PITTSGROVE PRESBYTERIAN CHURCH (1767) State Route 14, Alloway - Daretown and Daretown Roads	09/19/77
Elmer Borough	
3. DAVE C. SMITH HOUSE (1830) 104 South Main Street	05/17/76



REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1968

HISTORIC FEATURES LISTED ON THE NATIONAL REGISTER OF HISTORIC PLACES

1. HOLMELAND
2. SAMUEL AND SARAH NICHOLSON HOUSE
3. HANCOCK HOUSE
4. FINN'S POINT REAR RANGE LIGHT
5. FORT MOTT AND FINN'S POINT NAT'L CEMETERY DISTRICT
6. MARKET ST. HISTORIC DISTRICT
7. THOMAS MASKEL HOUSE
8. OLD UNION METHODIST CHURCH
9. CHELSEA HOUSE
10. EASTERN LOCK OF THE CHESAPEAKE AND DELAWARE CANAL
11. FAIRVIEW
12. FORT DELAWARE ON PEA PATCH ISLAND
13. GREENLAWN (OUTTEN DAVIS HOUSE: WILLIAM BRADY HOUSE)
14. MIDDLETOWN ACADEMY
15. MIDDLETOWN HISTORIC DISTRICT
16. PHILIP READING TANNERY
17. ST. JOSEPHS CHURCH
18. ARNOLD S. NAUDAIN HOUSE
19. NOXONTOWN
20. OLD ST. ANNE'S CHURCH
21. ACHMESTER
22. APPOQUINIMINK FRIENDS MEETINGHOUSE
23. CORBIT-SHARP HOUSE
24. ODESSA HISTORIC DISTRICT
25. OLD DRAWYERS CHURCH
26. DUNCAN BEARD SITE
27. HELL ISLAND SITE
28. COMDR. THOMAS MACDONOUGH HOUSE
29. SERECK SHALLCROSS HOUSE (OAKLAND)
30. WILLIAMS HOUSE
31. MONTEREY
32. PORT PENN HISTORIC DISTRICT
33. ASHTON HISTORIC DISTRICT
34. AUGUSTINE BEACH HOTEL
35. DILWORTH HOUSE
36. HAZEL GLEN
37. LISTON RANGE REAR LIGHT STATION
38. JOHN B. NELSON HOUSE
39. BRICK STORE
40. CLEARFIELD FARM
41. FLEMING HOUSE
42. BLOOMFIELD
43. ROY HOUSE
44. SUTTON HOUSE
45. BIDDLE HOUSE
46. DRAGON RUN FARM
47. LINDEN HILL
48. MCCOY HOUSE
49. ST. GEORGE'S CEMETERY AND CARETAKER'S HOUSE
50. HART HOUSE
51. HUGUENOT HOUSE (HOMESTEAD FARM, NAUDAIN HOUSE)
52. LISTON HOUSE
53. THOMAS SUTTON HOUSE (NEWBERRY)

Also Available On Aperture Card

PRC APERTURE CARD

HISTORIC SITES ELIGIBLE FOR LISTING ON THE NATIONAL REGISTER OF HISTORIC PLACES

A. DELAWARE CITY HISTORIC DISTRICT
B. ST. GEORGE'S HISTORIC DISTRICT
C. TOWNSEND HISTORIC DISTRICT

1 0 1 2 3
MILES

1 0 1 2 3
KILOMETERS

8306290435 - 38

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

HISTORIC SITES WITHIN 10 KILOMETERS (16 MILES) OF SITE

FIGURE 2.6 - 1

2.7 NOISE

PSE&G conducted an ambient sound level survey for the area surrounding HCGS and near various transmission corridors on August 18 and 19, 1982. Ambient sound levels were measured and compared to the New Jersey Administrative Code, Title 7, Chapter 29 (Noise Control for Industrial and Commercial Operations). Limits for continuous airborne sound levels at the nearest residential property line are 65 dBA between 7:00 a.m. and 10:00 p.m., and 55 dBA between 10:00 p.m. and 7:00 a.m. (Reference 2.7-1).

Thirty monitoring locations within an eight kilometer (five mile) radius of HCGS were selected. These locations should be representative of the surrounding area. Sixteen of these locations are in New Jersey; the rest are in Delaware. The locations encompassed normally accessible areas including population centers. The area consists mostly of rural areas and marshlands along the banks of the Delaware River. The points of monitoring are near most of the small settlements in the area, although there are some places where residences are widely scattered along the roads.

The ambient sound levels were measured twice at all locations, during day and night hours; these measurements are sufficient to assess differences due to human activities. Measurements at each monitoring point consisted of five-minute readings on the A-weighted scale, and octave band analyses. The A-weighted scale is designed to duplicate the human ear in its response to sound. An octave band analysis was performed immediately following each measurement. A B and K sound level meter PS931 Type 2204 with octave filter set and a B and K piston phone calibrator were used in the survey. Instruments were calibrated with standards traceable to the National Bureau of Standards, and rechecked after the test.

Tables 2.7-1 through 2.7-4 show day and night sound level readings and octave band analyses for locations indicated on Figure 2.7-1.

Points 5, 6 and 7 are located along the private access roads to HCGS and Salem Generating Station. Points 8 and 9 are located outside HCGS, within a few hundred feet of the center of the construction area. The nearest residential property is five kilometers (three miles) away.

Points 4, 5, 6, 7, 8, 12 and 15 are located within 50 meters (160 feet) of three existing 500 kilovolt transmission lines (see the attached map).

Sound levels at points 1 through 4 and points 10 through 30 were within New Jersey limits for day and night measurements for the A-weighted and octave band scales.

Although not near any residences, points 5 through 9 had sound levels above the New Jersey limits for residential property boundaries, for both A-weighted measurements and other octave band measurements. It is most probably construction at HCGS that caused these levels. The proximity of these monitoring points to Salem Generating Station, where both units were running at the time of measurement, also influenced sound levels at these monitoring points.

The entire area within an eight kilometer (five mile) radius of HCGS lies within the air approaches to Philadelphia, Pennsylvania and Wilmington, Delaware. A high frequency of air traffic during both day and night hours was apparent and could have influenced all the measurements made in this survey.

REFERENCES

2.7-1 Noise Control for Industrial and Commercial Operations, New Jersey Administrative Code, Title 7, Chapter 29-1.2.

TABLE 2.7-1

NEW JERSEY DAYTIME READINGS
FOR AMBIENT SOUND LEVEL

TEMPERATURE: 28.8°C (84°F)
WIND SPEED: 8 TO 16 KILOMETERS PER HOUR
(5 TO 10 MILES PER HOUR)

		Octave Band								
Point	A dBA	31.5	63	125	250	500	1K	2K	4K	8K
1	47	55	56	56	48	42	40	35	32	20
2(3)	44	47	45	42	33	26	22	19	26	45
3	41	57	55	52	50	38	36	34	25	20
4	43	54	53	51	50	38	35	33	28	20
5(2)	58	80	76	68	60	52	45	37.5	32	24
6(1)	55	76	70	63	57	50	48	42	35	28
7(1)	60	81	78	68	63	54	48	41	35	25
8(1)	59	81	76	67	60	54	49	45	38	28
9(1)	57	86	80	68	60	55	52	47	40	30
10	40	46	45	42	35	26	25	20	30	32
11	44	46	45	43	32	25	22	22	32	43
12	44	48	48	45	30	28	26	24.5	30	48
13	41.5	45	44	43	32	25	24	25	31	42
14	45	47	45	42	33	29	27	30	32	40
15	42	45	49	48	36	31.5	31	30	27	28
16	46	50	49	47	41	41	38	35	33	25

Measurements made between 4 and 8 p.m., August 18, 1982.

(1) Point near Hope Creek site; construction in progress, vehicular and machinery noise continuous.

(2) On access road to Hope Creek - Salem complex. Heavily trafficked in daylight hours. Virtually impossible to obtain measurements without vehicular noise influence.

(3) Eight kilohertz octave band out of limits; repeated measurements verified this reading.

TABLE 2.7-2

NEW JERSEY NIGHTTIME READINGS
FOR AMBIENT SOUND LEVEL

TEMPERATURE: 18.8°C (66°F)
WIND SPEED: 8 TO 16 KILOMETERS PER HOUR
(5 TO 10 MILES PER HOUR)

Point	A dBA	Octave Band 31.5	63	125	250	500	1K	2K	4K	8K
1	41	46	45	43	40	38	36.5	36	35	28
2	42	51	52	46	30	22	21	31	37	35
3	44	46	44	42	38	35	35	34	32	26
4	45	44	41	38	34	32	30	29	26	23
5	46	44	42	40	34	32	31	30	28	35
6(1)	42	50	42	40	33	34	33	32	30	28
7(1)	50	58	56	52	44	42	40.5	38	35	32.5
8(1)	55	64	62	60	53	52	50	45	40	30
9(1)	51	61	56	55	51	47	45	45	42	30
10	38	41	41	44	30	22	20	36	27	20
11	36	40	40	35	24	20	11	26	32	31
12	44.5	45	44	41	23	20	17	40	42	36
13	44	54	51	40	30	22	17	24	42	30
14	44	46	42	38	31	25	24	38	37	25
15	39.2	44	42	40	27	23	19	36	34	22
16	42	41	43	42	39	37	33	35	32	26

Measurements made between
11:00 p.m., August 17, 1982 and 3:30 a.m., August 18, 1982.

(1) Point near Hope Creek site; construction in progress, vehicular and machinery noise continuous.

TABLE 2.7-3

DELAWARE DAYTIME READINGS
FOR AMBIENT SOUND LEVEL

TEMPERATURE: 27.8°C (82°F)
WIND SPEED: 16 TO 24 KILOMETERS PER HOUR
(10 TO 15 MILES PER HOUR)

		Octave Band								
Point	A dBA	31.5	63	125	250	500	1K	2K	4K	8K
17	46	62	57	52	48	42	34	30	23	19
18	46	65	60	54	47	42	40	39	35	26
19	44	60	58	54	46	36	30	26	22	18
20	45	66	61	55	45	40	30	25	20	19
21	47	65	60	57	52	46	44	35	27	15
22	47	64	59	56	50	36	34	32	24	22
23	46	61	56	53	49	46	40	35	24	20
24	47	62	59	56	52	38	35	24	20	12
25	48	60	55	52	49	44	38	28	24	20
26	45	61	56	50	46	40	30	24	20	14
27	48	65	60	57	50	44	28	20	15	10
28	47	62	60	55	50	38	26	21	19	15
29	45	57	53	48	45	33	28	20	18	12
30	45	57	52	47	45	34	29	21	19	12

Measurements made between
1:30 p.m. and 9:15 p.m., August 19, 1982.

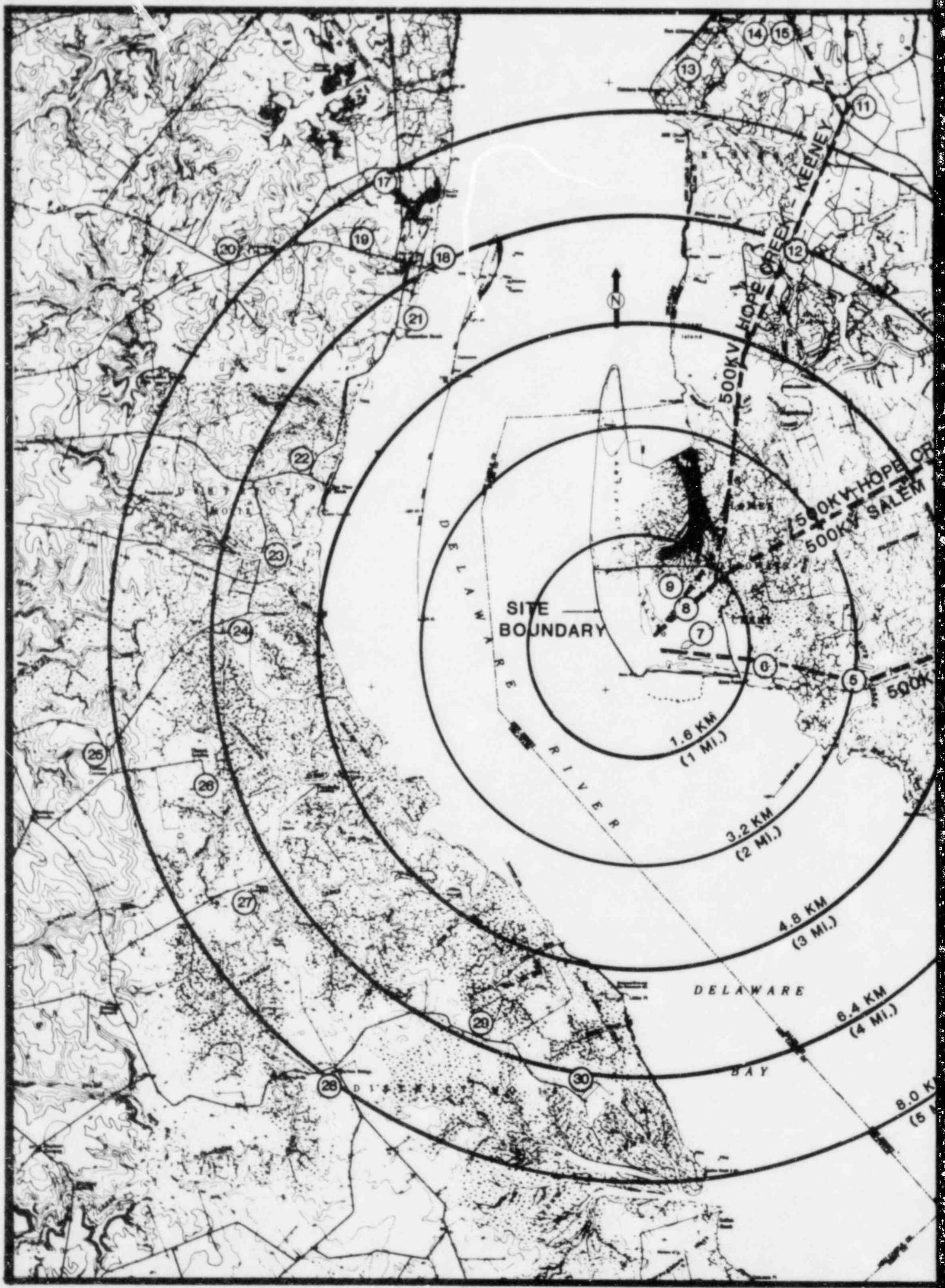
TABLE 2.7-4

DELAWARE NIGHTTIME READINGS
FOR AMBIENT SOUND LEVEL

TEMPERATURE: 17.8°C (64°F)
WIND SPEED: 16 TO 24 KILOMETERS PER HOUR
(10 TO 15 MILES PER HOUR)

		Octave Band								
Point	A dBA	31.5	63	125	250	500	1K	2K	4K	8K
17	40	57	50	46	40	35	26	24	17	12
18	48	68	60	52	45	41	37	35	32	24
19	41	58	55	48	40	34	27	21	19	16
20	40	63	57	49	38	36	26	20	18	15
21	38	54	50	42	35	32	26	22	18	12
22	40	56	50	47	42	36	32	26	20	14
23	44	58	53	49	46	40	32	29	20	16
24	36	60	56	52	47	33	29	22	18	10
25	40	57	54	49.5	42	35	29	22	20	17
26	45	60	55	49	47	39	28	21	16	10
27	44	59	56	49	46	37	25	19	13	8
28	40	56	53	50	42	32	24	20	15	12
29	39	53	49	46	41	28	24	19	16	10
30	40	52	49	45	40	24	22	19	17	10

Measurements made between
10:45 p.m., August 19, 1982 and 4:30 a.m., August 20, 1982.


SITE
BOUNDARY
1.6 KM
(1 MI.)
3.2 KM
(2 MI.)
4.8 KM
(3 MI.)
6.4 KM
(4 MI.)
8.0 K
(5
500KV HOPE CREEK KEENEY
500KV HOPE CR
500KV SALEM
500K
DELAWARE RIVER
DELAWARE
BAY
N

SCALE

1 0 1 2 3

MILES

1 0 1 2 3 4 5

KILOMETERS

LEGEND

NEW JERSEY AREA

1. NEAR HANCOCK HOUSE
2. POPLAR STREET
3. BUTTONWOOD AND POWELL STS.
4. AT BEGINNING OF SALEM - HOPE CREEK ACCESS ROAD
5. BRIDGE OVER HOPE CREEK
6. FORK OF ACCESS ROADS
7. FORK OF ACCESS ROADS
8. ROAD ADJACENT TO NUCLEAR DIVISION BUILDING
9. HOPE CREEK ACCESS ROAD
10. HAGERVILLE RD. AND WALNUT ST.
11. FT. ELSBORG AND MONEY ISLAND RDS.
12. END OF MONEY ISLAND ROAD
13. END OF FT. ELSBORG RD. (NEAR BAY)
14. LOCUST ST. AND RIVERVIEW DRIVE
15. NEAR SALEM COUNTRY CLUB
16. CANTON AND HARMERSVILLE ROADS

DELAWARE AREA

17. RTE. 9 AND ROAD 418
18. END OF TOWN (SMALL CONC. BRIDGE LOOKING TOWARD BAY)
19. NEAR POST WITH SIREN
20. PORT PENN RD. AND BOYD'S CORNER RD.
21. AUGUSTINE BEACH
22. ST. AUGUSTINE AND BELTS RDS.
23. MIDDLE OF WOODEN BRIDGE
24. ON RTE. 9 (224 WHEATLEY)
25. RTE. 9 AND ROAD 424
26. END OF THOMAS LANDING RD.
27. END OF PAVED ROAD
28. TAYLORS BRIDGE, FLEMINGS LANDING AND CEDAR SWAMP RDS.
29. NEAR POLE WITH SIREN (MARKED "29")
30. END OF CEDAR SWAMP ROAD

---- 500KV TRANSMISSION LINES

PRC APERTURE CARD

Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

NOISE SURVEY

8306290435-39

FIGURE 2.7 - 1

HCGS OLER

CHAPTER 3

THE STATION

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CHAPTER 3

THE STATION

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CHAPTER 3

THE STATION

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CHAPTER 3

THE STATION

3.1 EXTERNAL APPEARANCE

3.1.1 PHYSICAL APPEARANCE

PSE&G discussed the external appearance of the station during the construction permit stage. The external appearance was also described in the FES. The most significant appearance change to date has been the elimination of the Unit 2 cooling tower and the reactor building containment.

The following section is a combination of updated information and relevant material previously reported.

The station consists of one 1,067 megawatt nuclear generating unit with associated facilities.

Figure 3.1-1 shows an oblique graphic representation of the completed station. Figures 3.1-2 and 3.1-3 show the off-site appearance of the station from two accessible areas: from the intersection of the Artificial Island access road with Alloway Creek Neck Road, and from the Delaware River shipping channel approximately 1.6 kilometers (one mile) off shore, respectively.

The principal building at the station is a rectangular turbine building approximately 111 meters (364 feet) long in a north-south direction and 59 meters (195 feet) wide in an east-west direction. The building extends approximately 29 meters (96 feet) above grade. The turbine building is adjoined by the former Unit 2 turbine building, a portion of which is utilized as the administration facility, and the auxiliary building.

The T-shaped auxiliary building is subdivided into a radwaste/service area and a control/diesel generator area. The radwaste/service area is a rectangular structure approximately 168 meters (550 feet) long in a north-south direction and 27 meters (88 feet) wide in an east-west direction. The radwaste/service area extends approximately 21 meters (69 feet) above grade. The radwaste/service area is adjoined by the control/diesel generator area, reactor building, administration facility and turbine building. The control/diesel generator area is approximately 73 meters (241 feet) long in an east-west direction and 50 meters (165 feet) wide in a

north-south direction. The building extends approximately 29 meters (96 feet) above grade. The control/diesel generator area is adjoined by the reactor building, the radwaste/service area and the former Unit 2 reactor building.

The reactor building has a diameter approximately 50 meters (165 feet) across, extends 61 meters (200 feet) above grade, and is 59 meters (193 feet) wide in a north-south direction and 68 meters (224 feet) wide in an east-west direction. The reactor building is bounded by the control/diesel generator area and the radwaste/service area.

The rectangular service water intake structure extends 34 meters (112 feet) in a north-south direction and 23 meters (75 feet) in an east-west direction. It rises approximately 11 meters (35 feet) above grade, and is located approximately 244 meters (800 feet) west of the reactor building. The intake structure is bordered on each side by a cellular cofferdam extending 15 meters (50 feet) to the south and 30 meters (100 feet) to the north.

The hyperbolic natural draft cooling tower is the most prominent feature on Artificial Island. Its base diameter and height above nominal plant grade are approximately 132 meters (432 feet) and 157 meters (516 feet), respectively.

The switchyard, which is located approximately 107 meters (350 feet) east of the turbine building, measures 966 meters (600 feet) in a north-south direction and 229 meters (750 feet) in an east-west direction.

The auxiliary boiler building is 30 meters (100 feet) long in the east-west direction and 28 meters (93 feet) long in the north-south direction. The main portion of the building extends approximately 7 meters (23 feet) above grade. The auxiliary boiler building lies 91 meters (300 feet) north of the administration facility.

Access to HCGS is achieved by an 8.5 kilometer (5.3 mile) road that connects with Alloway Creek Neck Road about 4.8 kilometers (three miles) east of the site. A main gate and guardhouse facility at the intersection of the fence area with the access road controls entry to station.

Building access is coordinated with a road running throughout the station area. The parking area is located outside the fence perimeter.

Table 3.1-1 lists the sources and elevations of gaseous and liquid wastes within HCGS; these are shown on Figure 3.1-4.

3.1.2 AESTHETICS

The architectural design of the station reflects a functional facility with an aesthetic design that blends, as harmoniously as possible, with the surrounding environment. Planning of principal buildings, structures, roads and other equipment has been integrated into the overall architectural design.

The turbine buildings' exterior walls are a combination of precast concrete and metal panels. The exterior of the remaining structures, including the cooling tower, have a natural concrete finish in combination with smooth and textured surfaces. Roofs of the station facilities consist of built-up composition roofing, over either metal decking and insulation or structural concrete slabs.

The waterfront facilities, which include the concrete service water intake structure, are parallel to and flush with the shoreline. This substantially submerged structure is unobtrusive when viewed from the river.

The 500 kilovolt switchyard structures are constructed of tapered tubular steel and rigid aluminum bus work. Ground surfaces are level, and are covered with graded crushed rock to prevent weed growth and precipitation puddling.

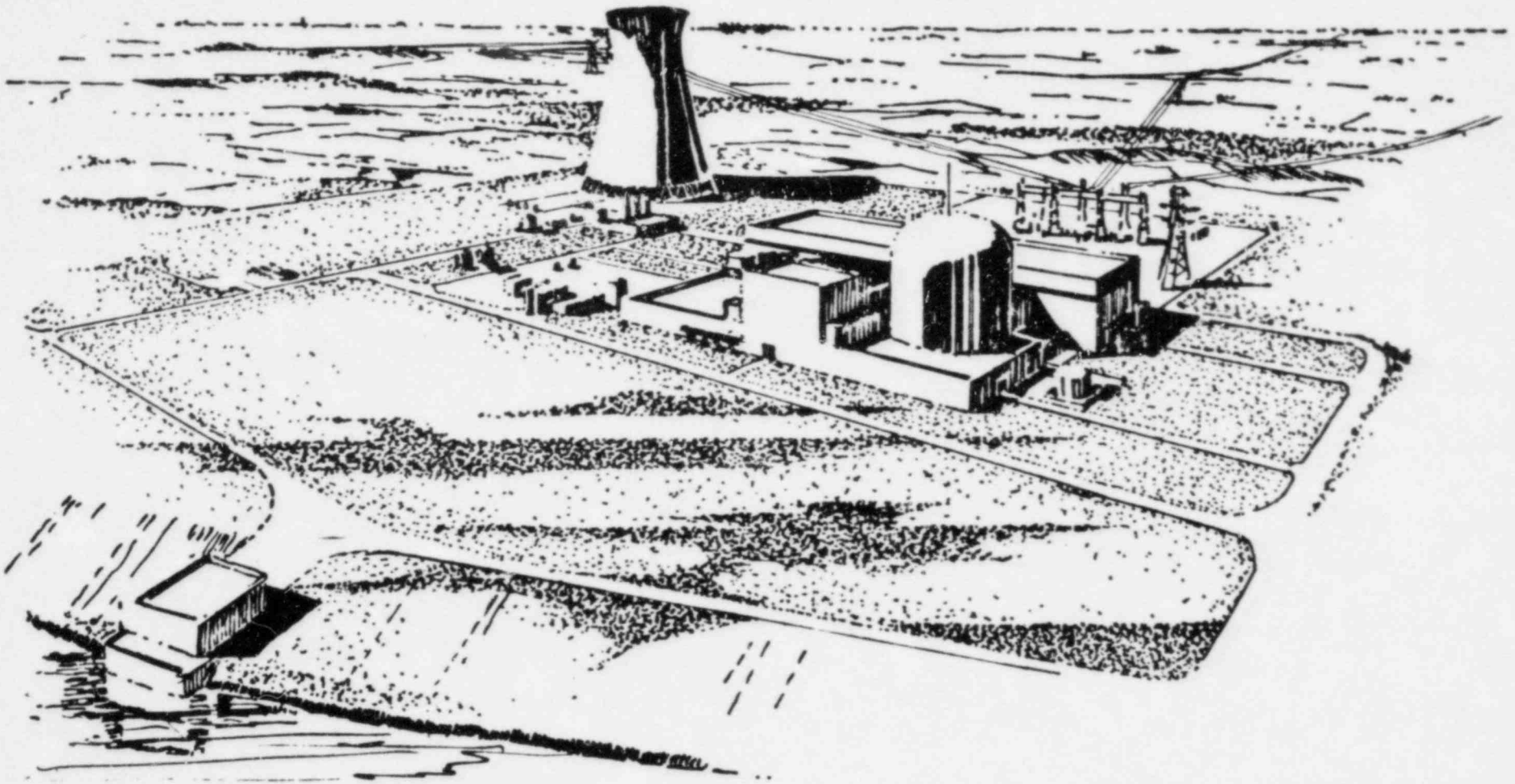
TABLE 3.1-1

GASEOUS AND LIQUID WASTE RELEASE POINTS

SOURCE	LOCATION ON FIGURE 3.1-4	HEIGHT ABOVE/BELOW GRADE m (ft)	DISTANCE TO EXCLUSION BOUNDARY m (ft)
GASEOUS RELEASE POINTS			
North Vent Stack(2)	35	+32 (105)	815 (2675)
South Vent Stack(2)	36	+32 (105)	937 (3075)
Reactor Building(2) (FRVS System)	18	+60.1 (200)	907 (2975)(1)
Stacks on Auxiliary Boiler Building	9	+18.6 (61)	472 (1550)
Evaporation and Drift from Unit 1 Cooling Tower	4	+157 (516)	524 (1720)
Diesel Generators (Auxiliary Building)	17	+31.4 (103)	305 (1000)
Fuel Oil Storage Tank	22	+15.3 (50)	110 (360)
LIQUID RELEASE POINTS			
Cooling Tower Blowdown Pipe	28	-3.3 (21)	0
North Storm Drain	29	-3.3 (21)	0
South Storm Drain	33	-3.3 (21)	0
Service Water Intake Screen and Strainer Wash Return	30	-4.6 (15)	0

(1) Distance to exclusion area boundary is measured from the north side of the reactor.

(2) Distances from gaseous radwaste release points are all in relation to the northern boundary of the exclusion area, which is the nearest land point excessible to man.



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

HOPE CREEK
GENERATING STATION

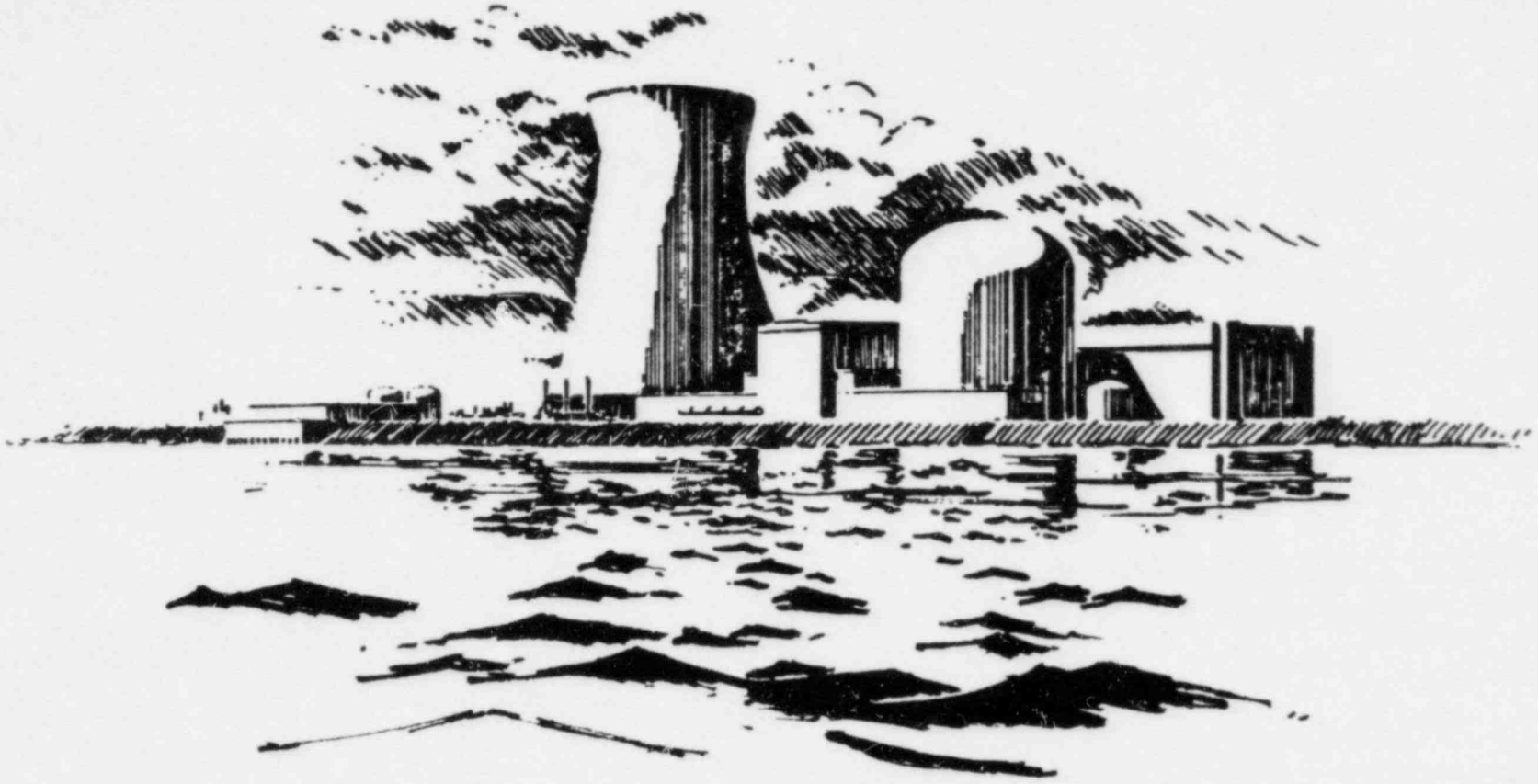
FIGURE 3.1 - 1

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

OFF-SITE APPEARANCE
FROM JUNCTION OF
ACCESS AND PUBLIC ROADS

FIGURE 3.1 - 2

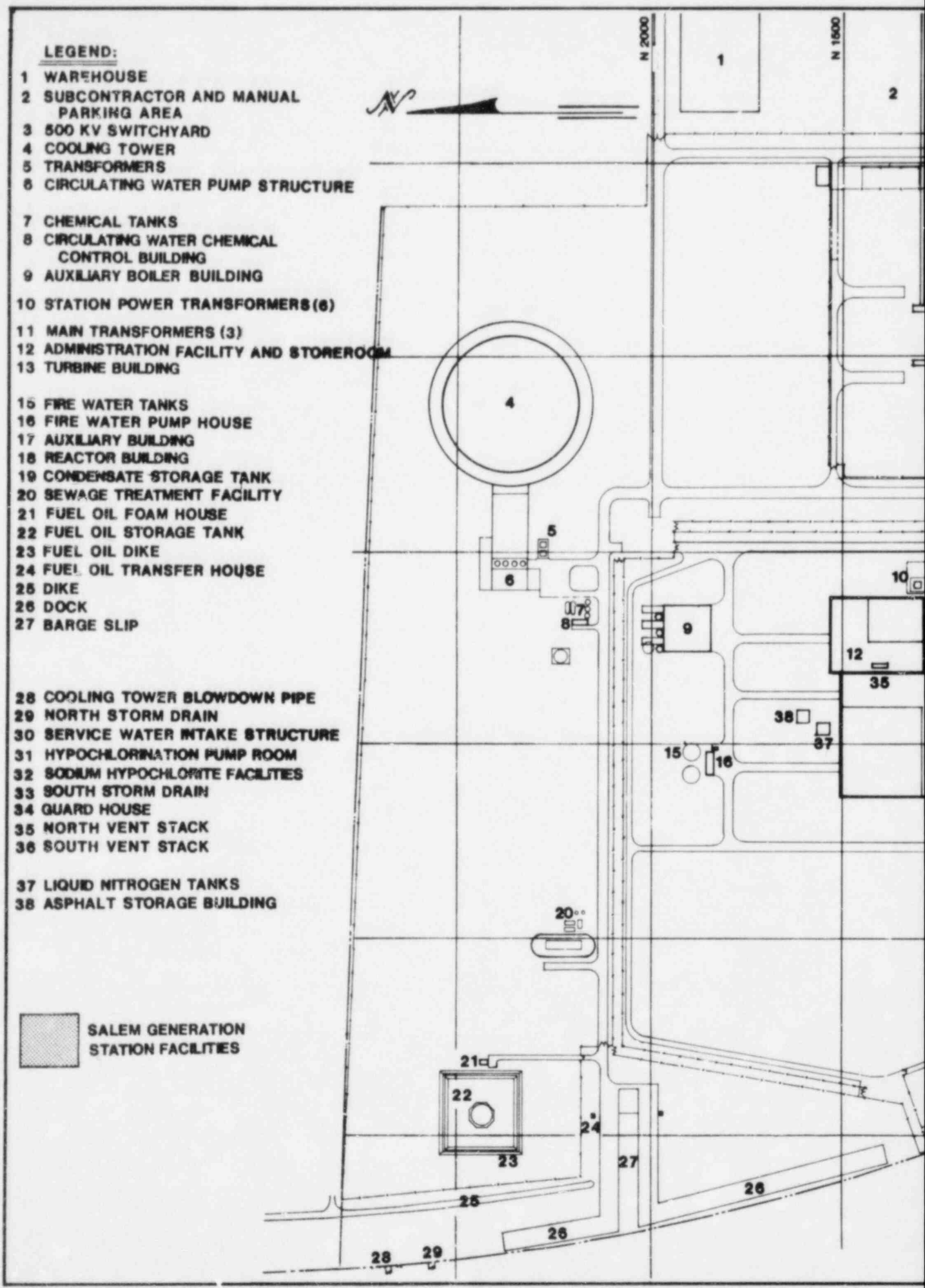


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

OFF-SITE APPEARANCE
FROM DELAWARE RIVER

FIGURE 3.1 - 3


LEGEND:
1 WAREHOUSE
2 SUBCONTRACTOR AND MANUAL PARKING AREA
3 500 KV SWITCHYARD
4 COOLING TOWER
5 TRANSFORMERS
6 CIRCULATING WATER PUMP STRUCTURE
7 CHEMICAL TANKS
8 CIRCULATING WATER CHEMICAL CONTROL BUILDING
9 AUXILIARY BOILER BUILDING
10 STATION POWER TRANSFORMERS (6)
11 MAIN TRANSFORMERS (3)
12 ADMINISTRATION FACILITY AND STOREROOM
13 TURBINE BUILDING
15 FIRE WATER TANKS
16 FIRE WATER PUMP HOUSE
17 AUXILIARY BUILDING
18 REACTOR BUILDING
19 CONDENSATE STORAGE TANK
20 SEWAGE TREATMENT FACILITY
21 FUEL OIL FOAM HOUSE
22 FUEL OIL STORAGE TANK
23 FUEL OIL DIKE
24 FUEL OIL TRANSFER HOUSE
25 DIKE
26 DOCK
27 BARGE SLIP
28 COOLING TOWER BLOWDOWN PIPE
29 NORTH STORM DRAIN
30 SERVICE WATER INTAKE STRUCTURE
31 HYPOCHLORINATION PUMP ROOM
32 SODIUM HYPOCHLORITE FACILITIES
33 SOUTH STORM DRAIN
34 GUARD HOUSE
35 NORTH VENT STACK
36 SOUTH VENT STACK
37 LIQUID NITROGEN TANKS
38 ASPHALT STORAGE BUILDING
SALEM GENERATION STATION FACILITIES
N
N 2000
N 1500
1
2
4
5
6
7
8
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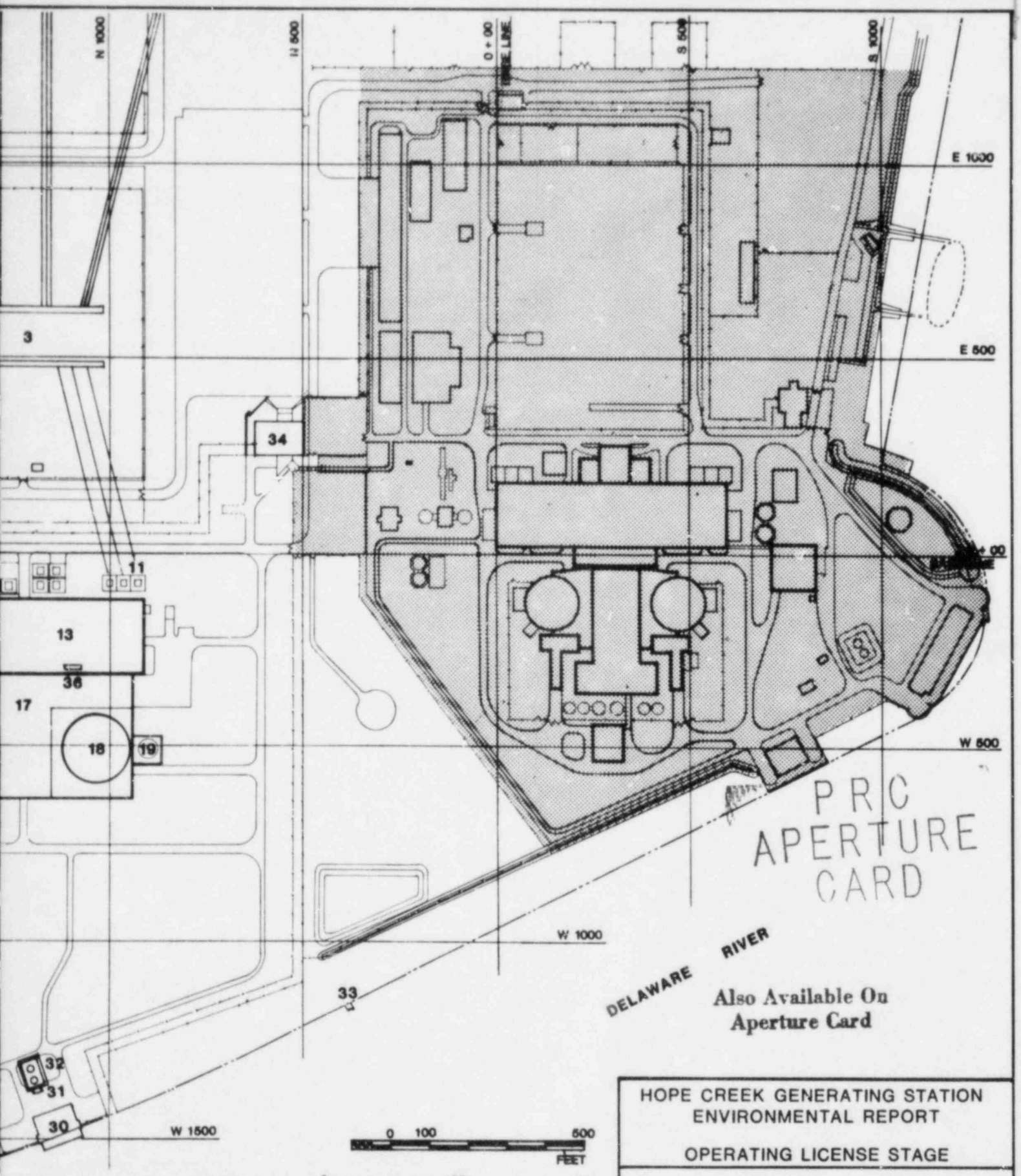

PRC APERTURE CARD

Also Available On Aperture Card

NOTE:
COORDINATES USED ARE FROM PSE&G COORDINATE SYSTEM

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

STATION LAYOUT

FIGURE 3.1 - 4

8306290435 -40

3.2 REACTOR AND STEAM ELECTRIC SYSTEM

PSE&G planned HCGS to have two nuclear units, and described it as such at the construction permit stage. On December 23, 1981, PSE&G cancelled further construction of Unit 2, but continued work on Unit 1. The plant now consists of a single unit of 1067 MWe net capacity, using the same nuclear and steam electric design concepts originally planned for both units.

The unit uses one General Electric BWR/4 light-water-moderated boiling water reactor nuclear steam supply system of 3293 MWt capacity. This system is also warranted to supply 6120 x 10^6 kilograms per hour (13,480 x 10^6 pounds per hour) saturated steam at 1020 psia at the reactor pressure vessel head. A Mark I containment encloses the reactor.

HCGS is equipped with one 1800 rpm General Electric tandem compound six-flow nonreheat turbine generator, capable of 1,118 megawatts maximum gross output at 1300 MVA and 25,000 volts. Steam exhausts to a double-pass, three shell horizontal deaerating type surface condenser (see Section 3.4). The capability exists to bypass up to 25 percent of the steam directly to the condenser. A natural draft cooling tower (see Section 3.4) dissipates heat rejected in the steam cycle. Figure 3.2-1 is a simplified flow diagram of the nuclear steam supply and turbine generator systems.

The architect/engineer and construction contractor is Bechtel Power Corporation.

Nuclear fuel used in the BWR consists of high-density uranium dioxide (UO_2) pellets, stacked into Zircaloy-2 cladding tubes. Each fuel bundle consists of 62 fuel rods and two water rods in an eight by eight array. There are 764 fuel bundles comprising the nuclear fuel in the reactor core. The initial core fuel loading consists of approximately 63,000 kilograms (139,000 pounds) of natural and artificially enriched uranium.

Electrical and thermal outputs are as follows:

Thermal:	3440 MWt (expected)	3293 MWt (warranted)
Electric:	1118 MWe (gross)	1067 MWe (net)

The station itself consumes 51 MWe at full power (73 MWe winter peak), accounting for the 1067 MWe net capacity.

Station heat rate, a measure of fuel utilization effectiveness, varies with turbine back pressure. Table 3.2-1 gives heat rate for various loads and turbine pressures. The turbine will trip if condenser pressure reaches 7.5 inches of mercury (absolute).

HCGS is scheduled to commence operation in January, 1986; it has a designed operating life of forty years.

HCGS OLER

TABLE 3.2-1

STATION HEAT RATE

HEAT RATE (Btu/kWh)[1]						
Unit Load (%)	TURBINE BACK PRESSURE (inches Hg)					
	2.5	3	4	5	6	7.5
Valves Wide Open or Reactor Stretch Heat Balance	10386	10464	10646	10885	11113	11467
Maximum Guaranteed	10363	10440	10653	10902	11150	11523
100% Maximum Calculated	10071	10147	10333	10555	10776	11119
75% Maximum Calculated	10383	10528	10830	11131	11442	11915
50% Maximum Calculated	10791	11028	11492	11934	12409	--
25% Maximum Calculated	12237	12702	13485	14293	--	--

(1) 3.97 Btu = 1 Kcal.

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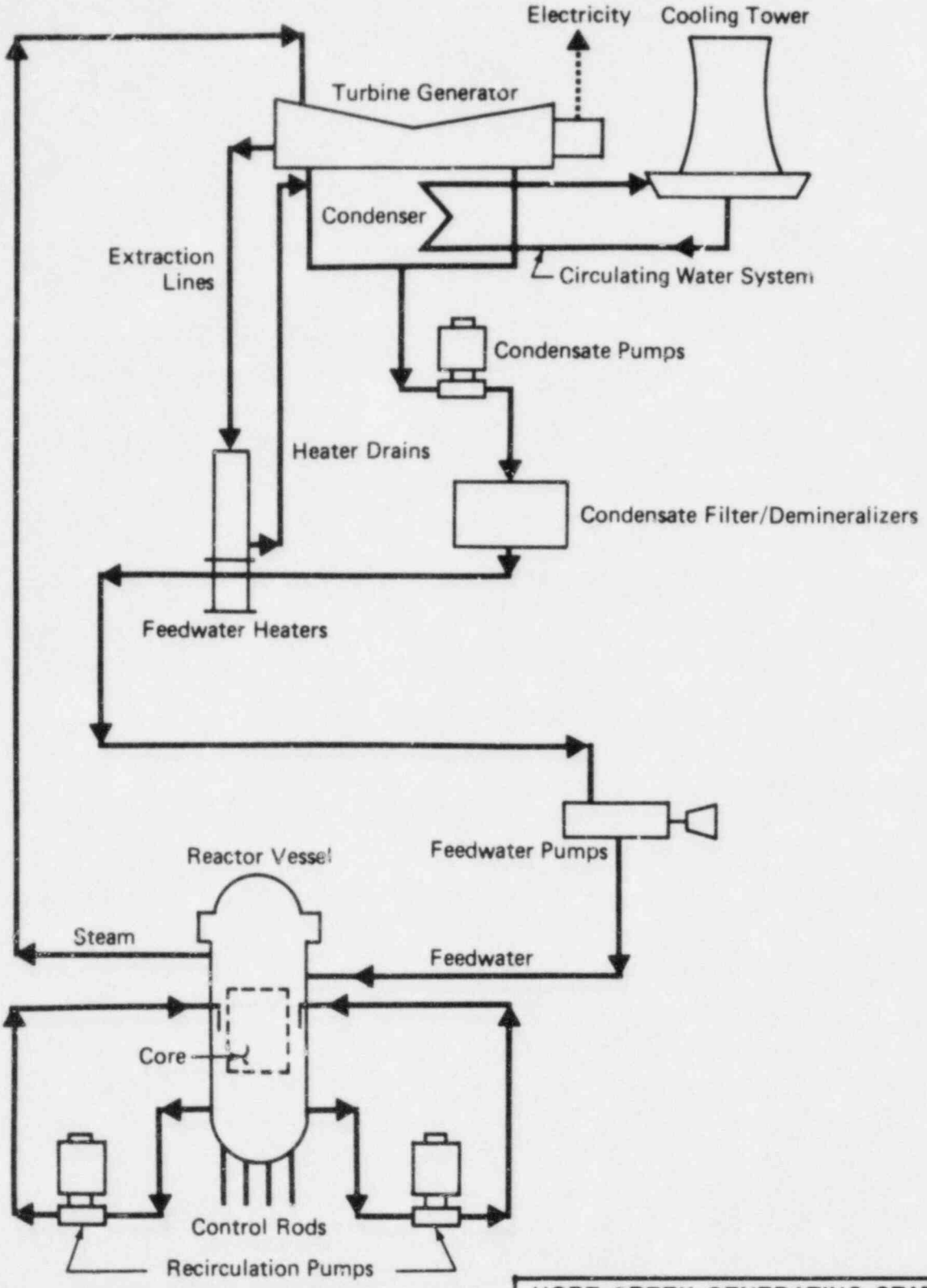


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SIMPLIFIED SCHEMATIC OF (BWR) REACTOR AND STEAM - ELECTRIC SYSTEM

FIGURE 3.2 - 1

3.3 STATION WATER USE

The current water use plans are similar in concept to plans at the construction permit stage. River water makes up evaporative cooling water losses via the station service water system. Fresh water for other uses is drawn from wells. This section reviews current water use plans, taking into account cancellation of Unit 2, design changes since the construction permit, and more specific design information now available. Refer to Figure 3.3-1 and Table 3.3-1 in conjunction with the text below.

Service water (see Section 3.4.2) is withdrawn from the Delaware River to supply the safety auxiliary cooling system (SACS) and the reactor auxiliary cooling system (RACS). The entire flow then proceeds to the cooling tower basin and acts as makeup to the circulating water system.

Flow through the service water system is approximately 124,400 liters per minute (32,860 gallons per minute) under normal conditions in which two of the four service water pumps operate. During its passage through the station, service water does not come into contact with any radioactive material or equipment.

At the construction permit stage a cold water bypass, to assist in the dilution of treated liquid radwaste, was planned. This has been eliminated, and the entire service water flow is directed to the cooling tower (see Section 3.4.4), as described above. The principal effect of this water use change is to reduce single-unit withdrawal from 160,000 liters per minute (42,500 gallons per minute) to 124,400 liters per minute (32,860 gallons per minute) and single unit return to the river from approximately 114,000 liters per minute (30,000 gallons per minute) to 80,900 liters per minute (21,360 gallons per minute).

The circulating water system (see Section 3.4.3) draws 2,080,000 liters per minute (552,000 gallons per minute) from the circulating water canal adjacent to the cooling tower basin by means of four pumps. These supply water to condense turbine steam, pumping the water through the main condenser and back to the cooling tower fill. Monthly average evaporative losses in the cooling tower consume between 35,300 liters per minute (9,600 gallons per minute) and 49,200 liters per minute (13,000 gallons per minute). Drift losses (0.0005 percent of the circulating water flow) will not exceed 10.5 liters per minute (2.75 gallons per minute). At the construction permit stage, drift losses had been estimated at 0.002 percent.

Cooling tower blowdown consists of the excess between service water flow and evaporation in the tower. During normal full power operation it ranges between 71,100 liters per minute (18,820 gallons per minute) and 88,100 liters per minute (23,260 gallons per minute).

Treated liquid radwaste (see Section 3.5) enters the blowdown pipe prior to discharge. Oily and low volume waste is collected, and subsequently treated as described in Section 3.6.

Two production wells approximately 244 meters (800 feet) deep supply fresh water to two 1.3 million liter (350,000 gallon) water storage tanks. These supply two 57,000 liter (15,000 gallon) makeup demineralizer feed tanks, and two 38,000 liter (10,000 gallon) domestic water storage tanks. All well water is chlorinated.

Each well's maximum capacity is 2500 liters per minute (650 gallons per minute), the flow needed to fill one firewater storage tank in one eight-hour shift. Up to 192,000 liters per day (51,000 gallons per day) are anticipated for potable use. Treated sanitary wastes discharge to the Delaware River via the north storm drain (see Section 3.7).

The makeup demineralizers supply reactor coolant as well as feedwater for the auxiliary boilers. Makeup demineralizer regenerant, auxiliary boiler blowdown and other nonradioactive liquid wastes are collected as oily water and low volume wastewater (see Section 3.6).

Many of the above water flows are relatively constant. Others vary with season or with station operating capacity. Figure 3.3-1 illustrates station water use. Table 3.3-1 lists flows for various conditions.

HCGS has been included in the DRBC Comprehensive Plan since June 17, 1975 (Docket Decision D-73-193CP). DRBC requires PSE&G to develop plans for supplemental storage in the Delaware Basin to compensate for HCGS's consumptive use when the freshwater flow at Trenton, New Jersey, is less than 85 cubic meters per second (3,000 cubic feet per second). PSE&G, as part of a joint effort with other Delaware Basin electric

utilities, filed an application with DRBC for such a reservoir on December 30, 1977. The application is still pending.

The reservoir is a requirement related to DRBC's overall water quality goals for the basin. There are no problems associated with supplying water of adequate quality or quantity to HCGS in any anticipated drought. Extremes of tidal elevation are allowed for in the intake structure design (see Section 3.4.1).

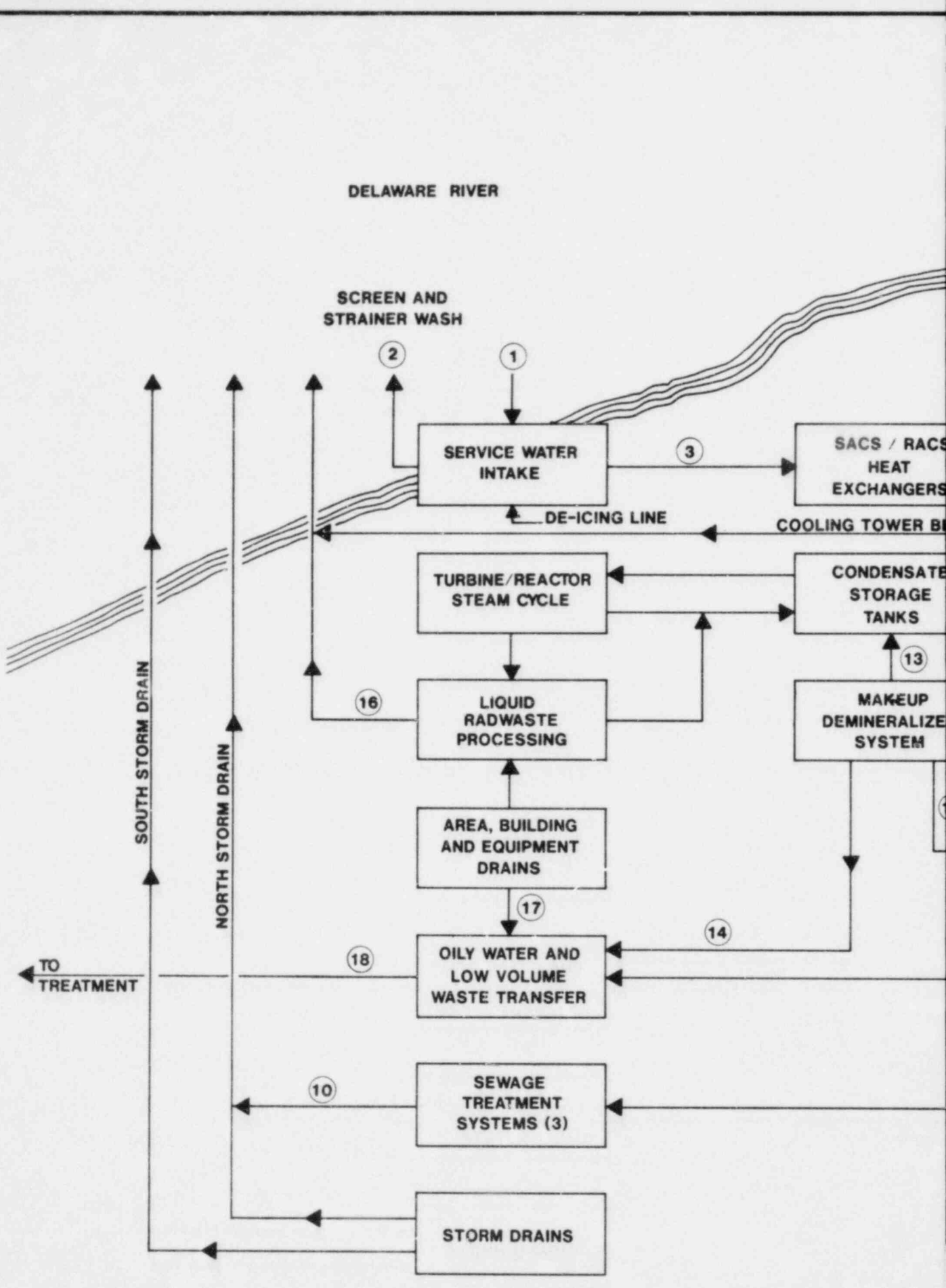
TABLE 3.3-1

WATER USE SUMMARY

	1	2	3	4	5[1]	6	7	8	9	10	11	12[2]	13[2]	14	15	16	17	18
Metric (liters/minute)																		
Daily Maximum @ 100%	127,000	6,700	120,300	120,300	50,000[4]	70,300	2,080,000	1,420	130	130	1,290	113	1,020	150[3]	57	28	173	380
Monthly Average @ 100%	131,000	6,600	124,400	124,400	43,500	80,900	2,080,000	770	130	130	640	38	527	75	19	2.6	96	190
Minimum Power Operation	131,000	6,600	124,400	124,400	30,100	94,300	1,160,000	770	130	130	640	38	527	75	19	2.6	96	190
Following Normal Shutdown	220,000	13,500	206,500	206,500	0	206,500	0	770	130	130	640	38	527	75	19	2.6	96	190
Following Emergency Shutdown	201,000	13,800	187,200	187,200	0	206,500	0	1,420	130	130	1,290	113	1,020	150[3]	57	28	173	380
English (gallons/minute)																		
Daily Maximum @ 100%	33,600	1,780	31,820	31,820	13,300[4]	18,520	552,000	375	35	35	340	30	270	40[3]	15	7.6	45	100
Monthly Average @ 100%	34,600	1,740	32,860	32,860	11,500	21,360	552,000	190	20	20	170	10	140	20	5	0.7	25	50
Minimum Power Operation	34,600	1,740	32,860	32,860	8,000	24,860	306,000	190	20	20	170	10	140	20	5	0.7	25	50
Following Normal Shutdown	58,000	3,560	54,440	54,440	0	54,440	0	190	20	20	170	10	140	20	5	0.7	25	50
Following Emergency Shutdown	53,200	3,640	49,560	49,560	0	49,560	0	375	35	35	340	30	270	40[3]	15	7.6	45	100

Use this table in connection with Figure 3.3-1.

(1)The only significant consumptive use. All other uses involve transfer or nonconsumptive water use.
(2)Design flow. Actual flow varies due to demand and inventory of condensate and demineralized water in storage.
(3)380 liters per minute (100 gallons per minute) instantaneous maximum is not sustained for full day.
(4)Based on 30°C (86°F) dry bulb temperacure and 90% relative humidity.


DELAWARE RIVER
SCREEN AND
STRAINER WASH
2
1
SERVICE WATER
INTAKE
3
SACS / RACS
HEAT
EXCHANGERS
DE-ICING LINE
COOLING TOWER BI
TURBINE/REACTOR
STEAM CYCLE
CONDENSATE
STORAGE
TANKS
13
16
LIQUID
RADWASTE
PROCESSING
MAKEUP
DEMINERALIZE
SYSTEM
SOUTH STORM DRAIN
NORTH STORM DRAIN
AREA, BUILDING
AND EQUIPMENT
DRAINS
17
14
TO
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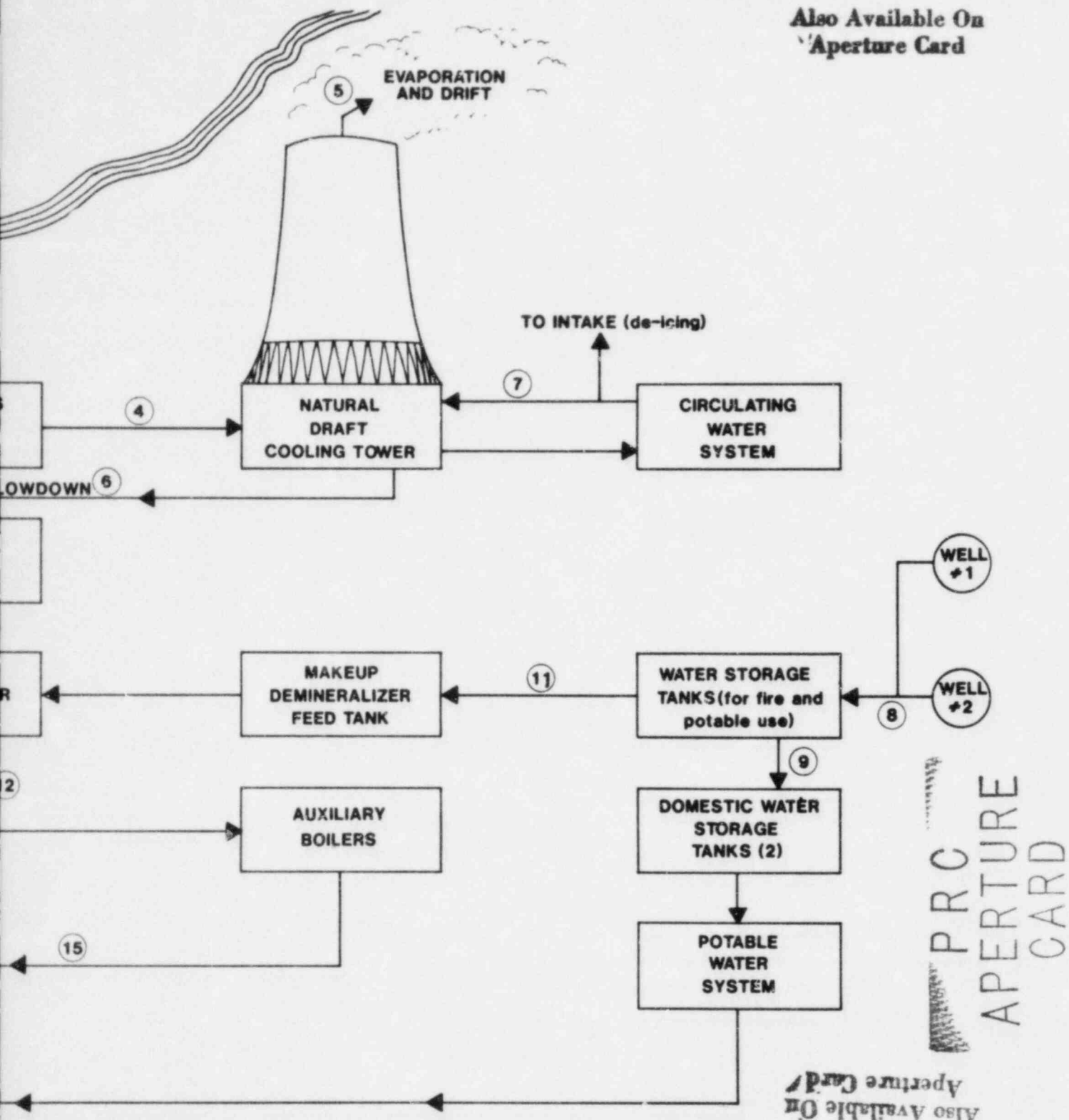

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OPERATING LICENSE STAGE

STATION WATER USE

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FIGURE 3.3 - 1

3.4 HEAT DISSIPATION SYSTEM

The heat dissipation system uses river water, first to accept heat rejected from certain essential heat exchangers, then as makeup to the closed cycle circulating water system. It is similar to the heat dissipation system described at the construction permit stage; however, the cancellation of Unit 2 has brought about a reduction of approximately 50 percent in total heat dissipated, and the number of service water pumps in service per unit during normal operation is now two, rather than the three service water pumps planned at the CP stage. A cold water bypass (roughly equivalent to the flow from the third service water pump) to aid in radwaste dilution proved unnecessary, and has not been installed. This change, and the availability of more detailed information on seasonal cooling tower performance, resulted in new values for cooling tower blowdown flows and temperatures. The discharge, instead of being 60 meters (200 feet) offshore and 1.4 meters (4.5 feet) in diameter, will terminate three meters (10 feet) offshore at mean tide, and be 1.2 meters (4.0 feet) in diameter.

3.4.1 INTAKE

The service water intake structure draws all water for heat dissipation from the Delaware River (Figure 3.4-1). This large reinforced concrete structure is located on the shoreline approximately 244 meters (800 feet) due west of the reactor building. The intake occupies 34 meters (112 feet) of shoreline, extends 23 meters (75 feet) inland, and rises 11 meters (35 feet) above finished grade (excluding the gantry crane). PSE&G has considered the recommendations given by Dr. E. C. Raney at the construction permit stage. The west face of the intake is parallel to and flush with the shoreline. A continuous line of trash racks extends 4 meters (13 feet) in front of the intake; river currents sweep the face of the intake structure, and the trash racks prevent heavy debris from entering the intake and damaging the traveling screens. The trash rack bars are coated carbon steel, 7.5 centimeters by 1.9 centimeters (three inches by 3/4 inch), and are set on 7.5 centimeter (three inch) centers. Mechanical rakes remove trash into a dumpster. Velocity through the trash racks is approximately three centimeters per second (0.1 foot per second).

Intake water flows into the structure under a curtain wall at a maximum velocity of approximately 0.1 meter per second (0.35 foot per second) into four openings, 3.4 meters (11 feet) high by 2.9 meters (9.5 feet) wide. Once inside, the water flows through one of four vertical traveling screens,

each located in a separate well, at a maximum velocity of approximately 0.12 meter per second (0.39 foot per second). All velocities are well below EPA guidelines for cooling water intake structures (Reference 3.4-1).

A traveling screen is an endless linkage of framed baskets. Each basket is approximately 0.75 meter (2-1/2 feet) high and 2.5 meters (8 feet, 4 inches) wide, and each holds a panel of No. 14 W&M gage monel wire mesh with 0.95 centimeter (3/8 inch) square openings.

Each basket has a trough on the lower lip. This "fish bucket" is designed to prevent reimpingement of fish by reducing the number which flip off the baskets as they rise from the water. The baskets allow organisms to remain in water while being lifted to fish return troughs. The screens are intended for continuous rotation.

Organisms, trash and other objects small enough to pass through the trash racks collect on the traveling screens. Streams of water remove these objects from the baskets and sluice them into flumes. Water from screen wash pumps issues from a series of spray nozzles near the top of the screen as the bucket turns over and starts to travel downward. The first series of nozzles provides a gentle flow at 20 psi to wash fish and loose debris into the fish return trough. This low pressure reduces potential descaling and buffeting of fish. A second series of nozzles provides a high pressure spray at 90 psi to wash any remaining debris into the debris trough.

Organisms and debris removed from the screens are returned to the Delaware River at a distance from the intake structure, to reduce the potential for reimpingement on the screens.

After passing through the four traveling screens, the river water enters the service water pumps. Under normal circumstances, two pumps operate, and two additional pumps act as spares. There are no seasonal or operational reductions in pumping. Each well contains a vertical wet pit turbine type service water pump rated at 62,500 liters per minute (16,500 gallons per minute) at 46 meters (150 feet) total head. Each service water pump discharges through a pipe to an automatic, self-cleaning service water strainer. Each strainer is of 250-micron mesh. The strainers continuously self-wash; the effluent is used for motor bearing cooling, before discharge.

If needed for deicing, up to 114,000 liters per minute (30,000 gallons per minute) of hotside circulating water

blowdown can be discharged through a 91 centimeter (36 inch) diameter header into 20 centimeter (8 inch) downcomers, to distribute warm water directly in front of the trash racks.

A separate dilution station and set of pumps continuously provide sodium hypochlorite to the service water system. A one-percent solution is injected into the service water behind the traveling screen in the service water pump pits. The dosage rate is based on a 0.5 milligram per liter free chlorine residual obtained at the outlet of the last service water heat exchanger.

3.4.2 SERVICE WATER SYSTEM

The service water pumps provide river water to cool the safety auxiliaries cooling system (SACS) and the reactor auxiliaries cooling system (RACS) heat exchangers during normal conditions (see Figure 3.4-2). The system satisfies filling and makeup requirements for the circulating water system. In this mode it adds approximately 54.3 x 10^6 kilocalories per hour (216 x 10^6 Btu per hour) to water flowing at 120,000 liters per minute (32,000 gallons per minute), raising the temperature 7.2°C (13°F). In an emergency it provides a reliable heat sink for the SACS during a loss-of-coolant accident and/or loss-of-power situation. The natural draft cooling tower is not essential to this function. Under such emergency conditions, the RACS heat exchanger service water line will be automatically isolated.

Under normal shutdown conditions, all four service water pumps operate to supply the four SACS and two RACS heat exchangers. In this case 107 x 10^6 kilocalories per hour (427 x 10^6 Btu per hour) are rejected, raising the temperature of the service water flow about 9°C (16°F). For long term normal shutdown, two service water pumps suffice to cool two SACS and two RACS heat exchangers. If the cooling tower is out of service, the RACS and SACS effluent may be diverted to the cooling tower blowdown line, or discharged to the intake structure via the deicing line.

Table 3.3-1 indicates system flows under various conditions. Table 3.4-1 shows monthly variations of various parameters, including inlet temperatures.

Average time of travel between the intake structure and the cooling tower basin, for normal two-pump operation, is approximately ten minutes.

3.4.3 CIRCULATING WATER SYSTEM

The circulating water system serves as the principal heat sink for normal plant processes. The system pumps water from the cooling tower through the main condenser and again back to the cooling tower, where heat rejection by evaporation to the atmosphere occurs. The system contains 34 million liters (nine million gallons) of water, recirculated at 2,080,000 liters per minute (552,000 gallons per minute).

The system consists of one natural draft cooling tower with make-up, blowdown, basin overflow and fill bypass systems; four circulating water pumps; a two pass surface condenser and a closed loop circulating water piping arrangement (see Figure 3.4-3).

Four vertical wet-pit circulating water pumps, each with a rated capacity of 520,000 liters per minute (138,000 gallons per minute) at approximately 30 meters (100 feet) total dynamic head, discharge into a 3.6 meter (12 foot) diameter tunnel leading to the main condenser.

The main condenser is a double-pass, three shell, horizontal, deaerating type surface condenser. The tubes are 12 meters (40 feet) in effective length, constructed of Titanium B-338, Grade II alloy, and have a 2.2 centimeter (0.875 inch) nominal diameter. The effective total surface area is 76,300 square meters (821,430 square feet). Each shell has two tube bundles, two inlet-outlet boxes, and two reversing-end water boxes. The waterboxes are rubber-lined, and have provisions for cathodic protection to resist corrosion.

From the condenser the water returns to the cooling tower to complete the cycle.

In normal operation, four circulating water pumps continuously operate. Since approximately 1.95×10^9 kilocalories per hour (7.76×10^9 Btu per hour) are rejected to a circulating water flow of 2,080,000 liters per minute (552,000 gallons per minute), the circulating water temperature rises about 15.5°C (28°F).

At least two pumps must operate in order to sustain electric power production. Under these conditions 1.10×10^9 kilocalories per hour (4.4×10^9 Btu per hour) are rejected to water flowing at 1,160,000 liters per minute (306,000 gallons per minute). Circulating water temperature rise is 16°C (29°F).

Following normal shutdown the pumps continue running until the temperature of the turbine condenser unit is below 38°C (100-105°F). This is done to extend the service life of the condenser tubes.

Since makeup water displaces approximately 121,000 liters per minute (32,000 gallons per minute), total average residence time between entering the circulating water system and discharge via blowdown or evaporation is about 4.5 hours. Since water normally circulates at 2,080,000 liters per minute (552,000 gallons per minute), average transit time through the circulating water system is 16 minutes.

Since the cooling tower evaporates water, dissolved and suspended solids could build up in the circulating water until deposition or scaling occurred. Blowing down a quantity of water from the cooling tower basin over a stationary weir to the Delaware River prevents deposition and scaling. Cycles of concentration in the circulating water system (relative to makeup water) will be maintained at 2.0 or less. See Table 3.4-2 for a list of anticipated constituents in the circulating water.

Treatment with sulfuric acid as needed on a seasonal basis maintains an appropriate Langlier Index to further control scaling.

The periodic addition of sodium hypochlorite at about five milligrams per liter chlorine at the circulating water pump pit produces a 0.5 milligram per liter chlorine residual at the condenser outlet. Chlorine residual levels in the cooling tower blowdown will comply with the NJPDES permit; the precise method of accomplishing this is still under study by Bechtel and PSE&G.

3.4.4 NATURAL DRAFT COOLING TOWER

A single counterflow type, hyperbolic natural draft cooling tower dissipates the heat from the circulating water system. The cooling tower stands approximately 244 meters (800 feet) northeast of the turbine building. Closed cycle cooling ensures compliance with New Jersey and DRBC thermal water quality standards (see Section 5.1.1).

The cooling tower has the design characteristics given in Table 3.4-3. Figures 3.4-4 and 3.4-5 show the performance curves.

Fabricated from reinforced concrete supported on a driven pipe pile foundation, the cooling tower is designed for a 45-year operating life. Cooling tower fill is non-combustible. A drift eliminator system provides a guaranteed drift rate not exceeding 0.0005 percent of total circulating water flow.

Aircraft warning strobe lights meet FAA requirements. A lightning protection system is provided. An impressed current cathodic protection system protects the pilings.

Usable basin depth is 1.8 meters (six feet), to maintain a minimum water inventory in the circulating water system of 34 million liters (nine million gallons). Extra freeboard provides 30 percent additional capacity.

The natural draft cooling tower is designed for ambient (dry) air temperatures of -18 to 38°C (0 to 100°F). Waste heat dissipation to ensure safe shutdown of the reactor does not require the natural draft cooling tower.

During start-up, before all systems reach their operating temperatures and flows, it is possible to divert up to 60 percent of the hot water flow directly to the cooling tower basin without passage through the fill. This bypass arrangement also may be used at low station loads in winter to provide freeze protection. Fill deicing, if necessary, is accomplished by distributing the entire circulating water flow over the outer or peripheral portions of the fill for the necessary period.

Duty, circulating water flow and meteorological conditions affect cooling tower performance. Consumptive water use varies from 35,300 liters per minute (9,600 gallons per minute) in January to 49,200 liters per minute (13,000 gallons per minute) in July. Cycles of concentration and blowdown temperatures vary also. See Table 3.4-1 for monthly average flows and cycles of concentration. Table 3.4-4 shows cold-side blowdown temperatures produced, with their probability of occurrence.

The use of sodium hypochlorite, described in Section 3.4.3, prevents the buildup of slime in the tower fill.

During scheduled outages, power equipment removes silt accumulations from the tower basin. The silt is trucked to

on-site areas, north and east of the station, that have been previously approved for dredged and excavated material.

The cooling tower produces a sound level of approximately 76 dBA at ground level, 31 meters (100 feet) from the basin curb, during normal operation.

3.4.5 DISCHARGE

Cold-side cooling tower blowdown and other station effluents flow through an underground conduit to the Delaware River (see Figure 3.4-6). The conduit terminates in a 1.22 meter (four foot) inside diameter horizontal pipe, that terminates approximately three meters (10 feet) offshore at mean tide, approximately 460 meters (1500 feet) upriver of the intake. The centerline of the opening is about 1.8 meters (6.0 feet) below mean low water. Normally, the discharge velocity is about 1.1 meters per second (3.5 feet per second).

Table 3.4-1 gives the blowdown flow quantities.

REFERENCES

3.4-1 U.S. Environmental Protection Agency, Development Document for Best Technology Available for the Location, Design, Construction, and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact, April, 1976.

TABLE 3.4-1

ESTIMATED COOLING WATER FLOWS AND TEMPERATURES
(NORMAL OPERATION - MONTHLY AVERAGES)

Month	Inlet Water Temp.		Makeup Water Flow		Cooling Tower Evaporation		Discharge Water Flow		Discharge Water Temp.(1)		Discharge Water Temp. Rise		Circulating Water Cycles of Concentration
	°C	°F	l/min(2)	gpm	l/min	gpm	l/min	gpm	°C	°F	°C	°F	
Jan.	2.4	36.3	124,400	32,860	36,300	9,600	88,100	23,260	17	63	14.6	26.7	1.41
Feb.	1.4	34.5	124,400	32,860	37,000	9,800	87,400	23,060	17.5	64	16.1	29.5	1.42
Mar.	6.2	43.2	124,400	32,860	39,700	10,500	84,700	22,360	19	66	12.8	22.8	1.47
Apr.	12.2	54.0	124,400	32,860	42,700	11,300	81,700	21,560	22	71	9.8	17.0	1.52
May.	18.9	66.0	120,300	31,820	45,400	12,000	74,900	19,820	25	77	6.1	11.0	1.61
June	23.6	74.5	120,300	31,820	47,300	12,500	73,000	19,320	28	82	4.2	7.5	1.65
July	27.1	81.0	120,300	31,820	49,200	13,000	71,100	18,820	29.5	85	2.4	4.0	1.69
Aug.	26.7	80.0	120,300	31,820	48,800	12,900	71,500	18,920	29	84	2.3	4.0	1.68
Sept.	24.6	76.4	120,300	31,820	46,900	12,400	73,400	19,420	26.5	80	1.9	3.6	1.64
Oct.	17.5	63.5	120,300	31,820	44,200	11,700	76,100	20,120	23	74	5.5	10.5	1.58
Nov.	9.5	49.1	124,400	32,860	40,800	10,800	83,600	22,060	20.5	69	11.0	19.9	1.49
Dec.	4.9	40.9	124,400	32,860	37,400	9,900	87,000	22,960	17.5	64	12.6	23.1	1.43

(1) See Table 3.4-4 also.
(2) l/min = liters per minute.

TABLE 3.4-2

CIRCULATING WATER CHEMISTRY

Circulating water has approximately the following analysis. Chemical constituents are expressed in milligrams per liter (mg/l) except as otherwise noted:

	Median(2)	Maximum(3)
Calcium as $CaCO_3$	394	740
Magnesium "	1,775	3,671
Hardness "	590	1,191
Sodium "	7,079	14,809
(1)Alkalinity (M.O.) as $CaCO_3$	51	80
(1)Sulfates "	865	1,728
(1)Chlorides "	8,614	17,177
Iron as Fe	3.13	10.73
Copper as Cu	0.05	0.24
Total dissolved solids	10,299	21,752
Suspended solids	179	411
(1)Ammonia as NH_3	0.51	3.09

(1) Water is treated with sulfuric acid to maintain proper Langlier Index with reduction in alkalinity and corresponding increase in sulfates. Ammonia level is reduced also by acid addition. Periodic chlorination to a 0.5 mg/l Cl residual at cooling tower supply is accomplished by addition of sodium hypochlorite at about 5 mg/l Cl at the circulating water pump pit.

(2) Values represent median concentration times annual average concentration factor (1.64).

(3) Values represent 90th percentile concentration times maximum monthly concentration factor (1.85).

TABLE 3.4-3

NATURAL DRAFT COOLING TOWER
DESIGN CHARACTERISTICS

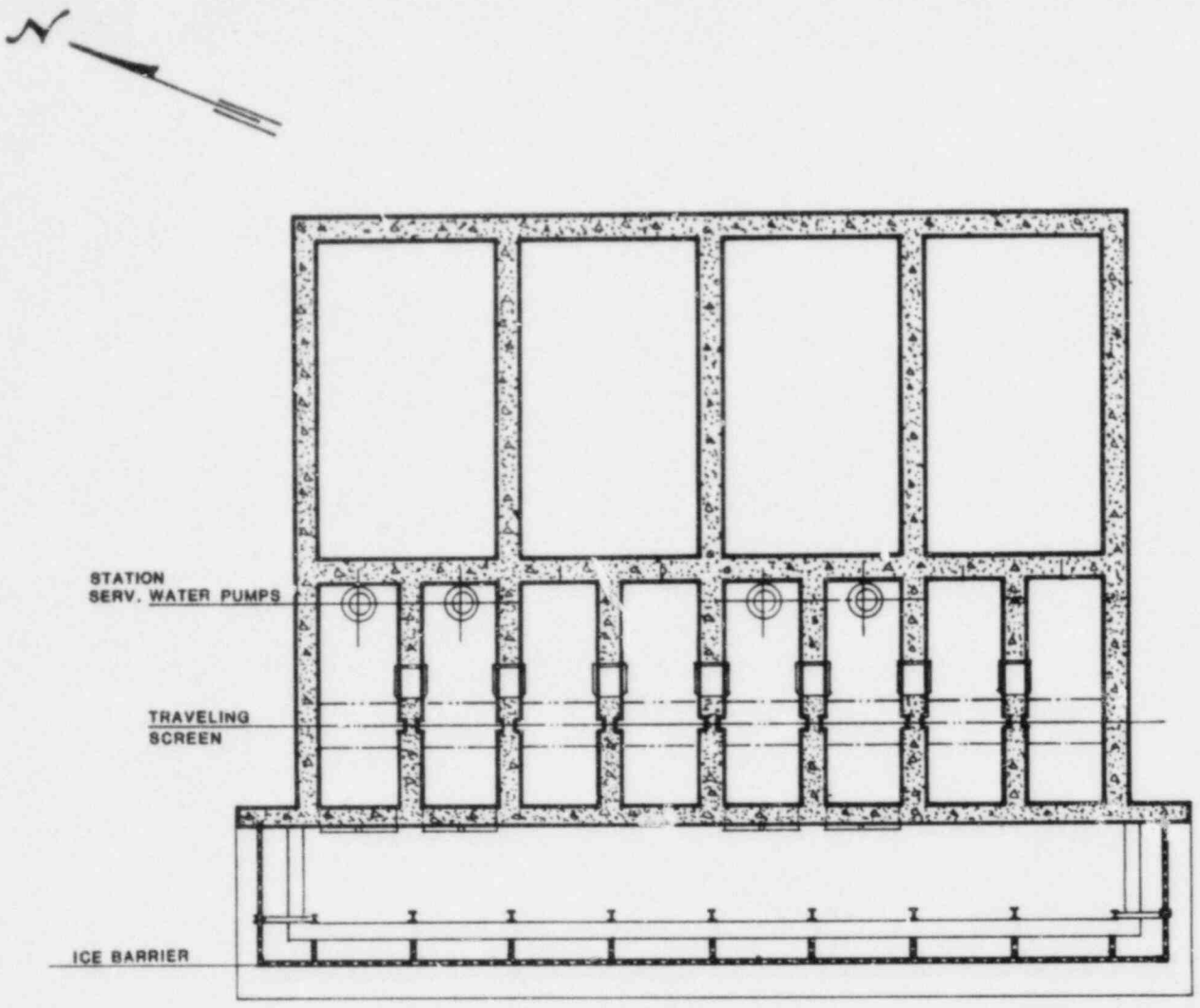
	Metric	English
Total Design Duty	2.01×10^9 KCal/hr	7.97×10^9 Btu/hr
Inlet Water Flow	2,080,000 liters/min	552,000 gpm
Inlet Water Temperature	48°C	119°F
Outlet Water Temperature	32°C	90°F
Ambient Wet Bulb	24°C	76°F
Relative Humidity	60%	60%
Range	16°C	29°F
Approach	7.8°C	14°F
Drift Loss	0.0005%	0.0005%
Drizzle Rate	None anticipated	None anticipated
Water Loading	274 liter/min-m^2	6.7 gpm/ft^2
Annual Average Air Flow Rate	2.6×10^4 m^3/sec	55×10^6 cfm
Principal Dimensions:		
Overall Height	156 meters	512 feet
Diameter @ Base	133 meters	432 feet
Diameter @ Throat	76 meters	249 feet
Diameter @ Outlet	82 meters	271 feet

TABLE 3.4-4

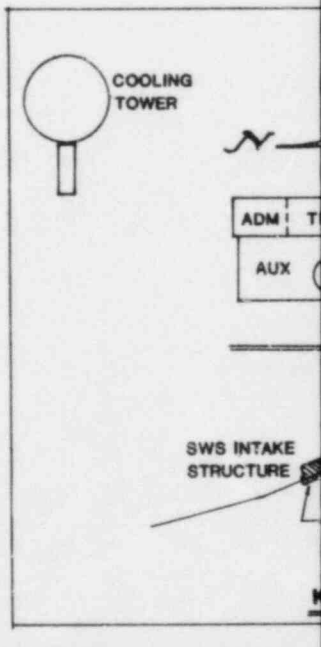
PREDICTED COOLING TOWER BLOWDOWN TEMPERATURES DURING NORMAL FULL-POWER OPERATION

Month	Average over the Month Indicated		Exceeded 5% of the Time		Maximum Daily Average		Maximum Instantaneous Value (3-hour)	
	°C	°F	°C	°F	°C	°F	°C	°F
Jan	17	63	22	71	25.5	78	28	82
Feb	17.5	64	21	70	24.5	76	28	82
Mar	19	66	23	74	27	81	29.5	85
Apr	22	71	26	79	28.5	83	30.5	87
May	25	77	27	81	30	86	31.5	89
Jun	28	82	30.5	87	32	90	34	93
Jul	29.5	85	31.5	89	33	91	34.5	94
Aug	29	84	31	88	32	90	34	93
Sep	26.5	80	30.5	87	32	90	34.5	94
Oct	23	74	28	82	30.5	87	31.5	89
Nov	20.5	69	25.5	78	29.5	85	30.5	87
Dec	17.5	64	22	72	25.5	78	28.5	83
Annual	23	73.3	-	-	33	91	34.5	94

Based on Wilmington, Delaware wet bulb temperature observations recorded at 3-hour intervals, January, 1948 to December, 1980. Four HCGS circulating water pumps in operation. Relative humidity = 70%.

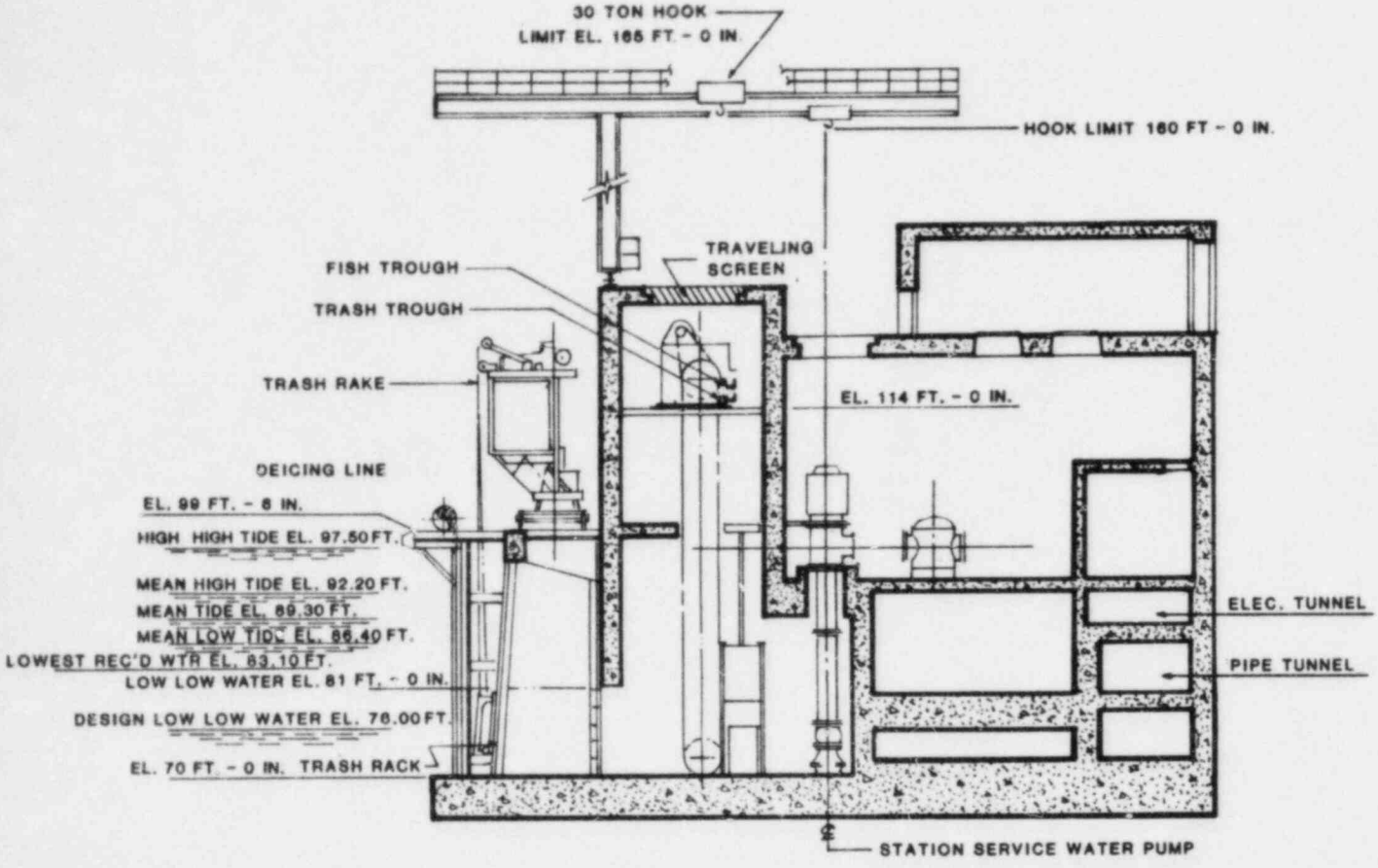


PLAN



NOTE:

ELEVATIONS GIVEN IN PUBLIC SERVICE DATUM (PSD)
PSD 89.0FT 0.0MSL



SECTION

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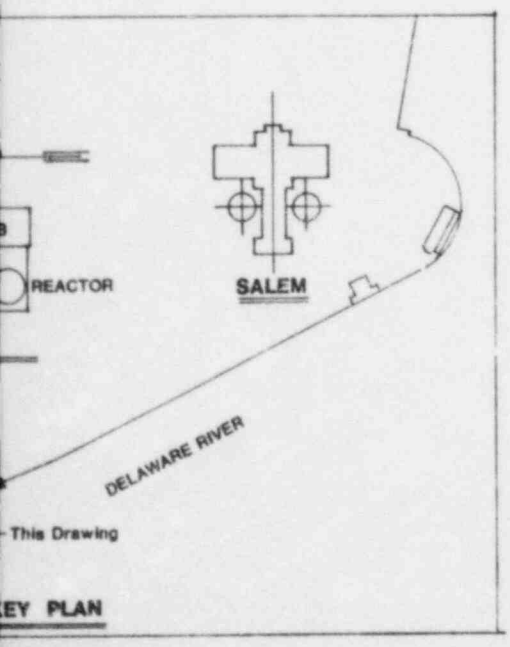

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SERVICE WATER SYSTEM
INTAKE STRUCTURE

GENERAL ARRANGEMENT

FIGURE 3.4 - 1

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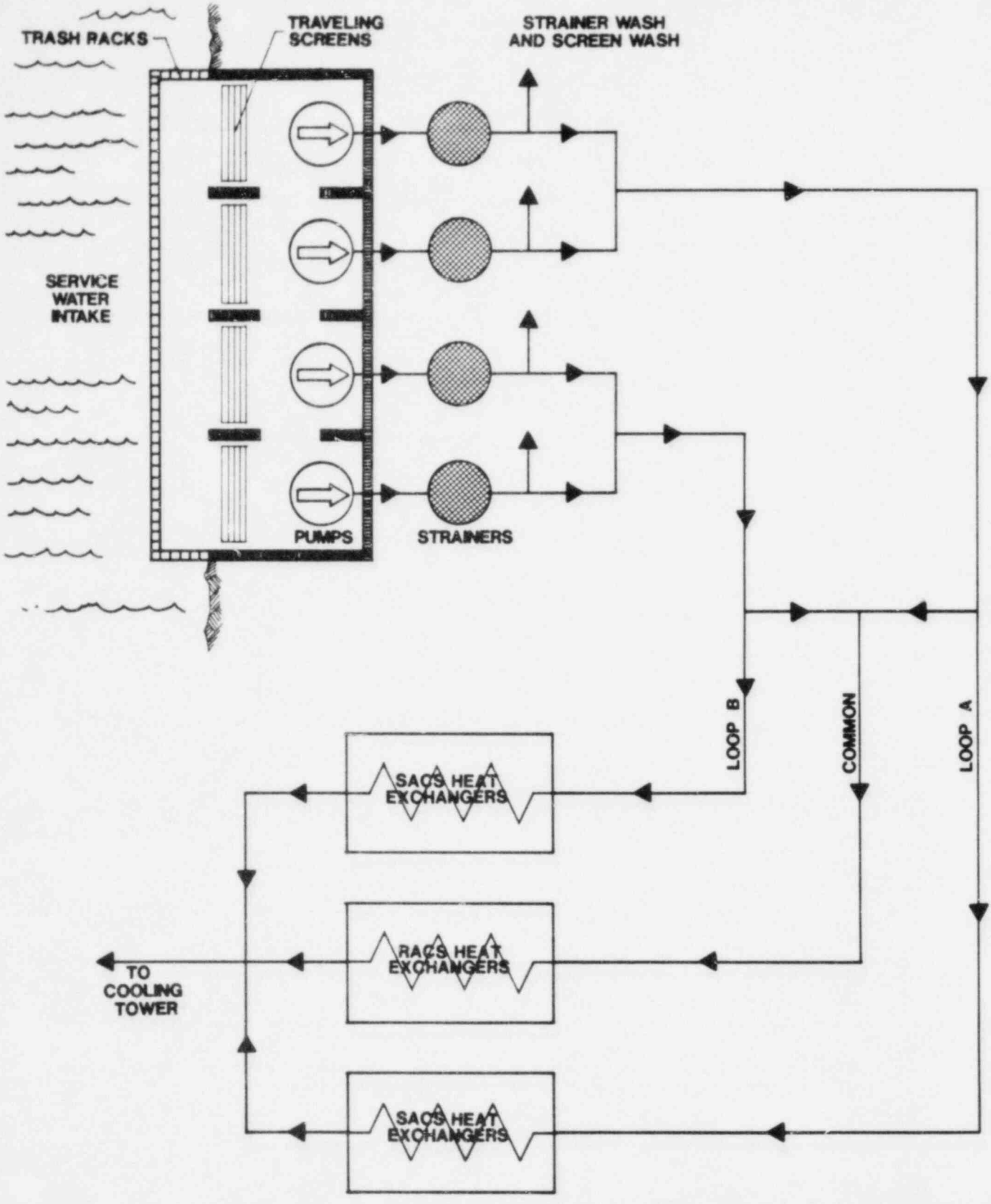

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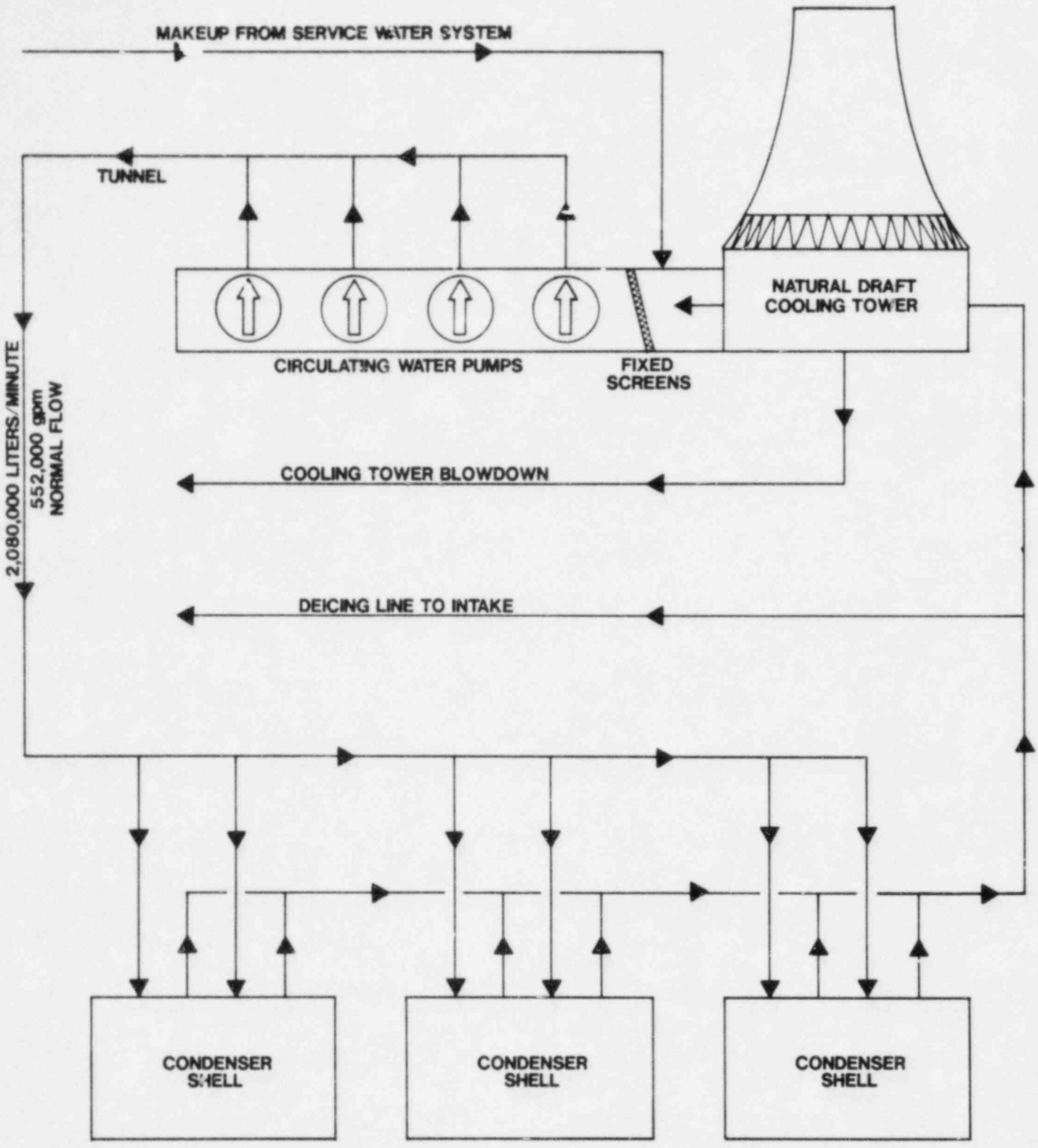
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SERVICE WATER
FLOW DIAGRAM

FIGURE 3.4 - 2

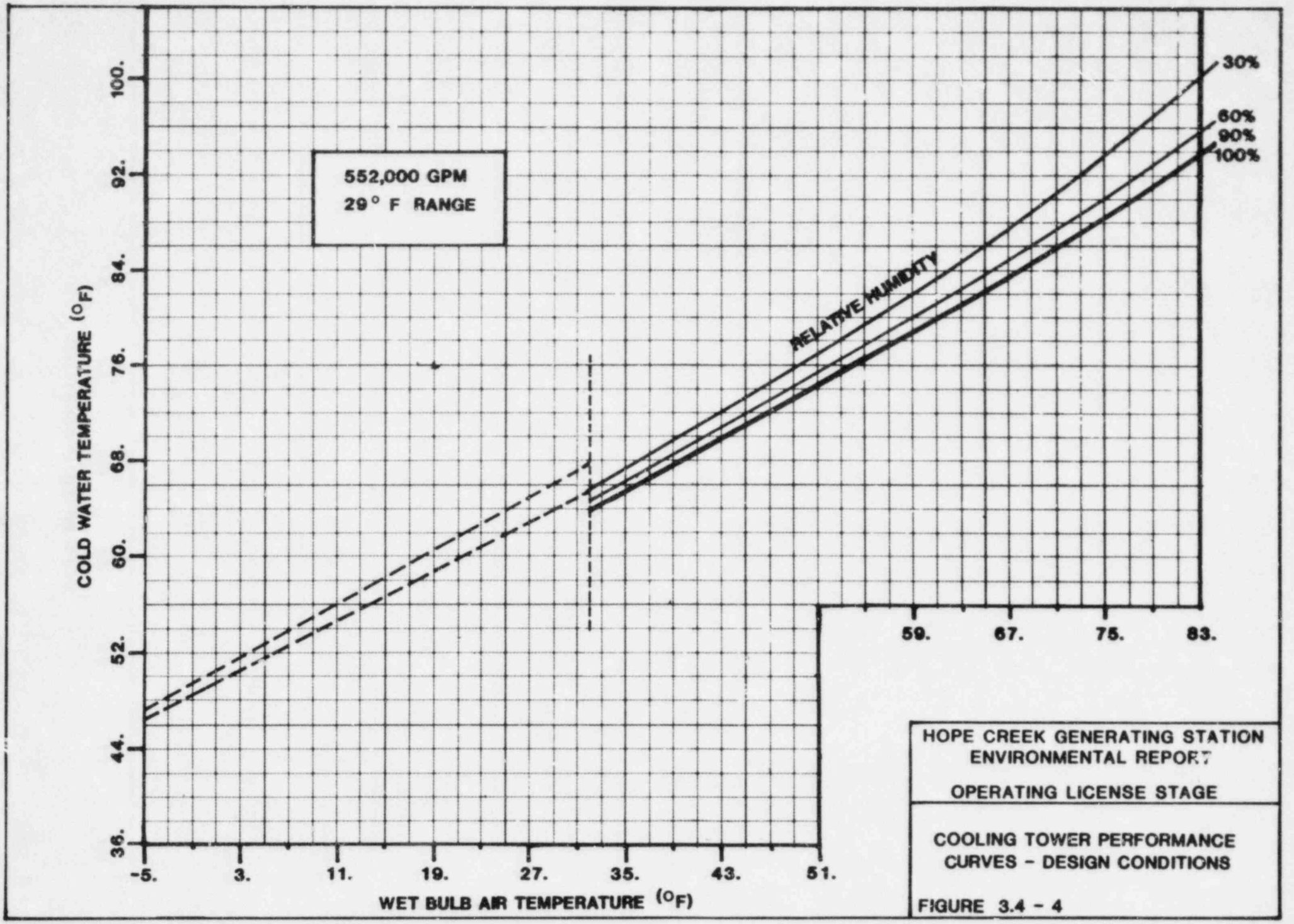


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

CIRCULATING WATER
FLOW DIAGRAM

FIGURE 3.4 - 3



HOPE CREEK GENERATING STATION
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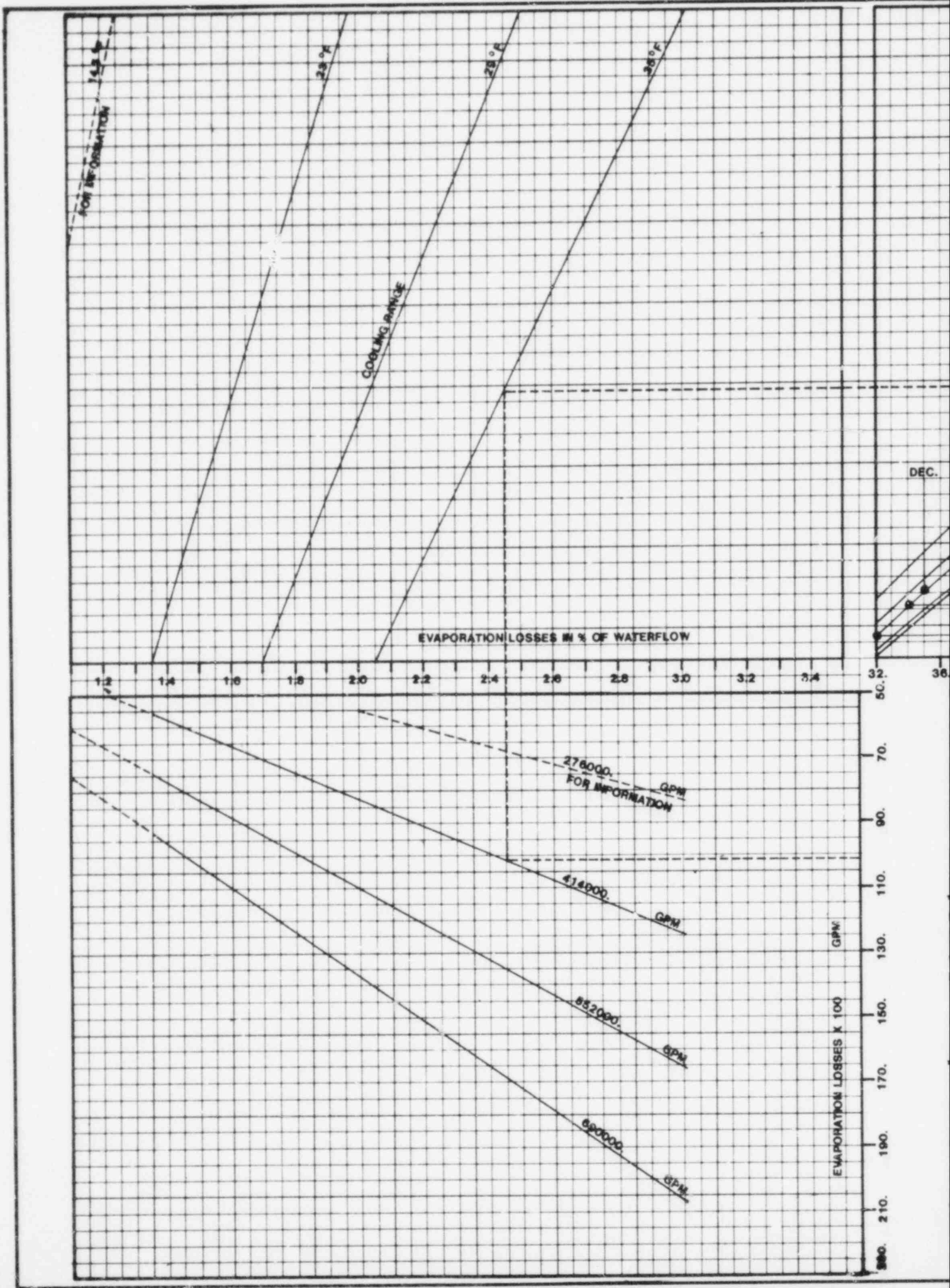
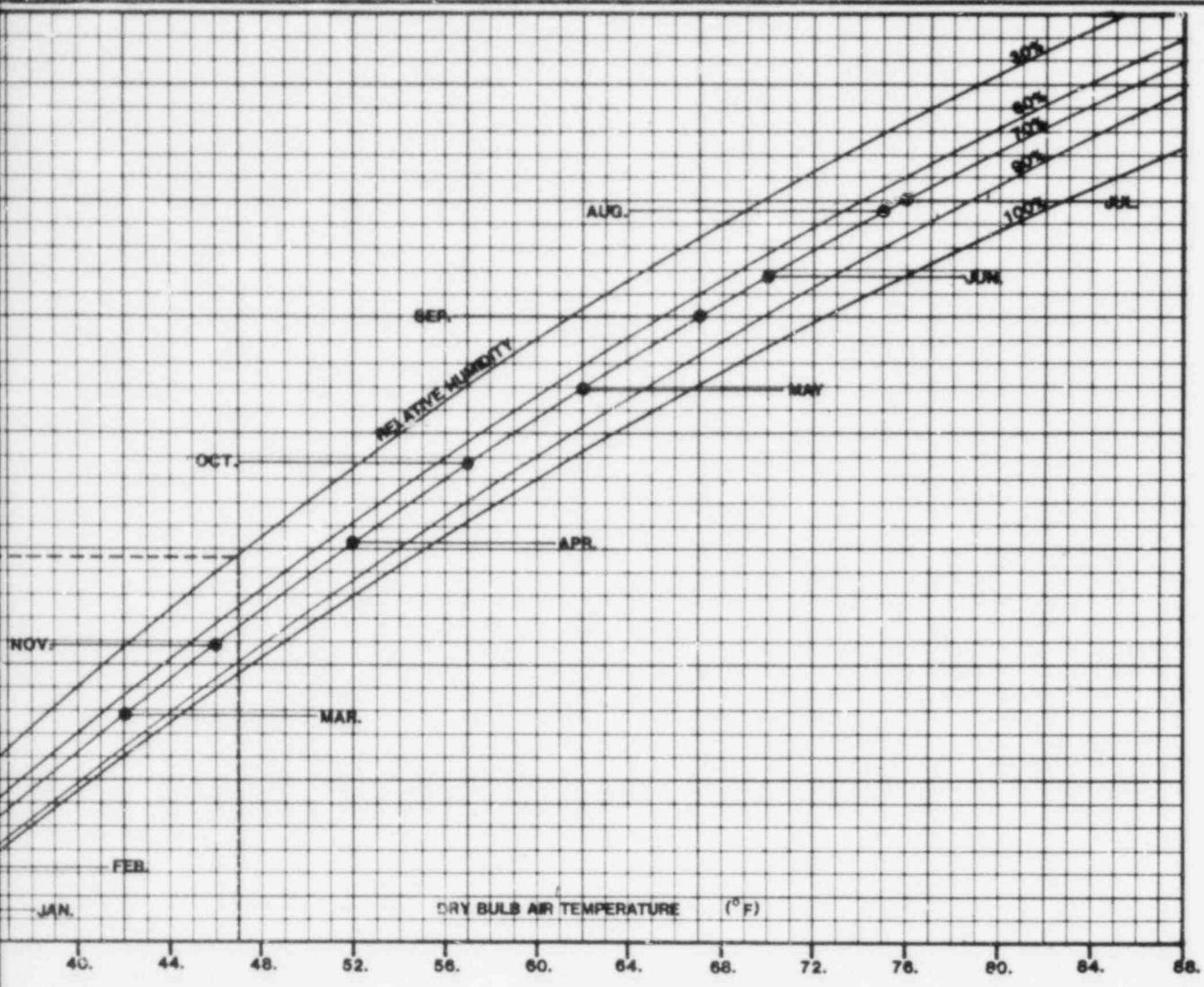
OPERATING LICENSE STAGE

COOLING TOWER PERFORMANCE
CURVES - DESIGN CONDITIONS

FIGURE 3.4 - 4


FOR INFORMATION 142.5
25°F
25°F
35°F
COOLING RANGE
EVAPORATION LOSSES IN % OF WATERFLOW
1:2
1:4
1:6
1:8
2:0
2:2
2:4
2:6
2:8
3:0
3:2
3:4
3.2
36.
DEC.
276000. GPM
FOR INFORMATION
414000. GPM
552000. GPM
690000. GPM
EVAPORATION LOSSES X 100 GPM
50.
70.
90.
110.
130.
150.
170.
190.
210.



NATURAL DRAFT COOLING TOWER

EVAPORATION LOSSES AS FUNCTION OF DRY BULB AIR TEMPERATURE, RELATIVE HUMIDITY, COOLING RANGE AND WATERFLOW

EXAMPLE

DRY BULB	47.0	°F
RELATIVE HUMIDITY	30	%
COOLING RANGE	35.00	°F
EVAPORATION LOSSES IN % WATERFLOW	2.45	
WATERFLOW	414000.	GPM
EVAPORATION LOSSES	10,200	GPM

DESIGN CONDITIONS

WATERFLOW	552000.	GPM
COOLING RANGE	29.00	°F
COLD WATER	90.00	°F
DRY BULB	87.2	°F
RELATIVE HUMIDITY	60	%

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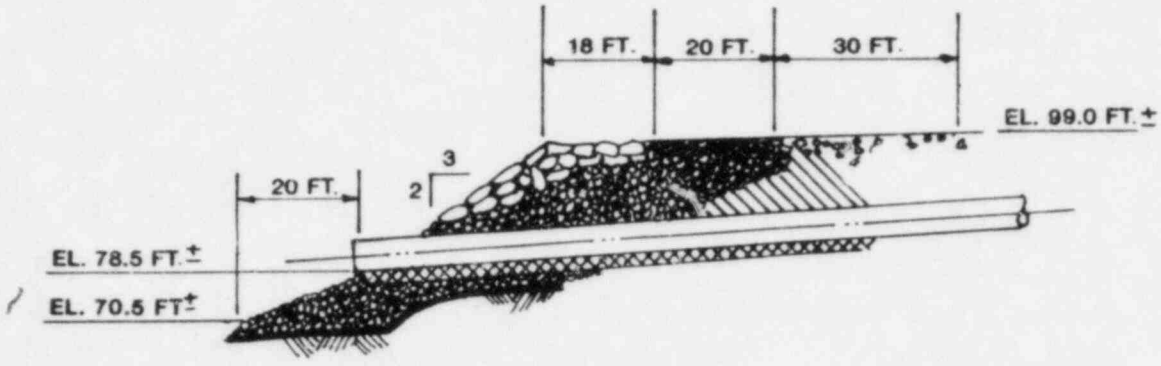
COOLING TOWER
EVAPORATION LOSSES

FIGURE 3.4 - 5



NOTE:

ELEVATIONS GIVEN IN
PUBLIC SERVICE DATUM (PSD)

PSD 89.0FT 0.0MSL

1 FOOT = 0.3048 METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

COOLING TOWER BLOWDOWN
DISCHARGE PIPE
CONFIGURATION

FIGURE 3.4 - 6

3.5 RADWASTE SYSTEMS AND SOURCE TERM

3.5.1 SOURCE TERM

This section gives noble gas source terms based on a nominal offgas release rate of 0.1 curie per second at 30 minutes decay (GE design basis). This section also gives the corresponding reactor coolant concentrations. The shielding design basis source terms and the design basis source terms for the waste management systems were derived from source terms in this section; these source terms correspond to an offgas release rate of 0.5 curie per second (five times the nominal offgas release rate) at 30 minutes decay (HCGS design basis). The source terms used for evaluation of compliance with Appendix I of 10 CFR 50 are based on the source terms in ANSI Standard N237-1976, as incorporated into NUREG-0016 and in accordance with Regulatory Guide 1.112. These source terms correspond to an offgas release rate of 0.05 curie per second at 30 minutes decay.

General Electric (GE) has evaluated radioactive material sources (activation products and fission products released from fuel) in operating boiling water reactors (BWRs). These source terms are reviewed and periodically revised as necessary to incorporate up-to-date information. Release of radioactive material from operating BWRs has resulted in doses to persons off site that are only a small fraction of 10 CFR 20 doses or of natural background doses.

The information provided in this section defines the design basis radioactive material levels in the reactor water, steam and offgas. The various radioisotopes listed have been grouped as coolant activation products, noncoolant activation products and fission products. The fission product levels are based on measurements of BWR reactor water and offgas at several stations. Emphasis was placed on observations made at KRB-1 and Dresden 2. The design basis radioactive materials levels do not necessarily include all the radioisotopes observed or theoretically predicted to be present. The radioisotopes included are considered significant to one or more of the following criteria:

a. Plant equipment/system design
b. Shielding design
c. Understanding of system operation and performance
d. Measurement practicability
e. Radiological consequences of radioactive material releases to the environment

For halogens, radioisotopes with half-lives of less than three minutes have been omitted. For other fission product radioisotopes in reactor water, radioisotopes with half-lives of less than 10 minutes are not considered.

3.5.1.1 Fission Products

Noble Radiogas Fission Products

The noble radiogas fission product source terms observed in operating BWRs are generally complex mixtures whose sources vary from miniscule defects in cladding to "tramp" uranium on external cladding surfaces. The relative concentrations or amounts of noble radiogas isotopes can be described as follows:

Equilibrium: $Rg = k_1 y$ (3.5-1)
Recoil: $Rg = k_2 ya$ (3.5-2)

The Nomenclature section of Section 3.5.1.1 defines the terms in these and succeeding equations. The constants k_1 and k_2 describe the fractions of the total fission that are involved in each of the releases. The equilibrium and recoil mixtures are the two extremes of the mixture spectrum that are physically possible. When a sufficient time delay occurs between the fission event and the release of the radiogases from the fuel to the coolant, the radiogases approach equilibrium levels in the fuel, and the equilibrium mixture results. When there is no delay or impedance between the fission event and the release of the radiogases, the recoil mixture is observed.

Prior to Vallecitos Boiling Water Reactor (VBWR) and Dresden 1 experience, it was assumed that noble radiogas leakage from the fuel would be the equilibrium mixture of the noble radiogases present in the fuel. VBWR and early Dresden 1 experience indicated that the actual mixture most often observed approached a distribution that was intermediate in character to the two extremes (Reference 3.5-1). This intermediate decay mixture is termed the "diffusion" mixture. It must be emphasized that this diffusion mixture is merely one possible point on the mixture spectrum ranging from the equilibrium to the recoil mixture, and does not have the absolute mathematical and mechanistic basis for the calculational methods possible for equilibrium and recoil mixtures; however, the diffusion distribution pattern described in Reference 3.5-1 is as follows:

Diffusion: $R_g = k_3 y a^{0.5}$ (3.5-3)

The constant k_3 describes the fraction of total fissions that is involved in the release. The value of the exponent of the decay constant, a, is midway between the values for equilibrium, 0, and recoil, 1.

Although the previously described diffusion mixture has been used by GE as a basis for design since 1963, the design basis release magnitude used has varied from 0.5 curie per second to 0.1 curie per second, as measured after a 30-minute decay (t = 30 minutes). The noble radiogas source term rate after a 30-minute decay has been used as a conventional measurable; it is consistent with the nominal design basis 30-minute gaseous radwaste system holdup system used in a number of plants. Since about 1967, the GE design basis release magnitude used (including the 1971 source terms) is an annual average of 0.1 curie per second (t = 30 minutes). This is considered to be an annual average, with some time above and some time below this value. This value was selected on the basis of operating experience rather than predictive assumptions. Several judgment factors, including the significance of environmental release, reactor water radioisotope concentrations, liquid radwaste handling and effluent disposal criteria, building air contamination, shielding design, and turbine and other component contamination affecting maintenance, have been considered in establishing this level.

Noble radiogas source terms from fuel above 0.1 curie per second (t = 30 minutes) can be tolerated for reasonable periods of time. Continual assessment of these values is made on the basis of actual operating experience in BWRs (Reference 3.5-2).

While the noble radiogas source term magnitude had been established at 0.1 curie per second (t = 30 minutes), it was recognized that there may be a more statistically applicable distribution for the noble radiogas mixture. Sufficient data were available from KRB operations from 1967 to mid-1971, along with Dresden 2 data from operation in 1970 and several months in 1971, to more accurately characterize the noble radiogas mixture pattern for an operating BWR.

The basic equation for each radioisotope used to analyze the collected data is:

$$R_y = K g y a^m [1-e^{-aT}][e^{-at}] \quad (3.5-4)$$

With the exception of Kr-85 (with a half-life of 10.74 years), the noble radiogas fission products in the fuel are essentially at an equilibrium condition after an irradiation period of several months (rate of formation is equal to the rate of decay). So for practical purposes, the term $(1-e^{-aT})$ approaches 1 and can be neglected when the reactor has been operating at steady-state for long periods of time. The term (e^{-at}) is used to adjust the releases from the fuel (t = 0) to the decay time for which values are needed. Historically, t = 30 minutes has been used. When discussing long-term, steady-state operation, and leakage from the fuel (t = 0), the following simplified form of Equation 3.5-4 can be used to describe the leakage of each noble radiogas:

$$Ry = Kgya^{m} \qquad (3.5\text{-}5)$$

The constant, Kg, describes the magnitude of leakage. The relative rates of leakage of the different noble radiogas isotopes are accounted for by the variable exponent, m, of the decay constant, a.

Dividing both sides of Equation 3.5-5 by y, the fission yield, and taking the logarithm of both sides, results in the following equation:

$$\log (Rg/y) = m \log (a) + \log (Kg) \qquad (3.5\text{-}6)$$

Equation 3.5-6 represents a straight line when log (Rg/y) is plotted versus log (a); m is the slope of the line. This straight line is obtained by plotting (Rg/y) versus (a) on logarithmic graph paper. By fitting actual data from KRB and Dresden 2 (using least squares techniques) to the equation, the slope, m, can be obtained. This can be estimated on the plotted graph. With radiogas leakage at KRB (over the nearly 5-year period) varying from 0.001 curie per second to 0.056 curie per second (t = 30 minutes), and with radiogas leakage at Dresden 2 varying from 0.001 curie per second to 0.169 curie per second (t = 30 minutes), the average value of m was determined. The value for m is 0.4, with a standard deviation of ± 0.07. Figure 3.5-1 illustrates this as a frequency histogram. As this figure shows, variations in m were observed in the range m = 0.1 to m = 0.6. After establishing the value of m = 0.4, the value of Kg can be calculated by selecting a value for Rg, or, as has been done historically, the GE design basis is set by the total source term magnitude at t = 30 minutes. With Rg at 30 minutes equaling 0.1 curie per second, Kg can be calculated as being 2.6×10^{7}, and Equation 3.5-4 becomes:

$$Rg = 2.6 \times 10^{7}\ ya^{0.4}\ [1-e^{-aT}][e^{-at}] \qquad (3.5\text{-}7)$$

This updated noble radiogas source term mixture has been termed the "1971 mixture" to differentiate it from the "diffusion mixture." The noble radiogas source term for each isotope can be calculated from Equation 3.5-7. The resultant source terms are presented in Table 3.5-1 as leakage from fuel at t = 0 and after a 30 minute decay. While Kr-85 can be calculated using Equation 3.5-7, the number of confirming experimental observations is limited by the difficulty of measuring very low release rates of this isotope. Therefore, the table provides an estimated range for Kr-85 based on a few actual measurements.

Normal operational release rates to the primary coolant are expected to be approximately 0.025 curie per second of the 13 commonly considered noble radiogases (as evaluated at 30 minutes) and 0.0001 curie per second of I-131. These values can be compared to the GE design basis values of 0.1 curie per second for the summation of the same 13 radiogases, and 0.0007 curie per second for I-131. Table 3.5-2 presents the source terms released to the reactor pressure vessel as a consequence of a power isolation event, which is the only anticipated operational occurrence in which significant activity is expected to be released.

Radiohalogen Fission Products

Historically, the radiohalogen design-basis source term was established by the same equation as that used for noble radiogases. In a fashion similar to that used with gases, a simplified equation can be shown to describe the release of each halogen radioisotope:

$$R_h = K_h ya^{n} \qquad (3.5\text{-}8)$$

The constant, K_h, describes the magnitude of leakage from fuel. The relative rates of halogen radioisotope leakage are expressed in terms of n, the exponent of the decay constant, a. As is done with the noble radiogases, the average value of n is determined to be 0.5 with a standard deviation of ± 0.19. Figure 3.5-2 illustrates this as a frequency histogram. As can be seen from this figure, variations in n were observed in the range of n = 0.1 to n = 0.9.

It appeared that the use of the previous method of calculating radiohalogen leakage from fuel was overly conservative. Figure 3.5-3 relates KRB and Dresden 2 noble radiogas leakage versus I-131 leakage. While it can be seen from Dresden 2

data, during the period August, 1970 to January, 1971, that there is a relationship between noble radiogas and I-131 leakage under one fuel condition, there is no simple relationship for all fuel conditions experienced. Also, it can be seen that, during this period, high radiogas leakages were not accompanied by high radioiodine leakage from the fuel. Except for one KRB datum point, all steady-state I-131 leakages observed at KRB or Dresden 2 were equal to or less than 505 microcuries per second. Even at Dresden 1 in March, 1965, when severe defects were experienced in stainless-steel-clad fuel, I-131 leakages greater than 500 microcuries per second were not experienced. Figure 3.5-3 shows that these higher radioiodine leakages from the fuel were related to noble radiogas source terms of less than the GE design basis value of 0.1 curie per second (t = 30 minutes). This may be partially explained by inherent limitations due to internal plant operational problems that caused plant derating.

In general, it would not be anticipated that operation at full power would continue for any significant time period with fuel cladding defects that would be indicated by I-131 leakage from the fuel in excess of 700 microcuries per second. When high radiohalogen leakages are observed, other fission products will normally be present in greater amounts.

Using these judgment factors and experience to date, the GE design basis radiohalogen source terms from fuel were established based on I-131 leakage of 700 microcuries per second. This value, as shown on Figure 3.5-3, accommodates the experience data and the GE design basis noble radiogas source term of 0.1 curies per second (t = 30 minutes). With the GE I-131 design basis source term established, Kh is calculated as being 2.4×10^{7}, and halogen radioisotope release can be expressed by the following equation:

$$Rh = 2.4 \times 10^{7}\, ya^{0.5}\, (1-e^{-aT})\, (e^{-at}) \qquad (3.5\text{-}9)$$

Concentrations of radiohalogens in reactor water can be calculated using the following equation:

$$C_h = \frac{Rh}{(a+b+d)M} \qquad (3.5\text{-}10)$$

Although carryover of most soluble radioisotopes from reactor water to steam is observed to be less than 0.1 percent (less than 0.001 fraction), the observed carryover for radiohalogens varies from 0.1 percent to about 2 percent on newer plants. The average of observed radiohalogen carryover measurements is 1.2 percent by weight of reactor water in steam,

with a standard deviation of ±0.9. In the present source term definition, a radiohalogen carryover of 2 percent (0.02 fraction) is used.

The radiohalogen release rate from the fuel can be calculated from Equation 3.5-9. Concentrations in reactor water can be calculated from Equation 3.5-10. Table 3.5-3 presents the resultant concentrations.

Other Fission Products

The observations of other fission products (and transuranic nuclides, including Np-239) in operating BWRs are not adequately correlated by simple equations. For these radioisotopes, design basis concentrations in reactor water have been estimated conservatively from experience data; these are presented in Table 3.5-4. Carryover of these radioisotopes from the reactor water to the steam is estimated to be less than 0.1 percent (less than 0.001 fraction). In addition to carryover, however, decay of noble radiogases in the steam leaving the reactor results in production of noble gas daughter radioisotopes in the steam and condensate systems.

Some daughter radioisotopes (e.g., yttrium and lanthanum) are not listed as being in reactor water. Their independent leakage to the coolant is negligible; however, these radioisotopes may be observed in some samples in equilibrium, or approaching equilibrium, with the parent radioisotope.

Except for Np-239, trace concentrations of transuranic isotopes have been observed in only a few samples where extensive and complex analyses were carried out. The predominant alpha emitter present in reactor water is Cm-242 at an estimated concentration of 10^{-6} microcurie per gram or less, which is below the maximum permissible concentration in drinking water continuously used by the general public. The concentration of alpha-emitting plutonium radioisotopes is more than one order of magnitude lower than that of Cm-242.

Plutonium-241 (a beta emitter) may also be present in concentrations comparable to the Cm-242 level.

Nomenclature

The following list of nomenclature defines the terms used in equations for source term calculations:

Rg = leakage rate of a noble gas radioisotope, microcuries per second
Rh = leakage rate of a halogen radioisotope, microcuries per second
y = fission yield of a radioisotope, atoms per fission
a = decay constant of a radioisotope, seconds
T = fuel irradiation time, seconds
t = decay time following leakage from fuel, seconds
m = noble radiogas decay constant exponent, dimensionless
n = radiohalogen decay constant exponent, dimensionless
Kg = a constant establishing the level of noble radiogas leakage from fuel, dimensionless
Kh = a constant establishing the level of radiohalogen leakage from fuel, dimensionless
Ch = concentration of a halogen radioisotope in reactor water, microcuries per gram
M = mass of cooling water in the operating reactor, grams
b = Q/M = cleanup system removal constant, seconds^{-1}
Q = cleanup system flow rate, grams per second
d = $\frac{C_s W}{Ch M}$ = halogen steam carryover removal constant, seconds^{-1}

Cs = concentration of halogen radioisotope in steam, microcuries per gram
W = steam flow rate, grams per second

3.5.1.2 Activation Products

Coolant Activation Products

The coolant activation products are not adequately correlated by simple equations. The HCGS design basis concentrations in reactor water and steam are estimated conservatively from experience data. Table 3.5-5 presents the resultant concentrations.

Noncoolant Activation Products

The activation products formed by activation of impurities in the coolant, or by corrosion of irradiated system materials, are not adequately correlated by simple equations. The HCGS design basis source terms for noncoolant activation products are estimated conservatively from experience data (Reference 3.5-3). The resultant concentrations in reactor water are presented in Table 3.5-6. Carryover of these isotopes from the reactor water to the steam is estimated to be less than 0.1 percent (less than 0.001 fraction) by weight of reactor water (Reference 3.5-3).

3.5.1.3 Tritium

In a BWR, tritium is produced by three principal methods:

a. Activation of naturally occurring deuterium in the reactor coolant.
b. Nuclear ternary fission of UO2 fuel.
c. Neutron reactions with boron used in reactivity control rods.

The control-rod-formed tritium, which may be released from a BWR in liquid or gaseous effluents, is believed to be negligible. The activation of deuterium in the reactor coolant is a prime source of tritium available for release from a BWR. Some ternary fission product tritium may also transfer from the fuel to the reactor coolant. This discussion is limited to the uncertainties associated with estimating the amounts of tritium available for release.

All of the tritium produced by activation of deuterium in the reactor coolant is available for release in liquid or gaseous effluents. The tritium formed in a BWR from deuterium activation can be calculated using the equation:

$$R_{act} = \frac{EN\ Va}{3.7 \times 10^{4} P} \qquad (3.5\text{-}11)$$

Where:

R_{act} = tritium formation rate by deuterium activation, microcuries per second per MWt

E = macroscopic thermal neutron cross section, centimeters^{-1}

N = thermal neutron flux, neutrons per square centimeter per second

V = coolant volume in core, cubic centimeters

a = tritium radioactive decay constant, 1.78×10^{-9} seconds^{-1}

P = reactor power level, MWt

For representative BWR designs, R_{act} is about $(1.3 \pm 0.4) \times 10^{-4}$ microcuries per second per MWt. The uncertainty indicated is derived from the estimated errors in selecting values for the coolant volume in the core, coolant density in the core, abundance of deuterium in light water

(some additional deuterium is present because of the H(n,gamma)D reaction), thermal neutron flux, and microscopic cross section for deuterium.

It is more difficult to estimate the fraction of ternary-fission-produced tritium which may transfer from the fuel to the reactor coolant (and is then available for release in liquid and gaseous effluents); however, since zircaloy-clad fuel rods are used in BWRs, essentially all fission product tritium remains in the fuel rods unless defects are present in the cladding material (Reference 3.5-4).

A study made at Dresden 1 in 1968 by the U.S. Public Health Service (USPHS) suggests that essentially all of the tritium released from the plant could be accounted for by the deuterium activation source (Reference 3.5-5). For purposes of estimating the leakage of tritium from defective fuel, it can be assumed that it leaks in a manner similar to the leakage of noble radiogases. Thus, the empirical relationship for "diffusion mixture" described in Section 3.5.1.1 also can be used for predicting the source term of individual noble gas radioisotopes. The equation that describes this relationship is:

$$R_{dif} = K y a^{0.5} \qquad (3.5\text{-}12)$$

where:

R_{dif} = leakage rate of tritium from fuel, microcuries per second

y = fission yield fraction, atoms per fission

a = radioactive decay constant, seconds^{-1}

K = a constant related to total tritium leakage rate, dimensionless

If the total noble radiogas source term is 0.1 curie per second (GE design basis) after a 30-minute decay, leakage from fuel can be calculated to be about 0.24 microcurie per second of tritium. To place this value in perspective, in the USPHS study, the observed leakage rate of Kr-85 (which has a half-life similar to that of tritium) was 0.06 to 0.4 times that calculated using the "diffusion mixture" relationship. This would suggest that the actual tritium leakage rate might range from 0.015 to 0.10 microcurie per second. Since the annual average noble radiogas leakage from a BWR is expected to be less than 0.1 curie per second (t = 30 minutes), the annual

average tritium release rate from the fission source can be conservatively estimated at 0.12 ± 0.12 microcurie per second, or 0.0 to 0.24 microcurie per second.

Based on this approach, the estimated total tritium appearance rate in reactor coolant and release rate in the effluent is about 20 curies per year.

Tritium formed in the reactor is generally present as tritiated oxide (HTO), and to a lesser degree as tritiated gas (HT). The tritium concentration (on a weight basis) in the steam formed in the reactor is the same as in the reactor water at any given time. This tritium concentration is also present in condensate and feedwater. Since radioactive effluents generally originate from the reactor and power cycle equipment, radioactive effluents also have this tritium concentration. The condensate storage tank receives treated water for the liquid waste management system and water from the condensate system. Thus, all plant process water has a common tritium concentration.

Offgases released from the plant contain tritium, which is present as HT (resulting from reactor water radiolysis) as well as HTO. In addition, tritium is contained in water vapor from the turbine gland seal steam packing exhauster, and a lesser amount is present in ventilation air (due to process steam and liquid radwaste leaks or evaporation from sumps, tanks and spills on floors). The remainder of the tritium leaves the plant in liquid effluents and with solid wastes. Essentially, all tritium in the reactor coolant is eventually released to the environs, either as water vapor and gas to the atmosphere, as liquid effluent to the plant discharge, or as solid waste.

Recombination of radiolysis gases in the air ejector offgas system forms water, which is condensed and returned to the main condenser. This tends to reduce the amount of tritium leaving in gaseous effluents. Reducing the gaseous tritium release results in a slightly higher tritium concentration in the plant process water. Reducing the amount of liquid effluent discharged also results in a higher process coolant equilibrium tritium concentration. Reduction due to radioactive decay is negligible, due to the 12-year half-life of tritium.

The USPHS study at Dresden 1 estimated that approximately 90 percent of the tritium release was observed in liquid effluent, with the remaining 10 percent leaving as gaseous effluent (Reference 3.5-5). Efforts to reduce the volume of liquid

effluent discharges may change this distribution so that a greater amount of tritium will leave as gaseous effluent. From a practical standpoint, the fraction of tritium leaving as liquid effluent may vary between 60 and 90 percent, with the remainder leaving in gaseous effluent.

3.5.1.4 Fuel Experience

A discussion of BWR fuel experience, including fuel failure experience, burnup experience, and the thermal conditions under which the experience was gained, is presented in References 3.5-6, 3.5-7 and 3.5-8.

3.5.1.5 Process Leakage Sources

Process leakage results in potential release paths for noble gases and other volatile fission products via ventilation systems. Liquids from process leaks are collected and routed to the liquid radwaste system. Section 3.5.2 discusses radioactive releases from the liquid waste management system. Radionuclide releases via ventilation paths have been at extremely low levels and have been insignificant compared to process offgas from operating BWR plants; however, because the implementation of improved process offgas treatment systems makes the ventilation release relatively significant, GE has conducted measurements to identify and quantify these low level releases and release paths through the ventilation systems. GE has maintained an awareness of measurements by the Electric Power Research Institute (EPRI) and other organizations and routine measurements by utilities with operating BWRs.

Leakage of fluids from the process systems may result in the release of radionuclides into plant buildings. In general, noble radiogases remain airborne and are released to the atmosphere with little delay via the building ventilation exhaust ducts. Other radionuclides are partitioned between air and water, and some amount of airborne radioiodines may plate-out on metal surfaces, concrete and paint, while some amount of radioiodine may be desorbed from the collecting surfaces and become airborne. Radioiodides are found in ventilation air as methyl iodide and as inorganic iodine, which is defined here as particulate, elemental and hypoiodous acid forms of iodine. Particulates are also present in the ventilation exhaust air.

The airborne radiological releases from BWR building heating, ventilating and air conditioning (HVAC) systems and the main condenser mechanical vacuum pump have been evaluated using

NUREG-0016, Reference 3.5-9, with supporting information obtained from NEDO-21159, Reference 3.5-10. Radioactive releases from ventilation systems are evaluated for compliance with 10 CFR 50, Appendix I, in Section 3.5.3. Section 5.2.4 evaluates exposures due to airborne radioactivity.

3.5.2 LIQUID RADWASTE SYSTEMS

The liquid waste management system (LWMS) is designed to collect, store, process and dispose of or recycle all radioactive or potentially radioactive liquid waste generated by plant operation or maintenance.

The LWMS consists of five process subsystems, each for the collection, storage, processing, monitoring and disposal of specific types of liquid wastes in accordance with their conductivity, chemical composition and radioactivity. These systems are:

a. Equipment drain (high purity waste)
b. Floor drain (low purity waste)
c. Regenerant waste (high conductivity waste)
d. Chemical waste (decontamination solution waste and chemistry lab drains)
e. Detergent drain waste (laundry waste and personnel decontamination drains).

Sufficient treatment capability is available to process liquid waste to meet condensate quality requirements for plant reuse (conductivity value of less than or equal to 0.1 umho per centimeter at 25°C (77°F)). Liquid wastes that cannot be processed to meet the quality requirement for reuse are solidified along with process concentrates for off-site shipment and disposal. Excess water is released in a controlled and monitored manner into the cooling tower blowdown line for dilution, and then discharged to the Delaware River.

Section 3.5.5 describes the process and effluent radiological monitoring and sampling systems for the LWMS. The LWMS has no safety function.

3.5.2.1 Design Bases

Design bases for the LWMS are as follows:

a. The system has the capability to process the maximum anticipated quantities of liquid waste without impairing the operation or availability of the plant

during both normal and expected occurrence conditions, satisfying the requirements of 10 CFR 20 and 10 CFR 50.

b. Alternate process routes, subsystem crossties and adequate storage volumes are included in the system design to provide for operational and anticipated surge waste volumes, which could occur during refueling, abnormal leakage, decontamination activities and equipment maintenance.

c. The system is designed so that no potentially radioactive liquids can be discharged to the environment unless they have been processed, monitored, and diluted by mixing with the cooling tower blowdown release. This results in off-site radiation exposures on an annual average basis that are within the limits of 10 CFR 20 and 10 CFR 50.

d. The LWMS is designed to keep the exposure to plant personnel "as low as is reasonably achievable" (ALARA) during normal operation and plant maintenance, in accordance with Regulatory Guide 8.8.

e. Expected radionuclide activity concentrations in the liquid waste management process equipment are based on 50,000 microcuries per second noble gas release rate, measured after 30 minutes decay. The maximum radionuclide concentrations are based on a corresponding noble gas release rate of 500,000 microcuries per second after 30 minutes decay (design basis).

   The concentation of radioactivity at the point of discharge shall not exceed concentration limits specified in 10 CFR 20, on an annual average basis.

f. All piping and equipment in the LWMS are non-Seismic Category I, with the exception of the primary containment, the reactor building enclosure isolation valves, and the associated piping between the isolation valves.

g. All atmospheric liquid radwaste tanks are provided with an overflow connection at least the size of the largest inlet connection. The overflow is connected below the tank vent and above the high level alarm setpoint. It is routed to the nearest drainage system compatible with its purity and chemical content.

Each liquid radwaste tank room is designed to contain the maximum liquid inventory in case the tank ruptures.

h. Processed wastes are collected in sample tanks prior to their reuse as condensate quality water, or their controlled discharge into the cooling tower blowdown line, where the wastes are diluted before they enter the Delaware River.

i. Tables 3.5-14 and 3.5-15 show the expected and maximum radionuclide activity inventories for LWMS components containing significant amounts of radioactive liquid. They are based upon the assumptions given in Table 3.5-7 and upon the following:

   1. Expected flow rates for the radwaste streams as shown on Figure 3.5-4 are given in Table 3.5-9.

   2. Design basis reactor water radionuclide activity concentrations are listed in Tables 3.5-1 through 3.5-5. Expected reactor water radionuclide activity concentrations are listed in Table 3.5-9.

   3. Decontamination factors for process components within the LWMS are given in Table 3.5-10.

   4. During the batch collection of waste streams in the collection tanks, the radionuclide inventory in the tanks undergoes radioactive decay. Table 3.5-11 shows expected holdup times.

   5. The planned refueling cycle is 18 months; however, for conservatism, one refueling shutdown per year is assummed.

The expected daily inputs and activity levels for each of the subsystems are shown in Tables 3.5-12 and 3.5-13.

The implementation of item 'h' in conjunction with the isolation function of the radiation monitoring system minimizes the potential for uncontrolled release due to operator error or equipment malfunction.

Control, monitoring and sampling of radioactive releases in accordance with GDC 60 and 64 of 10 CFR 50, Appendix A, are discussed in Sections 3.5.2.3 and 3.5.5.

Table 3.5-16 contains a summary of the design parameters for major components.

3.5.2.2 System Description

The LWMS collects, monitors, processes, stores and disposes of potentially radioactive liquid wastes collected throughout the plant. Potentially radioactive wastes are collected from the following sources:

a. Floor drains in controlled access areas that may generate potentially radioactive wastes.

b. Tanks and sumps that collect potentially radioactive wastes.

c. Piping and equipment that contain potentially radioactive wastes.

These potentially radioactive liquid wastes are collected in tanks located in the auxiliary building. System components are arranged in shielded enclosures to minimize exposure to plant personnel during operation, inspection and maintenance. Tanks, processing equipment, pumps, valves and instruments that may contain radioactivity are located in controlled access areas.

The LWMS normally operates on a batch basis. Administrative controls, and detection and alarm of abnormal conditions, provide protection against accidental discharge.

The LWMS is divided into several subsystems, so that the liquid wastes from various sources can be segregated and processed separately, according to the most economical and efficient process for each specific type of impurity and chemical content. Cross-connections between subsystems provide additional flexibility in processing the wastes by alternate methods, and provide redundancy if one subsystem becomes inoperative.

3.5.2.2.1 System Operation

Equipment Drain Processing Subsystem

The waste collector tanks in the equipment drain subsystem receive waste inputs from the clean radwaste (CRW) sumps in the plant enclosures and from other inputs listed in Table 3.5-13. These waste inputs have a high chemical purity (conductivity less than 10 umhos per centimeter, and less than 20 parts per million suspended solids); they are processed on a

batch basis through a precoat filter and a mixed-bed demineralizer. Cross-connections with the floor drain subsystem allow processing through the floor drain filter and demineralizer.

The processed wastes are collected in one of the two waste sample tanks for chemical and radioactivity analysis. If acceptable, the tank contents are returned to the condensate storage tank (CST) for plant reuse. A recycle routing from the waste sample tank allows the sampled water that does not meet the condensate quality requirements to be pumped back to a waste collector tank for additional processing by filtration and demineralization, or to the waste surge tank for transfer to and processing in the regenerant waste subsystem. If the plant condensate inventory is high, the sampled waste water is discharged to the cooling tower blowdown line for dilution prior to discharge to the Delaware River.

Additional collection capacity is also provided by a waste surge tank tied to the common inlet header of the waste collector tanks.

Floor Drain Processing System

The floor drain collector tanks receive low purity waste inputs from various floor drain (DRW) sumps in each plant enclosure and from other inputs listed in Table 3.5-13. These wastes typically have a conductivity of 10 to 100 umhos per centimeter, a maximum suspended solids concentration of 500 parts per million, and a radioactivity concentration of less than 10^{-3} microcurie per cubic centimeter.

The floor drain subsystem consists of two floor drain collector tanks, a precoat filter, a mixed-bed demineralizer train and two sample tanks. The wastes collected in the floor drain collector tank are processed on a batch basis. Cross-connections with the equipment drain subsystem also allow processing through the waste filter and demineralizer train.

The floor drain sample tanks collect the processed wastes, so that a sample may be taken for chemical and radioactivity analysis before discharge of the wastes. The discharge path depends on the water quality, cooling tower blowdown availability and plant water inventory. The treated floor drain wastes may be discharged from the plant to the Delaware River after mixing with the cooling tower blowdown. Off-standard quality water can be recycled to the floor drain collector tanks or to the waste neutralization tanks for processing in the regenerant waste subsystem. If the treated wastes meet the standards for condensate water quality used in the plant,

and if the water inventory permits their recycling, the processed floor drain wastes can be discharged to the CST for plant reuse.

Regenerant Waste Processing Subsystem

The regenerant waste subsystem collects wastes from the regeneration process for the condensate and radwaste demineralizers and the high conductivity drain sumps in the radwaste and turbine enclosures. These wastes collect in the waste neutralizer tanks, where they are neutralized, and buffered with solutions of sodium phosphate, if required, before being processed through the waste evaporators for concentration. The distillate resulting from the evaporation process is returned to the waste collector tanks. The waste evaporator concentrate is collected in the concentrated waste tanks for chemical pretreatment, and then transferred to the solid waste management system for solidification and off-site disposal. In addition, concentrate is transferred from the decontamination solution concentrated waste tank to the concentrated waste tanks.

Chemical Waste Processing Subsystem

Chemical wastes collected in the chemical waste tank consist of laboratory wastes, decontamination solutions and sample rack drains. After accumulating in the chemical waste tank, these wastes are neutralized to a pH value of 7 to 10, buffered with a solution of sodium phosphate, if required, and then processed by evaporation through the decontamination solution evaporator.

The chemical wastes are normally evaporated to reduce volume. The concentrate is discharged to the decontamination solution concentrated waste tank for radioactive decay, then transferred to the concentrated waste tanks. The vapors produced during this evaporation are sampled, and then discharged through the plant south vent. When the radioactivity concentration is low, a cross-connection with the floor drain subsystem allows the chemical wastes to be processed through the floor drain filter and demineralizer, and then diluted with the cooling tower blowdown and sent into the discharge canal.

Detergent Waste Processing Subsystem

Detergent-containing waste water from the controlled laundry and personnel decontamination facilities throughout the plant collects in the double-compartmented detergent drain tank. The detergent wastes are processed by filtration.

The effluent from the detergent drain filter is monitored for radioactivity, and discharged to the cooling tower blowdown for dilution and controlled release to the Delaware River. In the event of high conductivity and/or high radioactivity concentration, a cross-connection with the chemical waste subsystem allows the wastes to be diverted to the decontamination solution evaporator for further processing.

3.5.2.2.2 Process Equipment Description

The following paragraphs describe the major components of the LWMS.

Pumps

Three types of pumps used in the LWMS are as follows:

a. Sump pumps - The LWMS sump pumps are vertical-centrifugal, with a cast iron casing, stainless steel 316L shaft and bronze impellers, with a packing seal. High conductivity sump pumps are all stainless steel. Each sump is provided with two pumps. All the sump pumps except the drywell and reactor building sump pumps are controlled from the radwaste main control panel.

b. Process pumps - The LWMS process pumps are horizontal-centrifugal, manufacturer standard with a stainless steel ASA-351 casing and stainless steel A561 shaft. They are provided with mechanical seals.

c. Metering pumps - Body feed of filter aid to the filters in the LWMS, neutralization chemicals and buffering compounds are added with reciprocating positive displacement pumps.

Tanks

Tanks are sized to accommodate the expected volumes of waste generated in the five subsystems mentioned in Section 3.5.2.2.1. The tanks are constructed of stainless steel to provide a low corrosion rate during normal operation. They are provided with mixing eductors or air spargers. All radwaste tanks vent to the radwaste tank vent filtration unit, and discharge to the south plant vent. The liquid radwaste tanks are designed in accordance with API 620 code for 0 to 15 psig storage tanks.

3.5.2.2.3 Filters

Filters for the LWMS are as follows:

a. Equipment and floor drain filters - The waste collector and floor drain filters are pressure precoat type with wire-wound filter elements. They use diatomaceous earth as filter media. Both filters are provided with a common precoat tank and filter aid tank (for body feed), but with individual pumps. An individual filter holding pump is also provided for each filter.

   The filter precoat must be changed when the differential pressure across the filter exceeds a preset limit and initiates an alarm. The precoat is then backwashed to the waste sludge phase separator.

b. Detergent drain filter - The detergent drain process uses a cartridge filter that is replaced when the differential pressure across the filter reaches a preset limit and initiates an alarm.

   The filter vessels are constructed of stainless steel and are designed in accordance with ASME B&PV Code, Section VIII, Division 1. Each filter is located in a separate, shielded room to minimize exposure to personnel during operation and routine maintenance.

3.5.2.2.4 Demineralizers

The equipment and floor drain demineralizers are mixed-bed type. The strong acid and base mixed-bed resin gel-type (1:1 ratio by volume) is regenerated when the effluent conductivity exceeds a preset conductivity limit, as well as upon high differential pressure. Exhausted resins are sluiced to the radwaste demineralizer regeneration system for resin regeneration and reuse.

The carbon steel demineralizer vessels are rubber-lined. Fine mesh strainers are provided in the vessel discharge and in the downstream piping to prevent resin fines from being carried over to the sampling tanks.

When the resins cannot be regenerated effectively, they are discharged to the spent resin tank for radioactive decay, and then transferred to the solid waste management system for solidification and off-site disposal.

Each demineralizer vessel is located in a separate, shielded room to minimize exposure to personnel during operation and routine maintenance. The demineralizer vessel is designed per ASME BPV Code, Section VIII, Division 1.

3.5.2.2.5 Radwaste Evaporators

a. Waste evaporators - Two waste evaporators are arranged in parallel, for simultaneous operation, and as backup to each other. The waste evaporators are of a forced-circulation, submerged tube design, to minimize scale deposits; each has a design feed rate of 150 liters per minute (40 gallons per minute). Heating steam is provided from the plant heating steam system.

   The evaporator bottoms are discharged to a concentrated waste tank, from which they are fed to volume reduction equipment in the solid waste management system. The distillate from the evaporators is recycled to a waste collector tank. A grab sample of the distillate is periodically taken for chemical analysis.

b. Decontamination solution evaporator - The decontamination solution evaporator is a natural circulation type, with an internal, removable heating element, and a design feed rate of 20 liters per minute (five gallons per minute). The plant heating system provides heating steam.

   The evaporator bottoms are discharged to the decontamination solution concentrated waste tank, and then transferred to one of the concentrated waste tanks, from which they are fed to the volume reduction equipment in the solid waste management system. The vapor overhead is discharged to the environment through the south plant vent, where the activity level is monitored. The vapor overheads are not condensed nor recycled for plant use because of potential organic chemical contamination.

   The liquid radwaste evaporator vessels and internals are constructed of 316 L stainless steel, and are designed in accordance with ASME B&PV Code, Section VIII, Division 1.

Piping

The LWMS piping is designed to meet the requirements of ANSI B31.1 and Regulatory Guide 1.143. It is designed to minimize crud traps. No backing rings are used for the welded pipes. The piping material for each system is selected to minimize corrosion. Radioactive piping is routed through shielded areas to minimize personnel exposures.

3.5.2.3 Radioactive Releases

During processing of liquid by the LWMS, radioactive contaminants are removed so that the bulk of the liquid is restored to condensate quality water, which is either returned to the CST or discharged to the environment via the cooling tower blowdown line. The radioactivity removed from the liquid waste is concentrated in the filter media, ion exchange resins and evaporator bottoms. These concentrated wastes are sent to the solid waste management system for further volume reduction and solidification. If the liquid is recycled to the plant, it meets the purity requirements for condensate makeup. If the liquid is discharged, the activity concentration is consistent with the discharge criteria of 10 CFR 20. Tritiated water that is discharged from the systems is consistent with the discharge criteria of 10 CFR 20.

The resulting doses from radioactive effluents are within the guideline values of Appendix I of 10 CFR 50. In addition to the radioactivity limitations on releases, water quality standards for discharge and heat content may necessitate recycling of the water, rather than discharging.

Although the plant discharges vary as stated above, this analysis assumes the following, which are consistent with NUREG 0016:

a. Discharge of one percent of the high purity waste processing stream.

b. Discharge of 50 percent of the low purity waste processing stream.

c. Discharge of 10 percent of the chemical waste processing stream.

d. Discharge of 10 percent of the regenerant waste processing stream.

e. Discharge of 100 percent of the laundry drain waste processing stream.

Table 3.5-7 gives the assumptions and parameters used to calculate the yearly activity releases. The yearly activity releases for each waste stream and the total appear in Table 3.5-17.

The processed liquid radwaste that is not recycled in the plant is discharged into the cooling tower blowdown line on a batch basis, at flow rates of up to 666 liters per minute (176 gallons per minute) for the low purity waste processing system, and 95 liters per minute (25 gallons per minute) for the laundry drain waste processing system. (No pump flows are given for discharges from the high purity, chemical or regenerant waste processing streams since it is not planned to actually discharge any of those streams.) Flow is controlled by a flow control valve; therefore, the actual flow could be substantially less. The minimum monthly total cooling tower blowdown flow of 72,000 liters per minute (19,000 gallons per minute) dilutes the above discharge rates by at least a factor of 100 for the low purity waste, and by 750 for the laundry waste streams. This dilution occurs within the site boundary; the dilution is used in determining specific activity concentrations for the releases. These concentrations and a comparison to 10 CFR 20 limits appear in Table 3.5-18.

3.5.2.4 Estimated Doses

To ensure compliance with Appendix I of 10 CFR Part 50, dose calculations, based on the liquid source terms described above, are performed in accordance with Regulatory Guide 1.109 by use of the USNRC computer code LADTAP. For these purposes doses are calculated for a maximum individual consuming aquatic biota and receiving shoreline exposure at the edge of the initial mixing zone. There is no potable water or irrigation pathway for liquid effluents from HCGS. Table 3.5-19 gives input data for these calculations. The calculated doses are 0.0382 mrem per year to the total body of an adult and 0.272 mrem per year to the bone of an adult. These doses are well within the Appendix I design guides of 3.0 and 10.0 mrem per year to the total body and any organ, respectively.

3.5.3 GASEOUS RADWASTE SYSTEMS

The gaseous waste management systems include all systems that process potential sources of airborne releases of radioactive material during normal operation and anticipated operational occurrences. Included are the offgas system and various ventilation systems. These systems reduce radioactive gaseous releases from the plant by filtration or delay, which allows decay of radioisotopes prior to release.

The function of the offgas system is to collect and delay the release of noncondensable radioactive gases removed from the main condenser by the air ejectors during normal plant operation. Plant ventilation systems process airborne radioactive releases from other plant sources, such as equipment leakage, maintenance activities, the mechanical vacuum pump and the steam seal system.

3.5.3.1 Design Bases:

a. The gaseous waste management systems are designed to control and monitor the release of radioactive materials in gaseous effluents in accordance with General Design Criteria (GDC) 60 and 64 of 10 CFR 50, Appendix A.

b. The offgas system design basis source terms correspond to 500,000 microcuries per second of radioactive noble gases after 30-minute delay.

c. The gaseous waste systems are designed to limit offsite doses from routine plant releases to significantly less than the limits specified in 10 CFR 20, and to operate within the dose objectives established in 10 CFR 50, Appendix I.

d. The gaseous waste management systems are designed with sufficient capacity and redundancy to accommodate all anticipated processing requirements of the plant during normal operation, including anticipated operational occurrences.

e. Continuous monitoring is provided for all potential pathways of airborne radioactive releases, with main control room annunciation at levels higher than allowed limits.

f. Design provisions are incorporated that preclude the uncontrolled release of radioactivity to the environment as a result of any single operator error or any single active component failure.

g. The gaseous waste management systems are designed to keep the exposure to plant personnel as low as is reasonably achievable (ALARA) during normal operation and plant maintenance, in accordance with Regulatory Guide 8.8.

h. The offgas system is designed to provide at least 35 days and 36 hours of delay time for xenon and krypton, respectively, at an airflow rate of 75 standard cubic feet per minute.

i. Filtration units in the ventilation systems are designed, operated and maintained in accordance with the guidelines of Regulatory Guide 1.140.

j. The offgas system is designed to maintain the concentration of hydrogen in the gases exhausted from the main condenser below flammable limits.

k. Instrumentation is provided in the offgas system to detect abnormal concentrations of hydrogen and other system malfunctions.

l. The offgas system, except for the gas analyzers, is designed to withstand the effects of a hydrogen explosion without reach of the pressure boundary.

3.5.3.2 System Description

3.5.3.2.1 Offgas System

Steam jet air ejectors (SJAEs) continuously remove noncondensable gases from the main condenser during plant operation. The offgas consists of activation gases, fission product gases, radiolytic hydrogen and oxygen, and condenser air inleakage.

The offgas system is designed to reduce offgas radioactivity to levels permissible for release under all site atmospheric conditions.

The offgas system uses a catalytic recombiner and a cooler condenser for control of hydrogen concentration and volume reduction, respectively. Selective adsorption of fission product noble gases (xenon and krypton) on charcoal is used to provide time for delay before release.

3.5.3.2.1.1 Process Description

Figure 3.5-5 is the process flow diagram for the offgas system. Table 3.5-21 contains the process data for the maximum flow operating condition.

During start-up, mechanical vacuum pumps are used to draw a vacuum in the main condenser. Once condenser vacuum has been established by the mechanical vacuum pumps, a three-stage SJAE

train is placed in service using auxiliary steam. Once reactor steam is available, it replaces auxiliary steam.

The steam also provides dilution to maintain the hydrogen concentration below the combustible limit.

The offgas stream from the third-stage SJAE is first treated in the recombiner section of the offgas system. The purpose of the recombiner section is to eliminate the potential for explosion, by controlled recombination of the radiolytic hydrogen and oxygen, and to reduce the offgas volume. After the offgas stream has passed through the cooler condenser, the hydrogen concentration is reduced to less than 0.1 percent by volume. The offgas first passes through the preheater in order to vaporize any water droplets and to achieve a sufficient temperature to start the catalytic reaction. Steam used for preheating is provided from the nuclear boiler steam supply line or from auxiliary steam. The recombination process takes place inside the recombiner vessel. The temperature of the gases leaving the recombiner rises as a function of the influent hydrogen concentration. This temperature rise is due to the heat of reaction of the recombination process. The reaction temperature rises approximately 83°C (150°F) for each one percent of H_2 recombined. The catalyst is pellet-type, ceramic-base, coated with palladium. Each recombiner has an electric heater assembly.

The moisture in the offgas leaving the recombiner vessel is condensed in the cooler condenser, and the offgas stream is cooled to approximately 49°C (120°F). The remaining noncondensable gas (principally air with traces of krypton and xenon) is delayed in a series of eight, 24-inch diameter, 55-foot length holdup pipes. At a flow rate of 75 standard cubic feet per minute, this pipe provides a minimum delay of 10 minutes for the offgas prior to its entering the ambient charcoal treatment section.

Further offgas cooling and condensing of water vapor takes place in the glycol cooler condenser, where the offgas passes through stainless steel coils submerged in a glycol bath maintained at 2°C (35°F). The offgas exits the glycol cooler condenser at 4°C (40°F) and 100 percent relative humidity.

A reheater, consisting of self-limiting heat tracing on the process pipe, heats the offgas to 18°C (65°F), thereby lowering the relative humidity to 40 percent, the design condition for the charcoal beds.

Before entering the main charcoal vessels, the offgas stream passes through a guard bed. The function of the guard bed is to protect the main charcoal adsorbers from moisture if a

malfunction of moisture removal features occurs, as well as to adsorb impurities in the process gas that might adversely affect performance of the main charcoal vessels.

After passing through the guard bed, the offgas enters the main charcoal adsorption beds. The charcoal adsorption beds, maintained at 18°C (65°F) by redundant room heating and air conditioning units, selectively adsorb and delay the xenon and krypton from the bulk carrier gas. This delay permits the xenon and krypton to decay in place. The offgas stream then passes through a HEPA filter where radioactive particulate matter and any charcoal particles are retained.

The offgas stream is then directed to the north vent stack, where it is diluted with a minimum of 59,000 standard cubic feet per minute of air from the turbine building common area, solid radwaste system exhaust and chemical lab exhaust, before being released. Table 3.5-22 shows the estimated annual release rate from the offgas system.

All moisture removed from the process stream is returned to the main condenser, except for the condensate from the glycol cooler condenser, which is routed to the clean radwaste drainage (CRW) system.

3.5.3.2.1.2 System Design Considerations

Charcoal Holdup Time

The charcoal adsorber bed is designed for a delay time of 35 days for xenon under the condition of a 75 standard cubic feet per minute condenser inleakage rate using manufacturer's guaranteed adsorption coefficients (733 cubic centimeters per gram for xenon and 32 cubic centimenters per gram for krypton). The required charcoal mass of 146,000 kilograms (322,000 pounds) is obtained by the following equation from References 3.5-11 and3.5-12:

$$M = \frac{TV}{0.26K}$$

where:

T = holdup time, hours
K = dynamic adsorption coefficient, cubic centimeters per gram
V = air flow rate, standard cubic feet per minute
M = mass of charcoal, 10^3 pounds

Using the adsorption coefficients for the condition of 25°C (77°F) operation, 7°C (45°F) dew point, the NUREG-0016, Revision 1 (Reference 3.5-13) methodology yields delay times of 55 days and 3.1 days for xenon and krypton, respectively, for 146,000 kilograms (322,000 pounds) of charcoal. This estimate is very conservative since the adsorption coefficients for 18°C (65°F) operation and 4°C (40°F) dew point should be significantly higher than the ones for 25°C (77°F) operation and 7°C (45°F) dew point (330 cubic centimeters per gram for xenon and 18.5 cubic centimeters per gram for krypton).

Hydrogen Detonation Resistance

The pressure boundary of the offgas system is designed to withstand the effects of a hydrogen detonation during all anticipated modes of operation. In addition, the system includes features that reduce the probability of an explosion. Such features include:

a. Maintenance of nonexplosive mixture throughout the system - loss of dilution steam in SJAE will actuate an alarm and the suction valve of SJAE will be closed to isolate the offgas system.

b. Minimization of potential ignition sources, e.g., nonsparking valves.

c. Design with dual hydrogen analyzers which isolate when the setpoint is reached.

3.5.3.2.1.3 Component Description

Table 3.5-23 lists the materials of construction, design temperatures and pressures.

Recombiner Section:

a. Preheater - The preheater is a straight tube-and-shell heat exchanger with the process gas on the tube side and steam on the shell side. Main steam is used to heat the process gas before entering the recombiner. The process gas enters the preheater at 105°C (221°F) and is heated to 132°C (270°F). Auxiliary steam is also available for heating the process gas flow, should main steam be unavailable. Condensate from the shell side of the heat exchanger is collected in a flash pot and routed back to the main condenser.

b. Recombiner - The hydrogen and oxygen in the gas stream are recombined in the recombiner vessel by a catalyst bed made of palladium-coated ceramic pellets. Electric heaters with automatic temperature control are provided on the shell of each recombiner. The heaters are used to preheat the recombiner during start-up and to maintain it in a dry condition during shutdown.

c. Cooler condenser - The cooler condenser is a straight tube heat exchanger. Reactor auxiliary cooling system (RACS) cooling water is circulated on the tube side to condense the steam in the offgas stream. The offgas is cooled to 49°C (120°F), and directed to the holdup pipe. Control valves are used to automatically maintain a proper condensate level in the cooler condenser shell. The condensate is routed to the main condenser.

Holdup Pipe

A series of holdup pipes consisting of eight 24-inch diameter, 55-foot length pipes lies between the recombiner section and the charcoal treatment section. The purpose of the holdup pipe is to provide delay time (a minimum of 10 minutes for the design flow rate of 75 standard cubic feet per minute) to allow N-16 decay before the offgas enters the charcoal treatment system.

Charcoal Treatment Section:

a. Glycol cooler condenser - The function of the glycol cooler condenser is to condition the moisture level of the process gas to a 4°C (40°F) dew point before the process gas enters the charcoal bed.

Here, the offgas passes through stainless steel coils submerged in a cold glycol bath, which is maintained at an average temperature of 2°C (35°F). The glycol bath temperature is maintained by the redundant refrigeration system evaporator coils, which are also submerged in the glycol bath. Natural convection circulates the glycol solution between the process coil and the refrigeration coil. Water vapor condensed inside the process coil is collected in the condensate accumulator, which is designed to prevent reentrainment and/or reevaporation of water due to heat inleakage. Condensate is automatically drained from the accumulator to the CRW system.

The passive glycol system approach eliminates the use of glycol circulation pumps, thereby increasing the system reliability. Also, the glycol solution mass has sufficient thermal inertia to provide temperature stability and prevent refrigerator shortcycling. The inertia is such that at normal flow conditions a period of approximately three hours is required for a 3°C (5°F) temperature change to occur on either loss of cooling or loss of temperature control; therefore, in the event of a malfunction, there is sufficient time to take corrective action before the performance of the system is significantly affected.

b. Guard bed - The function of the guard bed is to protect the main charcoal adsorbers from moisture in the event of a malfunction of the cooler condenser or glycol cooler condenser, and to remove possible contaminants, which could be detrimental to the main charcoal adsorber bed, from the process stream. The guard bed contains approximately 90 kilograms (200 pounds) of activated charcoal. The guard bed has a differential pressure switch that alarms if the pressure drop through the guard bed becomes excessive due to moisture collection. The guard bed can be isolated and bypassed for regeneration by heated nitrogen.

c. Main charcoal adsorber bed - The main charcoal adsorber bed consists of ten eight-foot inside diameter vessels. Each vessel contains approximately 146,000 kilograms (32,200 pounds) of activated charcoal. After the offgas passes through the first vessel, three parallel paths are provided (three vessels in each path) to limit the system pressure drop. The vessels are connected at the top and bottom by four-inch piping.

   The charcoal adsorber vessels are maintained at a temperature of 18 ± 2°C (65 ± 3°F) by redundant heating and air conditioning systems. In the unlikely event that both air conditioning units are unable to function, the radioactive emissions from the offgas system might increase slightly; however, since substantial margin exists in the offgas system design, the releases would still be well below acceptance limits for expected air inleakage rates, radioactivity source terms and adsorption coefficients.

d. The charcoal vessel compartment air conditioning system consists of two redundant refrigerators and four direct expansion fan coil units (two units for each of

the two compartments). Each refrigerator handles two fan coil units, one for each compartment in which the refrigerator is cooled by RACS cooling water.

e. Outlet HEPA filter - A high efficiency particulate air (HEPA) filter is provided to collect any entrained particulates or charcoal fines prior to release. These filters are individually tested using the dioctyl phthalate (DOP) method. The filters are equipped with hinged covers to facilitate removal and replacement of the filter element.

3.5.3.2.1.4 Leakage of Radioactive Gases

Leakage of radioactive gases from the offgas system is limited by the use of welded construction wherever practicable and by the use of valves of a bellows seal design, or of valves employing double stem packing with leakoff connection being routed to the main condenser or pressurized with instrument air.

The offgas system operates at approximately 10 psig inlet and 0.5 psig outlet at all times, so that the differential pressure to the atmosphere is small.

All drains from the offgas system are directed either back to the main condenser or to CRW. During normal operation, only the drain from the condensate accumulator in the glycol condenser is directed to CRW. The liquid level in the condensate accumulator is automatically maintained by a level controller, and the drain valves are fail-closed; therefore, the possibility of gas leakage to the waste collector tanks is minimal.

3.5.3.2.1.5 Instrumentation and Control

The offgas system is monitored at appropriate locations for flow, temperature, pressure, moisture, conductivity, radiation and hydrogen concentration, to verify specified operation and control.

All the alarms of the offgas system are provided on local panels adjacent to the system equipment, and four common system trouble alarms are used on the main control room panel: three for the recombiner section including the standby system, and one for charcoal treatment section.

A sample is continously collected between the fourth and fifth holdup pipe sections for monitoring of the gaseous radioactivity input to the offgas sytem. The sample is representative of gaseous radioactivity released from the reactor and

therefore is indicative of the condition of the fuel cladding. Provision is made for grab sampling of the influent gases for the purpose of determining isotopic composition.

Two in-line radiation monitors are also provided downstream of the HEPA filter to continuously monitor activity released from the system.

Dilution steam flow (third-stage SJAE motive steam) is monitored for loss of flow upstream of the preheater, and alarmed in the main control room.

During certain transient modes of operation, the air ejectors may extract an air flow from the condenser in excess of the offgas system capacity (75 standard cubic feet per minute). This excess flow condition can be accommodated by operating both recombiner trains simultaneously. An excessive airflow higher than 150 standard cubic feet per minute will open the valve on the bypass line from the third stage SJAE section line to the condenser, and recycle the excess air back to the condenser. The offgas outlet temperature controls the steam supply to the preheater.

The temperatures of the recombiner vessel and the incoming gas are monitored by thermocouples, and alarms are provided to indicate a temperature condition above and below the design temperature, respectively.

Cooler condenser outlet temperature is recorded, and high temperature is alarmed at the local panel and in the main control room via a system trouble alarm. This temperature indicates if adequate cooling water flow exists in the cooler condenser.

Two thermal conductivity-type hydrogen analyzers are used to measure the hydrogen content in the offgas downstream of the cooler condenser. The sample gas is returned to the main process line upstream of the preheater. The hydrogen concentration output from the analyzers is indicated and recorded. Alarm and automatic shutdown capability are provided for high hydrogen concentrations (0.3 percent and 0.6 percent, respectively). An alarm is also provided for hydrogen analyzer failure. Each hydrogen analyzer is calibrated independently. Heat tracing is provided on the inlet and return sample lines to prevent condensation.

The condensate levels in the drain pot upstream of the preheater and in the cooler condenser are maintained by level control systems. These level control systems provide drainage to the main condenser during normal operation.

Glycol cooler condenser performance is monitored for outlet temperature and moisture. High process outlet temperature is alarmed at the local panel and in the main control room via a local control panel trouble alarm. A moisture element is located downstream of the cooler condenser. The moisture element senses the process offgas dew point temperature. This temperature is recorded at the local panel, adjacent to the system equipment, and in the plant computer. High moisture in the process stream is alarmed both locally and in the main control room via the local control panel trouble alarm.

Moisture condensed from the process offgas in the glycol cooler condenser is collected in the condensate accumulator. The condensate level is maintained within appropriate limits by a level control system. Condensate is normally drained to CRW. A conductivity element is provided in the drain to detect glycol inleakage. If glycol inleakage is detected, drain valves will be closed, an alarm will be actuated, and the condensate will be drained manually after system shutdown.

The guard bed is provided with differential pressure indication and temperature recording. High differential pressure and high temperature are alarmed at the local panel and in the main control room via a system trouble alarm.

The temperatures of the charcoal beds are monitored by thermocouples in the absorber vessels. High temperature and low temperature are alarmed in the main control room, via a system trouble alarm, and at the local panel. Individual adsorber charcoal temperature is recorded at the local control panel. Each vessel is provided with two spare thermocouples, which can be used if the operating thermocouple fails.

Differential pressure is measured across the HEPA filter. High differential pressure is alarmed locally and in the main control room via a system trouble alarm.

Process offgas flow rate is monitored downstream of the HEPA filter. High flow rate is alarmed in the main control room, via a system trouble alarm, and at the local panel. Flow rate is recorded on the local panel.

Two thermocouples are provided in each charcoal adsorber tank room. The thermocouples automatically operate the room heating and air conditioning units to maintain room temperature at 18 ± 2°C (65 ± 3°F). Room temperature is alarmed at the local panel and in the main control room via a system trouble alarm. The room temperature is also recorded on the local panel.

3.5.3.2.1.6 Offgas System Operating Procedure

Start-up

Before starting the offgas system, the following conditions are necessary:

a. Main steam or auxiliary steam must be available for the SJAEs and the preheater.
b. Cooling water (condensate) must be supplied to the SJAE intercondenser.
c. The recombiner must be preheated to approximately 150°C (300°F) by the electric heaters.
d. RACS cooling water must be supplied to the cooler condenser, glycol refrigeration units and compartment refrigeration units.
e. The glycol coolant must be chilled.
f. The adsorber rooms must be at 18°C (65°F), and air circulation fans must operate.

The SJAE train can be started up with main condenser pressure at five inches Hg, the vacuum initially being drawn by the mechanical vacuum pumps. The SJAE train is started by opening the third-stage motive steam supply valve and discharge valve, following which, the suction valve is opened. Using the same procedure, the second-stage and then the first-stage SJAEs are started up. During this time period, the mechanical vacuum pumps are in operation.

Initially, all the valves in the main process stream of the offgas system are open except for the inlet isolation valve and the isolation valve downstream of the cooler condenser. The inlet isolation valve is then opened, and the offgas is admitted into the recombiner section. If any unusual event occurs the recombiner section will be shut off immediately and until the event is resolved. The downstream isolation valve of the recombiner section is opened, and the offgas flows through the charcoal treatment system. The condenser mechanical vacuum pumps are turned off at this point.

Normal Operation and Shutdown

After start-up, the flow rate of noncondensables exhausted by the SJAE should stabilize, primarily as a function of reactor power level and condenser inleakage. The instrumentation discussed in Section 3.5.3.2.1.5 can be used to monitor system performance. Operator action is not required for steady-state system operation, including changes in offgas noncondensable flow rates from 0 to 75 standard cubic feet per minute.

Following a normal reactor shutdown or a reactor scram, normal operation is terminated by sequentially shutting the gas suction valves to the SJAEs, stopping steam flow to the SJAEs, and then shutting off the offgas system inlet valve.

During short shutdowns of the plant, when it is not necessary to break condenser vacuum, the offgas system is kept in service using auxiliary steam in the SJAEs. For long shutdown of the plant, the offgas system is kept in service after shutdown, until it is necessary to break condenser vacuum, or until the activity of the offgas indicates that the condenser atmosphere activity has reached acceptably low limits.

3.5.3.2.1.7 Equipment Malfunction

An equipment malfunction analysis, indicating the consequences of and design precautions taken to accommodate failure of various components of the offgas system, is presented in Table 3.5-24.

Operator Error

The potential for operator error resulting in high off-site releases is small. Offgas flow from the SJAEs must be directed through the recombiner and ambient charcoal systems. There are no system bypasses other than the mechanical vacuum pump. The systems are instrumented such that the operators can detect and correct failures of various components in the systems, as Table 3.5-24 indicates.

Serviceability and Reliability

Reliability of the offgas system is accomplished through redundancy and through the use of passive components.

A redundant SJAE system, including an intercondenser and after condenser, is provided. The recombiner train, including a preheater, recombiner, cooler condenser, and all valving and instrumentation, is also redundant. The redundant recombiner train is to be in the standby mode for immediate use at all times; it can be placed in or out of service from the local control panel. A redundant glycol refrigeration unit, charcoal adsorber vessels compartment refrigeration unit and compartment fan coil units are provided.

The guard bed and the first charcoal adsorber vessel can be bypassed if they become contaminated with moisture. In the unlikely event of flooding of the guard bed and/or first charcoal vessel, they can be regenerated by heated nitrogen. The

HEPA filter may also be manually bypassed temporarily if a high differential pressure condition exists. The HEPA filter is located in an individual room for serviceability during system operation.

Serviceability is enhanced, wherever possible, by using passive components, and by locating equipment and instruments that are not passive or that require periodic maintenance in accessible areas.

The entire offgas system can be purged by nitrogen for decontamination for maintenance. A part of the system can be purged as required without interrupting the system operation: the redundant recombiner train can be purged while the other train is in operation. Also, the charcoal guard bed, HEPA filter, and first main charcoal bed can be purged individually during a system operation. All the purge outlets are routed to downstream of the holdup pipe in order to be treated by the charcoal system before release.

Instruments for the recombiner system that require periodic maintenance are located outside the recombiner rooms. Instruments for the ambient charcoal system are either located outside rooms containing radioactive equipment, or are shielded from radioactive equipment. Instrumentation requiring calibration is accessible during system operation.

3.5.3.2.2 Other Radioactive Gas Release Paths

There are three general areas that contain sources of radioactive gas: the primary containment and reactor building enclosure, the turbine enclosure and the radwaste enclosure.

Primary Containment and Reactor Building Enclosure

The primary containment (drywell) and reactor building enclosure HVAC systems that are important for the treatment of potentially radioactive air are the filtration, recirculation and ventilation system (FRVS), the containment prepurge cleanup system (CPCS), and the reactor building ventilation systems (RBVS).

Air from the reactor building is normally exhausted by the reactor building ventilation system (RBVS) exhaust fans through HEPA filters.

Radiation monitors are provided in the exhaust ductwork of the RBVS to isolate normal HVAC and to initiate the FRVS on high radiation. Upon reactor building isolation, the FRVS recirculation system recirculates the reactor building air through

HEPA and charcoal filters for cleanup. After reaching a steady state, approximately 7.1 cubic meters per minute (250 cubic feet per minute) of air exhausted from the FRVS recirculation system is filtered again by the FRVS ventilation system, which is equipped with HEPA and charcoal filters, and then released to the atmosphere through a vent at the top of the reactor building; this maintains the building at a negative pressure of 0.25-inch water guage.

During power operation, radioactivity released from minor system leakage inside the drywell is contained, except for minor releases necessary to control drywell pressure. Pressure is controlled by bleeding air from the drywell through five-centimeter (two-inch) lines connected to the RBVS exhaust system prior to release to the environment.

After the reactor is shut down, and before the drywell and torus are purged by the RBVS, the containment atmosphere is first recirculated through the containment prepurge cleanup system (CPCS) for up to 30 hours, to reduce the level of atmospheric iodine and particulate radioactivity. After the prepurge cleanup process, the RBVS provides the supply air to and exhausts air from the drywell and torus for purge.

Radwaste Enclosure

The radwaste area supply system delivers filtered and tempered air that is distributed throughout the enclosure in quantities sufficient to maintain required temperatures. The equipment compartment exhaust system consists of three 33-1/3 percent capacity fans and 33-1/3 percent capacity filter plenums. The service area exhaust system consists of two 50-percent capacity fans without exhaust filtration since this is a non-radioactive area. The chemical lab exhaust system consists of two 100-percent capacity fans and two 100-percent capacity filter plenums. The solid radwaste area is supplied with filtered and tempered air in order to maintain design temperatures. The solid radwaste area exhaust system consists of two 50-percent capacity fans and two 50-percent capacity filter plenums. Each filter plenum has a bank of prefilters and a bank of HEPA filters. This exhaust system is balanced to ensure that the flow of air within the enclosure is into areas with higher potential for airborne radioactive contamination. The tank ventilation filter system provides a means of filtering and venting air from tanks and equipment housed in the radwaste enclosure. Two redundant fans and filter plenums are employed for this purpose. There are HEPA filters and charcoal adsorbers in each filter plenum. Since the flow of air from tanks and equipment varies, space air is admitted as required to maintain system volume.

All the exhaust system ducts transport the filtered air to either the north or south plant vents.

Each of the above exhaust systems and the respective supply systems are interlocked so that failure of the exhaust system shuts down the supply system. This condition is alarmed in the main control room.

Turbine Enclosure

During plant start-up, air is removed from the main condenser by two mechanical vacuum pumps. Each vacuum pump discharges to the south plant vent; if excessive release of radioactivity is detected at the vent, the pump trips, automatically closing the pump suction valves, and actuating an alarm.

In the past, discharge from the steam packing exhausters has presented a source of gaseous radioactive releases in some BWR plants; at HCGS, however, clean steam (produced from demineralized condensate) from the steam seal evaporator is provided for sealing purposes. Therefore, essentially no activity is released from this system.

The exhaust air from the turbine building ventilation system is monitored for radioactivity prior to its discharge to the atmosphere.

3.5.3.3 Radioactive Releases

The assumptions used in this evaluation are summarized in Table 3.5-7. The building vent locations, shape, effluent velocity and heat input are given on Table 3.5-27. The calculated annual releases appear in Table 3.5-22.

It is expected that the actual releases from the plant will be lower than those referenced above, due to the more realistic parameters associated with the equipment described in this chapter. Table 3.5-28 summarizes the charcoal filtration systems that reduce the airborne radioactive releases. Table 3.5-25 presents a comparison between the concentrations at the site boundary (901 meters (2960 feet)) using the annual X/Q value of 2.474E-7 second per cubic meter with the appropriate recommended concentrations presented in Table II Column 1 of 10 CFR 20.

3.5.3.4 Estimated Doses

Table 3.5-25 also presents the whole body dose at the site boundary. To assure compliance with Appendix I of

10 CFR Part 50, dose calculations, based on the gaseous source term referenced above, were performed in accordance with Regulatory Guide 1.109 by use of the USNRC computer code GASPAR (dated 2/20/76). One change was made to the code to allow for nuclide specific decay correction for transit time to the point of exposure. Maximum doses are calculated for an individual residing at the nearest residence. Input data for these calculations are given in Table 3.5-26. The critical location for noble gases is 5.2 kilometers (3.5 miles) NW. The calculated doses are 0.0227 mrad per year beta air dose and 0.0257 mrad per year gamma air dose for noble gases; the Appendix I design objectives are 20 and 10 mrad per year, respectively. Noble gas doses to the total body and skin are calculated as 0.017 mrem per year and 0.036 mrem per year, respectively; the respective limits for these pathways are 5.0 mrem per year and 15.0 mrem per year. For doses resulting from radioiodine and particulates, the critical location is the nearest residence. The Appendix I design objective for this pathway is 15 mrem per year to any organ. The thyroid dose from this source is calculated as 0.608 mrem per year. All calculated doses are within the appropriate Appendix I design objectives.

3.5.4 SOLID RADWASTE SYSTEM

3.5.4.1 Overall System Description

The solid radwaste system, as described in Section 11.4 of the HCGS FSAR, collects, reduces the volume, solidifies and packages low-level radioactive waste for its eventual shipment off site to a licensed burial site. The solid radwaste system shown in Figures 3.5-7 and 3.5-8 accepts dry solid trash, potentially radioactive lubricating oil from various pumps, processed concentrated chemical slurries, sludge and spent resins. The solid wastes are grouped for discussion purposes into four general categories. These four categories are:

a. Resin slurries
b. Concentrates from the liquid radioactive waste system
c. Compressible waste
d. Other waste

The various types of solid waste are processed differently in order to maximize the amount of volume reduction, and thus minimize the volume of waste requiring packaging and shipping off site for burial. The various treatment methods are described in the following sections.

3.5.4.2 Treatment of Radioactive Resins

The solid radioactive waste system accepts waste sludge and resin slurries from the waste sludge phase separator, the cleanup phase separators and the spent resin tank. These resin slurries are pumped directly into a radioactive waste centrifuge feed tank on a batch basis by the pumps of the liquid radioactive waste system. A decant pump is used to remove any excess water from the feed tank after allowing sufficient time for the resin material to settle. The slurries are then recirculated and agitated and the pH is adjusted. A small side stream is then taken off the recirculation loop for control metering, and sent to the centrifuge. The centrifuge separates the carrier water from the resin/sludge mixture, and then directs this moist, aerated slurry to one of the two waste extruder/evaporators. The extruder/evaporator mixes the slurry with asphalt at a temperature of approximately 300°F (150°C). This temperature is sufficiently high to evaporate any remaining water. The asphalt and resin mixture is extruded into 55-gallon drums as a more dense and concentrated product. The filled drums are moved using a monorail transport system, which is operated by remote control. A closed-circuit television monitors the operation of the system. The monorail system uses a turntable to place empty drums beneath the filling lines of the extruder/evaporator. After the drums are filled, the turntable rotates, and the monorail system removes the filled drums and transports them to the capping and radioactive swiping station. Upon arriving at this station, the drums are capped, radiation readings are taken, and the drums are swiped a final time, and properly labeled. The drums are then conveyed to the truck bay area where they are loaded into a waiting truck or placed into the radwaste storage area for subsequent disposal. The estimated quantity and activity of resin/slurry waste to be processed is listed below:

Source of Radioactive Waste Resin

	System	Anticipated Annual Volume	Activity
a.	Waste sludge phase separator	330,950 liters (87,430 gal)	6.18×10^{-1} uCi/cc (normal) 2.03×10^{0} uCi/cc (max)
b.	Clean-up phase separator	59,280 liters (15,660 gal)	$3.8 \times 10^{+2}$ uCi/cc (normal) $4.0 \times 10^{+2}$ uCi/cc (max)
c.	Spent resin tank	38,790 liters ($1370\ ft^3$)	3.3×10^{-1} uCi/cc (normal) $1.2 \times 10^{+1}$ uCi/cc (max)

3.5.4.3 Treatment of Concentrates from the Liquid Radioactive Waste System

The concentrated waste tank collects 10 to 25 percent solids by weight from the waste evaporators, and two to 10 percent solids by weight waste from the decontamination solution concentrated waste tank. The waste is then directed to the crystalizer, which raises the concentration to approximately 50 percent by weight by additional evaporation. Upon reaching 50 percent by weight, the concentrated waste is directed to the crystalizer bottoms tank for holding before subsequent routing to the solidification process. After this holding period, the waste is directed to the extruder/evaporator, where the remaining water is removed and the volume reduced in the manner described in the previous section.

The waste in the concentrated waste tank is expected to range from 10 to 25 percent of sodium sulfate by weight. It is estimated that annual volume of waste from the concentrated waste tanks is 635,900 liters (168,000 gallons). In order to estimate the quantity of waste produced, it may be assumed that this 635,900 liters of waste is 25 percent by weight solids and that 1,807,900 liters (477,600 gallons) is 10 percent solids by weight. Using this conservative assumption, it is easy to show that the 635,900 liters of 25 percent by weight waste could contain 158,984 kilograms (350,500 pounds) of solids. Each batch size will be 39,700 liters (10,500 gallons). The frequency for discharges is 45 days for the 25-percent waste, and seven days for the 10-percent waste. Radioactivity in this waste stream is expected to be less than 4.8×10^{-5} microcurie per cubic centimeter under normal conditions. The maximum activity of this waste stream is expected to be 8.5×10^{-1} microcurie per cubic centimeter.

The volume of waste from the decontamination solution concentrated waste tank estimated to require processing is 75,700 liters (20,000 gallons), two percent by weight without the laundry waste, and 227,100 liters (60,000 gallons), two percent by weight with the laundry waste. Each batch would be 2,300 liters (600 gallons), and would require processing every six weeks if the laundry waste is not processed, and every 19 days if the laundry is processed. The radioactivity in the waste stream is expected to be 1.0×10^{-3} microcurie per cubic centimeter under normal conditions; however, the maximum activity which could be expected is estimated to be 5.8×10^{-2} microcurie per cubic centimeter.

3.5.4.4 Compressible Waste

In order to minimize the large volume of slightly contaminated combustible waste which would require disposal, PSE&G has designed HCGS with provisions for the operation of compaction equipment. The dry solid trash that could be compacted would include cellulose-based paper, rags, wood, protective clothing, mop heads, polyethylene bags, and gloves. The volume of waste falling within this category is estimated to be 3,190 cubic meters (112,500 cubic feet), with radioactivity levels ranging from 6×10^{-4} to 5.0×10^{-3} microcurie per cubic centimeter.

3.5.4.5 Treatment of Other Waste

Other wastes, such as metals, wood, glass and polyvinyl chloride material, are estimated to be 1,345,058 liters (47,500 cubic feet); these can be compressed, where possible, using a compactor, or merely placed into 55-gallon drums for disposal. Non-compressible waste, such as contaminated pipe, equipment, and tools in various shapes and sizes, is placed in Department of Transportation approved shipping containers for off-site disposal.

3.5.5 PROCESS AND EFFLUENT MONITORING

The design of HCGS includes an extensive network of radiation monitors (see Figure 3.5-9). The process and effluent monitoring system is designed to continuously check radiation levels at various points in the plant, and to sound an alarm when levels exceed a pre-selected setpoint. This is in accordance with General Design Criteria 60 and 64 of 10 CFR 50 and Regulation Guide 1.21. Some channels, upon exceeding a setpoint, will automatically initiate the treatment of the waste, or direct the stream being monitored to an alternate location, or isolate the stream completely to minimize the contamination of clean systems.

Key process radiation monitors which could have an impact on environmental releases include the following:

Gaseous Channels

a. North plant vent radiation monitoring system and south plant vent radiation monitoring system
b. Reactor building exhaust radiation monitoring system
c. Reactor building ventilation system exhaust radiation monitoring system
d. Turbine building exhaust radiation monitoring system

e. Gaseous radwaste area exhaust radiation monitoring system and radwaste exhaust system radiation monitoring systems
f. Offgas radiation monitoring system
g. Offgas treatment radiation monitoring system
h. Main steam line radiation monitoring system
i. Filtration, recirculation and ventilation radiation monitoring system
j. Control room ventilation radiation monitoring system
k. Refueling floor exhaust radiation monitoring system

Liquid Channels

a. Liquid radwaste radiation monitoring system
b. Reactor auxiliary coolant system radiation monitor
c. Safety auxiliary cooling system radiation monitoring system
d. Heating steam condensate radiation monitoring system
e. Cooling tower blowdown radiation monitoring system

Section 3.5.5.1 and 3.5.5.2 briefly describe key channels:

3.5.5.1 Gaseous Channels

North Plant Vent - Radiation Monitoring System
South Plant Vent - Radiaiton Monitoring System

The north plant vent and the south plant vent systems are the final release points for all of the plant ventilation systems exhausts which may contain radioactive materials. The north and south plant vent radiation monitoring systems (NPV-RMS and SPV-RMS) are designed to monitor these release paths to the environment under normal and unusual conditions. The systems or areas routed to the south plant vent are: reactor building exhaust, steam packing exhaust, mechanical vacuum exhaust, turbine building exhaust, exhaust from compartments, service and area exhaust, oil storage area exhaust and auxiliary building exhaust. Systems or areas routed to the north plant vent are: offgas treatment system exhaust and radwaste and solidification system exhaust. The radiation monitoring systems for the north and south plant vents are identical; they consist of a noble gas channel, a particulate channel and an iodine channel. Sampling of these vents is performed using multiple isokinetic nozzles; the sample flow rate is controlled automatically to provide for isokinetic sampling under varying vent flow rates under normal operating conditions. The system is designed to provide an extended range capability of up to 10^3 microcuries per cubic centimeter of noble gas as indicated in NUREG-0578 and NUREG-0737.

Reactor Building Exhaust
Radiation Monitoring System

The reactor building exhaust radiation monitoring system (RBE-RMS) monitors the radioactivity concentrations in the reactor building exhaust. The system consists of three identical channels. If two of the three channels indicate high radioactivity, the system will initiate the start-up of the filtration, recirculation and ventilation system, and the system will also initiate isolation of the primary containment by closing any purge and ventilation valves which may be open.

Reactor Building Ventilation System Exhaust
Radiation Monitoring System

The reactor building ventilation system exhaust radiation monitoring system (RBVSE-RMS) monitors the radioactivity concentrations after the reactor building exhaust passes through the HEPA filters. The RBVSE-RMS does not have any control functions.

Turbine Building Exhaust Radiation Monitoring System

The steam to the turbines, since it is produced in the reactor, contains activation products. The turbine building exhaust radiation monitoring system (TBE-RMS) monitors the exhausted air from the turbine building to the south plant vent. The south plant vent radiation monitoring system also monitors this exhausted air.

Gaseous Radwaste Area Exhaust Radiation Monitoring System
Radwaste Exhaust System Radiation Monitoring System

Exhaust to the environment from the gaseous radwaste processing area, recombiner compartment, must pass through the gaseous radwaste area exhaust radiation monitoring system (GRAE-RMS) before it is eventually routed to the vent.

The radwaste exhaust system radiation monitoring system (RES-RMS) monitors the exhaust from the radwaste processing area of the auxiliary building before the exhaust is eventually routed to the south plant vent.

Offgas Radiation Monitoring System

The offgas radiation monitoring system (OG-RMS) monitors the radioactivity concentrations in the condenser offgas. The sampling techniques utilized provide for a two-minute delay, to facilitate the decay of N-16, before two gamma-sensitive detectors, positioned adjacent to a vertical sample chamber, monitor the sample.

Offgas Treatment Radiation Monitoring System

The offgas treatment radiation monitoring system (OGT-RMS) monitors the radioactivity concentrations from the ambient charcoal offgas system. Two gamma-sensitive detectors are located downstream of the offgas system discharge valve from which treated offgas is routed to the north plant vent. High radioactivity from either detector will isolate the offgas system.

Main Steam Line Radiation Monitoring System

In the event of gross fuel failure, high activity will be carried over to the main steam line. The main steam line radiation monitoring system (MSL-RMS) will provide indication of high activity should this occur. In order to prevent accident situations from deteriorating, the main steam line radiation monitors will initiate a reactor trip and containment isolation, if they detect gross fuel failure, and will isolate the main steam line. There are four detectors which are placed so that they can monitor all steam lines. The detectors have a setpoint that is sufficiently high to prevent isolation from false signals, while at the same time sufficiently low to prevent any significant activity in the main steam line from circulating undetected through the system. The channels are located downstream of the main steam line isolation valves; these channels are intended for operation when the reactor is critical, with the steam lines unisolated. The system is designed using two independent vital power supplies; the system initiates a reactor trip using a one out of two, taken twice, logic; therefore, in order for a trip signal to be generated, at least two channels must indicate high radiation. The output from these channels is recorded and displayed in the control room.

Filtration, Recirculation and Ventilation System Vent Radiation Monitoring System

The filtration, recirculation and ventilation system radiation monitoring system (FRVS-RMS) monitors all discharges from the FRVS system. Since activity discharged when the plant is in the FRVS mode could be higher than normal, high range detectors are provided for this system. The detectors utilized satisfy NUREG-0578 and NUREG-0737 criteria. Capability exists to obtain high activity iodine samples from the FRVS vent using a specially designed iodine collection device.

Control Room Ventilation
Radiation Monitoring System

The control room ventilation radiation monitoring system (CRV-RMS) monitors the radioactivity concentrations of the control

room inlet air. Two redundant channels (beta detectors) are provided. Each channel provides contacts which will also open on a channel failure. Two-out-of-two logic initiates closure of the main control room ventilation isolation valves and initiates recirculation and filtration of the main control room air.

Refueling Floor Exhaust
Radiation Monitoring System

The refueling floor exhaust radiation monitoring system (RFE-RMS) monitors the radioactivity concentration in the reactor building fuel handling area ventilation duct, during normal and refueling conditions.

The system consists of three beta detectors, which initiate closure of the containment prepurge cleanup system isolation dampers and initiate start-up of the filtration, recirculation and ventilation system.

3.5.5.2 Liquid Channels

Liquid Radwaste Radiation Monitoring System

An in-line gamma radiation detector monitors discharges from the liquid radwaste system (LR-RMS) before the dilution of the discharges by the cooling tower blowdown line and final discharge through the circulating water canal occur. Upon sensing high radiation, if the concentrations at the discharge point exceed 10 CFR 20, Appendix B concentration limits, the discharge line will be isolated, and all liquid discharges from the hold-up tanks will be terminated.

Reactor Auxiliary Cooling System Radiation Monitoring System

This off-line channel monitors the closed loop cooling water which services the reactor auxiliaries systems (RACS). The RACS provides a heat sink for the removal of heat from the various safeguard system components during a design basis loss of coolant accident (LOCA). In the event that the coolant accumulated in the RAC surge tank should become contaminated, as indicated by the radiation monitor, the coolant may be drained to the liquid radwaste system for processing.

Safety Auxiliary Cooling System Radiation Monitoring System

Although not a safety-related system, the safety auxiliary cooling system radiation monitoring sytem (SAC-RMS) consists of two independent channels which monitor the cooling water loops downstream of the RHR heat exchangers.

Heating Steam Condensate Radiation Monitoring System

Two heating steam condensate monitors are utilized at HCGS to measure the radioactivity in the liquid radwaste process streams. One monitor measures the radioactivity in the venting system condensate waste, while the other monitor measures the radioactivity in the vents steam condensate decontamination waste.

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3.5-13 U.S. Nuclear Regulatory Commission, Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-GALE Code), NUREG-0016, April, 1976.

TABLE 3.5-1

NOBLE RADIOGAS SOURCE TERMS
(GE DESIGN BASIS)

Isotope	Half-life	Source Term t = 0 (uCi/s)	Source Term t = 30 min (uCi/s)
Kr-83m	1.86 h	3.4 E3	2.9 E3
Kr-85m	4.4 h	6.1 E3	5.6 E3
Kr-85	10.74 yr	10 to 20(1)	10 to 20(1)
Kr-87	76.0 min	2.0 E4	1.5 E4
Kr-88	2.79 h	2.0 E4	1.8 E4
Kr-89	3.18 min	1.3 E5	1.8 E2
Kr-90	32.3 s	2.8 E5	-
Kr-91	8.6 s	3.3 E5	-
Kr-92	1.84 s	3.3 E5	-
Kr-93	1.29 s	9.9 E4	-
Kr-94	1.0 s	2.3 E4	-
Kr-95	0.5 s	2.1 E3	-
Kr-97	1.0 s	1.4 E1	-
Xe-131m	11.96 day	1.5 E1	1.5 E1
Xe-133m	2.26 day	2.9 E2	2.8 E2
Xe-133	5.27 day	8.2 E3	8.2 E3
Xe-135m	15.7 min	2.6 E4	6.9 E3
Xe-135	9.16 h	2.2 E4	2.2 E4
Xe-137	3.82 min	1.5 E5	6.7 E2
Xe-138	14.2 min	8.9 E4	2.1 E4
Xe-139	40 s	2.8 E5	-
Xe-140	13.6 s	3.0 E5	-

TABLE 3.5-1 (Continued) (Page 2 of 2)

Isotope	Half-life	Source Term t = 0 (uCi/s)	Source Term t = 30 min (uCi/s)
Xe-141	1.72 s	2.4 E5	-
Xe-142	1.22 s	7.3 E4	-
Xe-143	0.96 s	1.2 E4	-
Xe-144	9.0 s	5.6 E2	-
Totals		2.5 E6	1.0 E5

(1) Estimated from experimental observations.

TABLE 3.5-2

POWER ISOLATION EVENT - ANTICIPATED OCCURRENCE

Isotope	Isotopic Spiking Activity (Ci/Bundle)
I-131	2.1
I-132	3.2
I-133	5.0
I-134	5.4
I-135	4.8
Kr-83m	0.9
Kr-85m	2.2
Kr-85	0.5
Kr-87	4.3
Kr-88	6.1
Kr-89	8.0
Kr-131m	0.1
Xe-133m	0.3
Xe-133	11.6
Xe-135m	1.8
Xe-135	11.0
Xe-137	10.5
Xe-138	10.6

TABLE 3.5-3

HALOGEN RADIOISOTOPES IN REACTOR WATER
(GE DESIGN BASIS)

Isotope	Half-life		Concentration (uCi/g)
Br-83	2.40	h	1.5 E-2
Br-84	31.8	min	2.7 E-2
Br-85	3.0	min	1.7 E-2
I-131	8.065	day	1.3 E-2
I-132	2.284	h	1.2 E-1
I-133	10.8	h	8.9 E-2
I-134	52.3	min	2.4 E-1
I-135	6.7	h	1.3 E-1

TABLE 3.5-4

OTHER FISSION PRODUCT RADIOISOTOPES IN REACTOR WATER
(GE DESIGN BASIS)

Isotope	Half-life	Concentration (uCi/g)
Sr-89	50.8 day	3.1 E-3
Sr-90	28.9 yr	2.3 E-4
Sr-91	9.67 h	6.9 E-2
Sr-92	2.69 h	1.1 E-1
Zr-95	65.5 day	4.0 E-5
Zr-97	16.8 h	3.2 E-5
Nb-95	35.1 day	4.2 E-5
Mo-99	66.6 h	2.2 E-2
Tc-99m	6.007 h	2.8 E-1
Tc-101	14.2 min	1.4 E-1
Ru-103	39.8 day	1.9 E-5
Ru-106	368 day	2.6 E-6
Te-129m	34.1 day	4.0 E-5
Te-132	78.0 h	4.9 E-2
Cs-134	2.06 yr	1.6 E-4
Cs-136	13.0 day	1.1 E-4
Cs-137	30.2 yr	2.4 E-4
Cs-138	32.3 min	1.9 E-1
Ba-139	83.2 min	1.6 E-1
Ba-140	12.8 day	9.0 E-3
Ba-141	18.3 min	1.7 E-1
Ba-142	10.7 min	1.7 E-1
Ce-141	32.53 day	3.9 E-5
Ce-143	33.0 h	3.5 E-5
Ce-144	284.4 day	3.5 E-5
Pr-143	13.58 day	3.8 E-5
Nd-147	11.06 day	1.4 E-5
Np-239	2.35 day	2.4 E-1

TABLE 3.5-5

COOLANT ACTIVATION PRODUCTS IN REACTOR WATER AND STEAM

Isotope	Half-life	Steam Concentration (uCi/g)	Reactor Water Concentration (uCi/g)
N-13	9.99 min	7 E-3	4 E-2
N-16	7.13 s	5 E1	4 E1
N-17	4.14 s	2 E-2	6 E-3
O-19	26.8 s	8 E-1	7 E-1
F-18	109.8 min	4 E-3	4 E-3

TABLE 3.5-6

NONCOOLANT ACTIVATION PRODUCTS IN REACTOR WATER

Isotope	Half-life		Concentration (uCi/g)
Na-24	15.0	h	2.0 E-3
P-32	14.31	day	2.0 E-5
Cr-51	27.8	day	5.0 E-4
Mn-54	313.0	day	4.0 E-5
Mn-56	2.582	h	5.0 E-2
Co-58	71.4	day	5.0 E-3
Co-60	5.258	yr	5.0 E-4
Fe-59	45.0	day	8.0 E-5
Ni-65	2.55	h	3.0 E-4
Zn-65	243.7	day	2.0 E-6
Zn-69m	13.7	day	3.0 E-5
Ag-110m	253.0	day	6.0 E-5
W-187	23.9	h	3.0 E-3

TABLE 3.5-7 (Page 1 of 5)

ASSUMPTIONS AND PARAMETERS USED FOR EVALUATION OF RADIOACTIVE RELEASES

ITEM	VALUE OR REFERENCE
1. GENERAL	
a) Maximum core thermal power (MWt) evaluated for safety considerations	3458
b) Total quantity of tritium released (Ci/yr) through liquid pathway	26
2. NUCLEAR STEAM SUPPLY SYSTEM	
a) Total steam flow (lb/hr)(1)	1.4E7(2)
b) Mass of reactor coolant (lb) in vessel at full power	3.8E5
3. REACTOR WATER CLEANUP SYSTEM	
a) Average flow rate (lb/hr)	1.3E5
b) Powdex demineralizer size (ft^2)	135
c) Replacement frequency (days)	3.4
d) Backwash volume (gal/event)	1080
4. CONDENSATE DEMINERALIZERS(3)	
a) Average flow rate (lb/hr) total	1.4E7 (100% of steam flow)
b) Deep bed demineralizer size (ft^3 of resin per vessel)	312

(1) 1 pound = 0.454 kilogram, 1 foot = 0.3 meter, 1 gallon = 3.8 liters.
(2) Typical: 1.4E7 = 1.4×10^7.
(3) Spent resins from the radwaste demineralizer are sluiced to the solid radwaste system.

TABLE 3.5-7 (Continued) (Page 2 of 5)

ITEM	VALUE OR REFERENCE
c) Number of demineralizers	6 plus 1 standby
d) Regeneration frequency (days) (4)	5
e) Regeneration time (days)	30 (5-day regeneration frequency times 6 demineralizers)
f) Is ultrasonic resin cleaning (URC) used? If so, state amount of waste liquid between cleanings	Yes, 22,200 gal/cycle(5)
g) Regenerant volume (gal/event)	59400
Regenerant activity (uCi/cc)	Table 3.5-8
5. LIQUID WASTE PROCESSING SYSTEM	
a) Sources, flow rates and expected activities in flow streams	Table 3.5-12
b) Holdup times for collection, processing and discharge	Table 3.5-11
c) Capacities of tanks and processing equipment	Table 3.5-20
d) Decontamination factors	Table 3.5-10
e) Fraction from each stream discharged	
High purity waste processing stream	0.01
Low purity waste processing stream	0.50
Chemical waste processing stream	0.10
Regenerant waste processing stream	0.10
Laundry drain waste processing stream	1.00

(4) The regeneration frequency for the condensate demineralizer is 30 days per vessel with ultrasonic resin cleaning (URC) cycles between regenerations.

(5) Two in-place scrubs/URC cycle generate 7500 gallons of waste water each. One URC operation generates 7200 gallons of waste water. The total waste per cycle is 22,200 gallons.

TABLE 3.5-7 (Continued) (Page 3 of 5)

ITEM	VALUE OR REFERENCE
f) Radwaste demineralizer regeneration frequency (days)	52
Radwaste floor drain demineralizer regeneration frequency (days)	25
Radwaste high conductivity demineralizer regeneration volume (gal/event)	22478
Radwaste low conductivity demineralizer regeneration frequency (gal/event)	30950
g) Liquid source terms for normal operation (Ci/yr)	Table 3.5-17
6. MAIN CONDENSER AND TURBINE GLAND SEAL AIR REMOVAL SYSTEMS	
a) Holdup time for offgas prior to offgas treatment (hr)	0.17
b) Description of offgas treatment system	Section 3.5.3
c) Offgas treatment systems (charcoal delay system)	
1) Mass of charcoal (lb)	322000
2) Operating/dew point temperatures (°F)	65/40
3) Dynamic absorption coeff. Xe, Kr (cm^3/g)	330/18.5
d) Gland seal steam flow (lb/hr) and source	2.2E4, non-radioactive steam
e) Gland seal holdup time (hr)	NA
f) Radioactive iodine reduction systems for the gland seal system	NA

TABLE 3.5-7 (Continued) (Page 4 of 5)

ITEM	VALUE OR REFERENCE
7. VENTILATION AND EXHAUST SYSTEMS	
a) Provisions to reduce releases in individual buildings	Table 3.5-28
b) Decontamination factors in individual buildings	Table 3.5-28
c) Release rates (Ci/yr)	Table 3.5-22
d) Release points - heights, temperatures, size and shape of orifices	Table 3.5-27
e) Containment purge frequency (per year)	___
8. EXPECTED RADIONUCLIDE ACTIVITY CONCENTRATIONS IN REACTOR COOLANT AND MAIN STEAM USED FOR EVALUATION OF RADIOACTIVE RELEASES	Table 3.5-9
9. INPUT FILE USED FOR GALE CODE DETERMINATION OF ANNUAL LIQUID AND GASEOUS RELEASES	

TABLE 3.5-7 (Continued) (Page 5 of 5)

	ITEM	VALUE OR REFERENCE	SOURCE
LIQUID GALE CARDS			2
0.632 0.333		2.0 1.0E-25 092382 1 0 0	
CARD 1	NAME	NAME OF REACTOR: HCGS	TYPE = BWR
CARD 2	POWTH	THERMAL POWER LEVEL (MEGAWATTS)	3458
CARD 3	GTO	TOTAL STEAM FLOW (MILLION LBS/HR)	14.0
CARD 4	WLIQ	MASS OF WATER IN REACTOR VESSEL (MILLION LBS)	0.38
CARD 5	GDE	CLEAN-UP DEMINERALIZER FLOW (MILLION LBS/HR)	0.13
CARD 6	REGENT	CONDENSATE DEMINERALIZER REGENERATION TIME (DAYS)	30.0
CARD 7	FFCDM	FRACTION FEED WATER THROUGH CONDENSATE DEMIN	1.00
CARD 8		HIGH PURITY WASTE INPUT 30501. GPD AT .145 PCA	
CARD 9		DFI = 1.0E02DFCS = 1.0E01DFO = 1.0E02	
CARD 10		COLLECTION 0.761 DAYS PROCESS 0.0895DAYS FRACT DISCH	0.01
CARD 11		LOW PURITY WASTE INPUT 5700. GPD AT .001	
CARD 12		DFI = 1.0E02DFCS = 2.0E00DFO = 1.0E02	
CARD 13		COLLECTION 2.105 DAYS PROCESS 0.0718DAYS FRACT DISCH	0.5
CARD 14		CHEMICAL WASTE INPUT 600. GPD AT .02 PCA	
CARD 15		DFI = 1.0E00DFCS = 1.0E00DFO = 1.0E00	
CARD 16		COLLECTION 2.667 DAYS PROCESS .0895 DAYS FRACT DISCH	0.1
CARD 17		REGENERATION SOLTNS INPUT GPD	6285.0
CARD 18		DFI = 1.0E03DFCS = 1.0E04DFO = 1.0E04	
CARD 19		COLLECTION 3.18 DAYS PROCESS .437 DAYS FRACT DISCH	0.1
CARD 20	GGS	GLAND SEAL STEAM FLOW (THOUSAND LBS/HR)	0.0
CARD 21	TIM3	GLAND SEAL HOLDUP TIME (HOURS)	0.0
CARD 22	TIM4	AIR EJECTOR OFFGAS HOLDUP TIME (HOURS)	0.17
CARD 23		CONTAINMENT BLDG. CHARCOAL 00.0 HEPA?99.0	
CARD 24		TURBINE BLDG. CHARCOAL 00.0 HEPA?00.0	
CARD 25	FIL3	GLAND SEAL VENT, IODINE PF	00.0
CARD 26	FIL4	AIR EJECTOR OFFGAS IODINE PF	1.0
CARD 27		AUXILIARY BLDG. CHARCOAL 00.0 HEPA?99.0	
CARD 28		RADWASTE BLDG. CHARCOAL 70.0 HEPA?99.0	
CARD 29	KCHAR	CHARCOAL DELAY SYSTEM 0=NO,1=YES,2=CRYOGENIC DISTILL	1.0
CARD 30	KKR	KRYPTON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	18.5
CARD 31	KXE	XENON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	330.0
CARD 32	KMASS	MASS OF CHARCOAL (THOUSAND LBS)	322.0
CARD 33	PFLAUN	DETERGENT WASTE DECONTAMINATION FACTOR	1.0

TABLE 3.5-8

LIQUID WASTE MANAGEMENT SYSTEM FLOWS[1]

Subsystem	Stream No.	Average Batch Interval for Normal Operation (days)	Volume[3] per Batch (gal)	Nominal Flow Rate[3] (gpm)	Average Volume[3] per Day for Normal Operation (gal)	Normal Activity Concentration (uCi/cc)	Maximum Activity Concentration (uCi/cc)	Comments
Equipment drain	1	-	-	-	83,500	1.2E-2[2]	9.4E-1	Max act. some flows NA
Equipment drain	2	0.164	13,660	182	83,500	1.09E-2	9.24E-4	
Equipment drain	3	0.164	13,660	182	83,500	5.45E-3	9.19E-1	
Equipment drain	4	0.164	13,660	182	83,500	1.09E-4	9.19E-3	
Equipment drain	5	1.164	13,660	450	83,500	1.09E-4	9.19E-3	
Floor drain	6	-	-	-	10,400	2.88E-6	1.5E-3	
Floor drain	7	0.76	7,908	176	10,400	2.88E-6	3.46E-4	
Floor drain	8	0.76	7,908	176	10,400	1.44E-6	3.46E-4	
Floor drain	9	0.76	7,908	176	10,400	2.88E-8	3.46E-6	
Floor drain	10	0.76	7,908	176	10,400	2.88E-8	3.46E-6	
Regenerant waste	11	-	-	-	12,360	-	-	Flows NA
Regenerant waste	12	1.07	13,180	40	12,360	1.46E-4	2.58E0	
Regenerant waste	13	1.07	12,515	35	11,730	1.7E-4	2.2E4	

(1) Refer to Figure 3.5-4.
(2) 1.2E-2 = 1.2 x 10^{-2}.
(3) 1 gallon = 3.8 liters.

TABLE 3.5-8 (Continued)

Subsystem	Stream No.	Average Batch Interval for Normal Operation (days)	Volume per Batch (gal)	Nominal Flow Rate (gpm)	Average Volume per Day for Normal Operation (gal)	Normal Activity Concentration (uCi/cc)	Maximum Activity Concentration (uCi/cc)	Comments
Regenerant waste	14	1.07	12,515	50	11,730	1.7E-4	2.2E4	
Regenerant waste	15	1.07	709	5	664	2.71E-3	4.8E1	
Regenerant waste	16	1.07	709	50	664	NA	8.48E-1	
Chemical waste	17	NA	-	-	NA	NA	NA	
Chemical waste	18	1	4,000	-	NA	1.6E-2	1.6E-2	
Chemical waste	19	NA	109.85	NA	NA	5.83E-1	5.83E-1	
Chemical waste	20	NA	109.85	NA	NA	5.83E-1	5.83E-1	
Chemical waste	21	NA	NA	-	NA	-	1.77E-2	
Detergent drain waste	22	1	1,500	-	1,500	1.03E-5	7.88E-3	
Detergent drain waste	23	1	1,500	25	1,500	7.81E-6	3.53E-4	
Detergent drain waste	24	1	1,500	25	1,500	1.56E-14	1.00E-7	

TABLE 3.5-9 (Page 1 of 4)

EXPECTED RADIONUCLIDE ACTIVITY CONCENTRATIONS IN REACTOR COOLANT AND MAIN STEAM[1] USED FOR EVALUATION OF RADIOACTIVE RELEASES (in uCi/gm)

Isotope	Reactor Coolant[2]	Reactor Steam[2]
Noble Gases		
Ar-41	-	0
Kr-83m	-	9.1E-3[3]
Kr-85m	-	1.6E-3
Kr-85	-	5.0E-6
Kr-87	-	5.5E-3
Kr-88	-	5.5E-3
Kr-89	-	3.4E-2
Xe-131m	-	3.9E-6
Xe-133m	-	7.5E-5
Xe-133	-	2.1E-3
Xe-135m	-	7.0E-3
Xe-135	-	6.0E-3
Xe-137	-	3.9E-2
Xe-138	-	2.3E-2
Halogens[4]		
Br-83	1.1E-3	1.7E-5[5]
Br-84	1.4E-3	3.0E-5
I-131	1.9E-3	3.0E-5
I-132	1.1E-2	1.7E-4
I-133	8.0E-3	1.2E-4
I-134	1.4E-2	3.0E-4
I-135	8.0E-3	1.2E-4
Cesium		
Cs-134	3E-5	3E-8
Cs-136	8E-5	8E-8
Cs-137	2E-5	2E-8
Cs-138	1E-2	1E-5
Tritium[6]		
H-3	1E-2	1E-2

See page 4 for notes.

TABLE 3.5-9 (Continued) (Page 2 of 4)

Isotope	Reactor Coolant(2)	Reactor Steam(2)
Other Nuclides		
Na-24	9E-3	9E-6
P-32	2E-4	2E-7
Cr-51	6E-3	6E-6
Mn-54	7E-5	7E-8
Mn-56	5E-2	5E-5
Fe-55	9E-4	9E-7
Fe-59	3E-5	3E-8
Co-58	2E-4	2E-7
Co-60	4E-4	4E-7
Ni-65	3E-4	3E-7
Cu-64	3E-2	3E-5
Zn-65	2E-4	2E-7
Zn-69m	2E-3	2E-6
Sr-89	9E-5	9E-8
Sr-90	7E-6	7E-9
Sr-91	4E-3	4E-6
Sr-92	1E-2	1E-5
Y-91	4E-5	4E-8
Y-92	6E-3	6E-6
Y-93	4E-3	4E-6
Zr-95	7E-6	7E-9
Nb-95	7E-6	7E-9
Nb-98	4E-3	4E-6
Mo-99	2E-3	2E-6
Tc-99m	2E-2	2E-5
Tc-104	8E-2	8E-5
Ru-103	2E-5	2E-8
Ru-105	2E-3	2E-6
Ru-106	3E-6	3E-9
Ag-110m	9E-7	9E-10
Te-129m	4E-5	4E-8
Te-131m	9E-5	9E-8
Te-132	9E-6	9E-9
Ba-139	1E-2	1E-5
Ba-140	4E-4	4E-7
La-142	5E-3	5E-6
Ce-141	3E-5	3E-8
Ce-143	3E-5	3E-8
Ce-144	3E-6	3E-9
Pr-143	4E-5	4E-8
W-187	3E-4	3E-7
Np-239	8E-3	8E-6

TABLE 3.5-9 (Continued) (Page 3 of 4)

Isotope	Reactor Coolant(2)	Reactor Steam(2)
Sr-90	7E-6	7E-9
Sr-91	4E-3	4E-6
Sr-92	1E-2	1E-5
Y-91	4E-5	4E-8
Y-92	6E-3	6E-6
Y-93	4E-3	4E-6
Zr-95	8E-6	8E-9
Zr-97	6E-6	6E-9
Nb-95	8E-6	8E-9
Nb-98	4E-3	4E-6
Mo-99	2E-3	2E-6
Tc-99m	2E-2	2E-5
Tc-101	9E-2	9E-5
Tc-104	8E-2	8E-5
Ru-103	2E-5	2E-8
Ru-105	2E-3	2E-6
Ru-106	3E-6	3E-9
Ag-110m	1E-6	1E-9
Te-129m	4E-5	4E-8
Te-131m	1E-4	1E-7
Te-132	1E-6	1E-8
Ba-139	1E-2	1E-5
Ba-140	4E-4	4E-7
Ba-141	1E-2	1E-5
Ba-142	6E-3	6E-6
La-142	5E-3	5E-6
Ce-141	3E-5	3E-8
Ce-143	3E-5	3E-8
Ce-144	3E-6	3E-9
Pr-143	4E-5	4E-8
Nd-147	3E-6	3E-9
W-187	3E-4	3E-7
Np-239	8E-3	8E-6

TABLE 3.5-9 (Continued) (Page 4 of 4)

(1) The reactor coolant concentration is specified at the nozzle where reactor water leaves the reactor vessel. Similarly, the reactor steam concentration is specified at time 0 at the nozzle.

(2) Normal expected concentrations correspond to 50,000 uCi offgas release rate at 30 minutes.

(3) 1.1E-3 = 1.1×10^{-3}

(4) All halogen concentrations have been adjusted lower to account for the reduced I-131 source term which was reported in Revision 1 of NUREG0016.

(5) Halogen concentrations listed in reactor steam are based on a carryover of 0.015. For a carryover of 0.004 the halogen reactor steam concentrations would be reduced proportionately.

(6) Measured values increased to account for liquid recycle.

TABLE 3.5-10

DECONTAMINATION FACTORS USED FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10 CFR 50[1]

I. HIGH PURITY WASTE SUBSYSTEM	Filter	Demineralizer	Total DF
Halogens	1	100	100
Cs, Rb	1	10	10
Other Nuclides	1	100	100

II. LOW PURITY WASTE SUBSYSTEM	Filter	Demineralizer	Total DF
Halogens	1	100	100
Cs, Rb	1	2	2
Other Nuclides	1	100	100

III. CHEMICAL WASTE SUBSYSTEM	Evaporator	Total DF
Halogens	1[2]	1[2]
Cs, Rb	1[2]	1[2]
Other Nuclides	1[2]	1[2]

IV. REGENERANT WASTE SUBSYSTEM	Evaporator	Total DF
Halogens	1,000	1,000
Cs, Rb	10,000	10,000
Other Nuclides	10,000	10,000

V. DETERGENT WASTE SUBSYSTEM

A DF of 1 is used for the detergent waste filter for all nuclides.

(1) From NUREG-0016 Revision 1.

(2) It is possible that detergent-based decontamination solutions could be used; therefore, the more conservative DFs for detergent wastes are used for the chemical waste subsystem.

TABLE 3.5-11

EXPECTED HOLDUP TIME FOR COLLECTION, PROCESSING AND DISCHARGE USED FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10 CFR 50

Process		Holdup Time (Days)
I.	HIGH PURITY WASTE SUBSYSTEM	
	a. Collection	0.761
	b. Processing	0.0895
	c. Discharge Time	0.0
	d. Total	0.851
II.	LOW PURITY WASTE SUBSYSTEM	
	a. Collection	2.105
	b. Processing	0.0473
	c. Discharge Time	0.0245 (1)
	d. Total	2.177
III.	CHEMICAL WASTE SUBSYSTEM	
	a. Collection	2.667
	b. Processing	0.0895
	c. Discharge Time	0.0
	d. Total	2.756
IV.	REGENERANT WASTE SUBSYSTEM	
	a. Collection	3.18
	b. Processing	0.437
	c. Discharge Time	0.0
	d. Total	3.62

(1) NUREG-0016, Rev. 1 recommends the use of T = (T processing + 1/2 T discharge) for the sum of processing and discharge time entry. This value of 0.0245 for discharge is 1/2 T discharge.

TABLE 3.5-12

AVERAGE DAILY INPUTS AND ACTIVITIES TO THE LIQUID WASTE MANAGEMENT SYSTEM

Source	Expected Daily Input Flow Rate (gal/day)	Fraction of Primary Coolant (PCA) (1)
I. HIGH PURITY WASTE SUBSYSTEM		
Equipment Drains		
- Drywell	3400(1)	1.00
- Reactor Building	3700(1)	0.1
- Radwaste Area	1100(1)	0.1
- Turbine Building	3000(1)	0.001
Ultrasonic Resin Cleaner	10212	0.05
Resin Rinse	7121	0.002
Clean-up Phase Separator	640(1)	0.002
Radwaste Demineralizer Regeneration	1328	0.003
Total	30501	0.145
II. LOW PURITY WASTE SYSTEM		
Floor Drains		
- Drywell	700(1)	0.001
- Reactor Building	2000(1)	0.001
- Radwaste Area	1000(1)	0.001
- Turbine Building	2000(1)	0.001
Total	5700	0.001
III. CHEMICAL WASTE SYSTEM		
Lab Drains	500(1)	0.02
Chemical Lab Waste	100(1)	0.02
Total	600	0.02
IV. REGENERANT WASTE SYSTEM	6285	(2)
V. DETERGENT WASTE SUBSYSTEM	1000(1)	-

(1) Obtained from NUREG-0016 Revision 1.
(2) Calculated by the GALE Code.

TABLE 3.5-13

BATCHED INPUTS TO THE LIQUID WASTE MANAGEMENT SYSTEM FROM THE SOLID WASTE MANAGEMENT SYSTEM FOR NORMAL OPERATION

	FIRST INTERMEDIATE COLLECTOR INPUT			SECOND INTERMEDIATE COLLECTOR INPUT			LIQUID RADWASTE INPUT TO EQUIPMENT DRAIN COLLECTION TANK FROM EACH SECOND INTERMEDIATE COLLECTOR	
Source	Collector	Batch Size (gal)[2]	Batch Frequency per Collector (days)	Collector	Batch Size (gal)[2]	Batch Frequency per Collector (days)	Batch Size (gal)[2]	Batch Frequency (days)
RWCU Filter Demineralizers	RWCU back-wash receiv-ing tank	1100	1/3.4[1]	RWCU phase separator	2,200	1/6.8	2,000	1/6.8
Fuel Pool Filter Demineralizers	Waste sludge phase separator	2160	1/10.4	-	-	-	2,135	1/10.4
Radwaste Filters	Waste sludge phase separator	1748	3.5/1	-	-	-	1,736	3.5/1
Evaporator Bottoms								
a. Crystallizer mode	Concentrated tank	10,500	1/7	Crystallizer	10,500	1/7	9,253 (process) 10,729 (Condensate)	1/7
b. Evap/extruder mode	Concentrated tank	1540	1/7	Evaporator/ extruder	3080	1/14	1,156	1/14
RWCU Phase Separator								
a. Centrifuge mode	Centrifuge feed tank	990	1/20	Centrifuge	990	1/20	885	1/20
b. Evap/extruder mode	-	-	-	Evaporator/ extruder	-	1/20	56	1/20

(1) 1/3.4 means 1 batch per 3.4 days.
(2) 1 gallon = 3.8 liters.

TABLE 3.5-13 (Continued)

Source	FIRST INTERMEDIATE COLLECTOR INPUT			SECOND INTERMEDIATE COLLECTOR INPUT			LIQUID RADWASTE INPUT TO EQUIPMENT DRAIN COLLECTION TANK FROM EACH SECOND INTERMEDIATE COLLECTOR	
	Collector	Batch Size (gal)	Batch Frequency per Collector (days)	Collector	Batch Size (gal)	Batch Frequency per Collector (days)	Batch Size (gal)	Batch Frequency (days)
Waste Sludge Phase Separator								
a. Centrifuge mode	Centrifuge feed tank	957	1/1.5	Centrifuge	957	1/1.5	855	1/1.5
b. Evap/extruder mode	-	-	-	Evaporator/ extruder	-	1/1.5	54	1/1.5
Spent Resin Tank								
a. Centrifuge mode	Centrifuge feed tank	929	1/12.2	Centrifuge	929	1/12.2	633	1/12.2
b. Evap/extruder mode	-	-	-	Evaporator/ extruder	-	1/12.2	157	1/12.2

TABLE 3.5-14 (Page 1 of 4)

EXPECTED RADIONUCLIDE ACTIVITY INVENTORIES OF LIQUID WASTE MANAGEMENT SYSTEM COMPONENTS[1] (Curies)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Br-83	1.17E-3[2]	1.17E-5	1.18E-1	5.71E-5	1.19E-1	6.12E-4	5.70E-4	1.88E-1	-	3.75E-7
Br-84	4.86E-4	4.86E-6	4.86E-2	1.20E-5	4.86E-2	2.32E-4	2.34E-4	-	-	1.54E-7
Br-85	-	-	-	-	-	-	-	-	-	-
I-131	4.08E-3	4.10E-5	7.05E-1	4.26E-4	1.65E0	3.26E-3	1.60E-2	4.03E1	3.89E2	2.15E-6
I-132	2.06E-2	2.06E-4	3.12E0	1.82E-3	6.10E0	1.48E-2	4.81E-2	4.44E0	1.53E1	9.62E-6
I-133	2.30E-2	2.30E-4	3.43E0	2.02E-3	5.28E0	1.65E-2	2.86E-2	2.58E1	2.83E1	1.06E-5
I-134	6.82E-3	6.82E-5	6.82E-1	2.29E-4	6.82E-1	3.53E-3	3.28E-3	1.39E-1	-	2.16E-6
I-135	2.19E-2	2.19E-4	2.63E0	1.47E-3	2.84E0	1.33E-2	1.37E-2	9.40E0	6.24E0	8.27E-6
Rb-89	-	-	-	-	-	-	-	-	-	-
Cs-134	1.29E-5	2.57E-5	-	2.75E-4	2.27E-2	-	2.51E-3	1.27E-1	1.38E0	-
Cs-136	8.70E-6	1.74E-5	-	1.84E-4	1.46E-2	-	1.49E-3	-	3.13E-1	-
Cs-137	1.80E-5	3.59E-5	1.36E-2	4.13E-4	3.40E-2	-	3.78E-3	1.96E-1	2.12E0	1.06E-5
Cs-138	3.34E-3	1.67E-3	3.34E-1	4.16E-3	3.34E-1	1.73E-3	1.61E-3	-	-	-
Na-24	-	-	1.35E-1	-	1.85E-1	-	-	-	-	-
P-32	-	-	-	-	-	-	-	-	-	-

(1) The calculated radionuclide activity inventories are based on a reactor coolant activity corresponding to a noble gas release rate of 50,000 uCi/s after 30 minutes decay.

(2) 1.17E-3 = 1.17×10^{-3}.

TABLE 3.5-14 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Cr-51	-	-	-	-	1.37E-1	-	1.46E-3	-	4.87E0	-
Mn-54	-	-	-	-	-	-	-	-	-	-
Mn-56	8.26E-3	8.25E-5	8.43E-1	4.12E-4	8.44E-1	4.36E-3	4.06E-3	-	-	2.67E-6
Fe-55	-	-	-	-	-	-	-	-	-	-
Fe-59	-	-	-	-	-	-	-	-	-	-
Co-58	3.21E-3	3.21E-5	5.64E-1	3.42E-4	1.40E0	2.60E-3	1.53E-2	6.19E0	6.94E1	1.72E-6
Co-60	-	-	-	-	1.42E-1	-	1.57E-3	-	8.77E0	-
Ni-63	-	-	-	-	-	-	-	-	-	-
Ni-65	-	-	-	-	-	-	-	-	-	-
Cu-64	-	-	-	-	-	-	-	-	-	-
Zn-65	-	-	-	-	-	-	-	-	-	-
Zn-69	-	-	-	-	-	-	-	-	-	-
Sr-89	1.03E-3	1.03E-5	1.80E-1	1.09E-4	4.46E-1	8.31E-4	4.84E-3	1.89E0	2.12E1	5.49E-7
Sr-90	-	-	1.36E-2	-	3.40E-2	-	-	1.97E-1	2.08E0	-
Sr-91	1.41E-2	1.41E-4	1.85E-2	1.06E-3	2.19E0	9.15E-3	1.07E-2	6.11E-1	4.74E-1	5.77E-6
Sr-92	9.51E-3	9.51E-5	9.75E-1	4.82E-4	9.77E-1	5.04E-3	4.70E-3	1.30E-1	-	3.09E-6
Y-91m	7.89E-3	7.89E-5	1.07E0	6.42E-4	1.29E0	5.06E-3	4.70E-3	3.93E-1	3.05E-1	3.34E-6
Y-92	8.02E-3	8.02E-5	9.51E-1	5.68E-4	8.77E-1	4.84E-3	6.30E-3	2.80E-1	1.69E-1	3.00E-6
Y-93	-	-	-	-	-	-	-	-	-	-
Zr-95	-	-	-	-	-	-	-	-	2.84E0	-

TABLE 3.5-14 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Zr-97	-	-	-	-	-	-	-	-	-	-
Nb-95	-	-	-	-	-	-	-	-	3.49E0	-
Nb-98	-	-	-	-	-	-	-	-	-	-
Mo-99	6.58E-3	6.58E-5	1.10E0	6.12E-4	2.29E0	5.13E-3	1.80E-2	1.15E0	4.55E0	3.37E-6
Tc-99m	4.75E-2	4.75E-4	5.89E0	3.31E-3	7.32E0	2.94E-2	4.19E-2	1.19E0	4.86E0	1.85E-5
Tc-101	1.07E-3	1.08E-5	1.07E-1	1.30E-5	1.07E-1	5.54E-4	5.15E-4	-	-	3.39E-7
Tc-104	-	-	-	-	-	-	-	-	-	-
Ru-103	-	-	-	-	-	-	-	-	1.10E-1	-
Ru-105	-	-	-	-	-	-	-	-	-	-
Ru-106	-	-	-	-	-	-	-	-	-	-
Ag-110m	-	-	-	-	-	-	-	-	-	-
Te-129m	-	-	-	-	-	-	-	-	2.17E-1	-
Te-131m	-	-	-	-	-	-	-	-	-	-
Te-132	1.51E-2	1.51E-4	2.54E0	1.53E-3	5.43E0	1.19E-2	4.43E-2	3.07E0	1.45E1	7.78E-6
Ba-139	7.24E-3	7.24E-5	7.25E-1	2.98E-4	7.24E-1	3.75E-3	3.49E-3	-	-	2.30E-6
Ba-140	2.85E-3	2.85E-5	4.96E-1	3.00E-4	1.19E0	2.29E-3	1.21E-2	2.43E0	2.68E1	1.51E-6
Ba-141	1.67E-3	1.67E-5	1.67E-1	2.57E-5	1.67E-1	8.65E-4	8.04E-4	-	-	5.30E-7
Ba-142	1.02E-3	1.02E-5	1.02E-1	-	1.02E-1	5.29E-4	4.92E-4	-	-	3.24E-7
La-142	1.02E-3	1.02E-5	1.02E-1	4.81E-5	1.02E-1	5.29E-4	4.92E-4	-	3.02E1	3.24E-7

TABLE 3.5-14 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Ce-141	-	-	-	-	1.37E-2	-	1.52E-4	-	9.76E-1	-
Ce-143	-	-	-	-	-	-	-	-	-	-
Ce-144	-	-	-	-	-	-	-	-	2.99E-1	-
Pr-143	-	-	-	-	-	-	-	-	1.18E-1	-
Nd-147	-	-	-	-	-	-	-	-	-	-
W-187	1.58E-3	1.58E-5	2.42E-1	1.43E-4	3.93E-1	1.16E-3	2.23E-3	-	-	-
Np-239	7.08E-2	7.08E-4	1.17E-1	7.03E-3	2.37E1	5.48E-2	2.98E-1	1.05E1	3.36E1	3.59E-5
Total	2.89E-1	4.62E-3	3.95E1	2.80E-2	6.72E1	1.97E-1	2.98E-1	1.09E2	6.84E2	1.35E-4

TABLE 3.5-15 (Page 1 of 4)

MAXIMUM RADIONUCLIDE ACTIVITY INVENTORIES OF LIQUID WASTE MANAGEMENT SYSTEM COMPONENTS[1] (Curies)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Br-83	1.17E-2[2]	1.17E-4	1.18E0	5.71E-4	1.19E0	6.12E-3	5.70E-3	1.88E0	-	3.75E-6
Br-84	4.86E-3	4.86E-5	4.86E-1	1.20E-4	4.86E-1	2.52E-3	2.34E-3	-	-	1.54E-6
Br-85	-	-	-	-	-	-	-	-	-	-
I-131	4.08E-2	4.10E-4	7.05E0	4.26E-3	1.65E1	3.26E-2	1.60E-1	4.03E2	3.89E3	2.15E-5
I-132	2.06E-1	2.06E-4	3.12E1	1.82E-2	6.10E1	1.48E-1	4.81E-1	4.44E1	1.53E2	9.62E-5
I-133	2.30E-1	2.30E-4	3.43E1	2.02E-2	5.28E1	1.65E-1	2.86E-1	2.58E2	2.83E2	1.06E-4
I-134	6.82E-2	6.82E-4	6.82E0	2.29E-3	6.82E0	3.53E-2	3.28E-2	1.39E0	-	2.16E-5
I-135	2.19E-1	2.19E-3	2.63E1	1.47E-2	2.84E1	1.33E-1	1.37E-1	9.40E1	6.24E1	8.27E-5
Rb-89	-	-	-	-	-	-	-	-	-	-
Cs-134	1.29E-4	2.57E-4	-	2.75E-3	2.27E-1	-	2.51E-3	1.27E0	1.38E1	-
Cs-136	8.70E-5	1.74E-4	-	1.84E-3	1.46E-1	-	1.49E-3	-	3.13E0	-
Cs-137	1.80E-4	3.59E-4	1.36E-1	4.13E-3	3.40E-1	-	3.78E-3	1.96E0	2.12E1	1.06E-5
Cs-138	3.34E-2	1.67E-2	3.34E0	4.16E-2	3.34E0	1.73E-2	1.61E-2	-	-	-
Na-24	-	-	1.35E-1	-	1.85E-1	-	-	-	-	-

[1] The maximum radionuclide activity inventories are based on a reactor coolant activity corresponding to a noble gas release rate of 500,000 uCi/s after 30 minutes decay.

[2] 1.17E-2 = 1.17×10^{-2}.

TABLE 3.5-15 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
P-32	-	-	-	-	-	-	-	-	-	-
Cr-51	-	-	-	-	1.37E-1	-	1.46E-3	-	4.87E0	-
Mn-54	-	-	-	-	-	-	-	-	-	-
Mn-56	8.26E-3	8.25E-5	8.43E-1	4.12E-4	8.44E-1	4.36E-3	4.06E-3	-	-	2.67E-6
Fe-55	-	-	-	-	-	-	-	-	-	-
Fe-59	-	-	-	-	-	-	-	-	-	-
Co-58	3.21E-3	3.21E-5	5.64E-1	3.42E-4	1.40E0	2.60E-3	1.53E-2	6.19E0	6.94E1	1.72E-6
Co-60	-	-	-	-	1.42E-1	-	1.57E-3	-	8.77E0	-
Ni-63	-	-	-	-	-	-	-	-	-	-
Ni-65	-	-	-	-	-	-	-	-	-	-
Cu-64	-	-	-	-	-	-	-	-	-	-
Zn-65	-	-	-	-	-	-	-	-	-	-
Zn-69	-	-	-	-	-	-	-	-	-	-
Sr-89	1.03E-2	1.03E-4	1.80E0	1.09E-3	4.46E0	8.31E-3	4.84E-2	1.89E1	2.12E2	5.49E-6
Sr-90	-	-	1.36E-1	-	3.40E-1	-	-	1.97E0	2.08E1	-
Sr-91	1.41E-1	1.41E-3	1.85E-1	1.06E-2	2.19E1	9.15E-2	1.07E-1	6.11E0	4.74E0	5.77E-5
Sr-92	9.51E-2	9.51E-4	9.75E0	4.82E-3	9.77E0	5.04E-2	4.70E-2	1.30E0	-	3.09E-5
Y-91m	7.89E-2	7.89E-4	1.07E1	6.42E-3	1.29E1	5.06E-2	4.70E-2	3.93E0	3.05E0	3.34E-5
Y-92	8.02E-2	8.02E-4	9.51E0	5.68E-3	8.77E0	4.84E-2	6.30E-2	2.80E0	1.69E0	3.00E-5
Y-93	-	-	-	-	-	-	-	-	-	-

TABLE 3.5-15 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Zr-95	-	-	-	-	-	-	-	-	2.84E0	-
Zr-97	-	-	-	-	-	-	-	-	-	-
Nb-95	-	-	-	-	-	-	-	-	3.49E0	-
Nb-98	-	-	-	-	-	-	-	-	-	-
Mo-99	6.58E-2	6.58E-4	1.10E1	6.12E-3	2.29E1	5.13E-2	1.80E-1	1.15E1	4.55E1	3.37E-5
Tc-99m	4.75E-1	4.75E-3	5.89E1	3.31E-2	7.32E1	2.94E-1	4.19E-1	1.91E1	4.86E1	1.85E-4
Tc-101	1.07E-2	1.08E-4	1.07E0	1.30E-4	1.07E0	5.54E-3	5.15E-3	-	-	3.39E-6
Tc-104	-	-	-	-	-	-	-	-	-	-
Ru-103	-	-	-	-	-	-	-	-	1.10E0	-
Ru-105	-	-	-	-	-	-	-	-	-	-
Ru-106	-	-	-	-	-	-	-	-	-	-
Ag-110m	-	-	-	-	-	-	-	-	-	-
Te-129m	-	-	-	-	-	-	-	-	2.17E0	-
Te-131m	-	-	-	-	-	-	-	-	-	-
Te-132	1.51E-1	1.51E-3	2.54E1	1.53E-2	5.43E1	1.19E-1	4.43E-1	3.07E1	1.45E2	7.78E-5
Ba-139	7.24E-2	7,24E-4	7.25E0	2.98E-3	7.24E0	3.75E-2	3.49E-2	-	-	2.30E-5
Ba-140	2.85E-2	2.85E-4	4.96E0	3.00E-3	1.19E1	2.29E-2	1.21E-1	2.43E1	2.68E2	1.15E-5
Ba-141	1.67E-2	1.67E-4	1.67E0	2.57E-4	1.67E0	8.65E-3	8.04E-3	-	-	5.30E-6
Ba-142	1.02E-2	1.02E-4	1.02E0	-	1.02E0	5.29E-3	4.92E-3	-	-	3.24E-6
La-142	1.02E-2	1.02E-4	1.02E0	4.81E-4	1.02E0	5.29E-3	4.92E-3	-	3.02E2	3.24E-6

TABLE 3.5-15 (Continued)

Isotope	Floor Drain Collection Tank	Floor Drain Sample Tank	Waste Collector Tank	Waste Sample Tank	Waste Surge Tank	Chemical Waste Tank	Decontamination Solution Concentrated Waste Tank	Waste Neutralizer Tank	Concentrated Waste Tank	Detergent Drain Tank
Ce-141	-	-	-	-	1.37E-1	-	1.52E-3	-	9.76E0	-
Ce-143	-	-	-	-	-	-	-	-	-	-
Ce-144	-	-	-	-	-	-	-	-	2.99E0	-
Pr-143	-	-	-	-	-	-	-	-	1.18E0	-
Nd-147	-	-	-	-	-	-	-	-	-	-
W-187	1.58E-3	1.58E-5	2.42E-1	1.43E-4	3.93E-1	1.16E-3	2.23E-3	-	-	-
Np-239	7.08E-1	7.08E-3	1.17E2	7.03E-2	2.37E2	5.48E-1	-	1.05E2	3.36E2	3.59E-4
Total	2.81E0	4.55E-2	3.95E2	2.73E-1	6.51E2	1.91E0	4.56E0	1.07E3	5.99E3	1.23E-3

TABLE 3.5-16

LIQUID WASTE MANAGEMENT SYSTEM COMPONENT PARAMETERS

Component	Quantity	Design Press/Temp (psig/°F)(1)	Type	Material	Capacity, each (gal)(2)	Diam/Height (ft and in.)(3)	Code
Tanks							
Waste collector tanks	2	15/200	Vert/cyl	304 L SS	32,000	16' 0"/26' 0"	API 620
Floor drain collector tanks	2	15/200	Vert/cyl	304 L SS	17,000	12' 6"/23' 1"	API 620
Waste surge tank	1	03/200	Vert/cyl	304 L SS	67,500	29' 0"/26' 0"	API 620
Waste neutralizer tanks	2	15/200	Vert/cyl	316 L SS	27,500	15' 0"/26' 3"	API 620
Concentrated waste tanks	2	15/200	Vert/cyl	316 L SS	12,000	10' 3"/23' 7"	API 620
Detergent drain tank	1	15/200	Hor/cyl	304 L SS	2,000	6' 6"/9' 2"	API 620
Decontamination solution concentrated waste tank	1	15/200	Vert/cyl	316 L SS	700	4' 0"/10' 7"	API 620
Chemical waste tank	1	15/200	Vert/cyl	316 L SS	4,500	7' 0"/19' 0"	API 620
Waste sample tanks	2	15/200	Vert/cyl	304 L SS	15,500	12' 6"/22' 10"	API 620
Floor drain sample tanks	2	15/200	Vert/cyl	304 L SS	15,500	12' 6"/22' 10"	API 620
Waste evaporator distillate tanks	2	15/200	Hor/cyl	304 L SS	1,100	4' 6"/10' 0"	API 620
Chemical addition tanks	3	Atm	Vert/cyl	316 L SS	250	3' 6"/6' 0"	API 620
Anti-foamant addition tank	1	Atm	Vert/cyl	316 LL	10	1' 0"/2' 6"	API 620
Waste evaporator condensate return tank	1	Atm	Hor/cyl	Galv Steel	430	3' 6"/6' 4"	ASME Sect. VIII
Decontamination solution evaporator condensate return tank	1	Atm	Hor/cyl	Galv Steel	30	1' 4"/3' 6"	ASME Sect. VIII

(1) (°F-32) x 0.555 = °C.
(2) 1 gallon = 3.785 liters.
(3) 1 foot = 0.3048 meter; 1 inch = 2.54 centimeters.

TABLE 3.5-16 (Continued)

Component	Quantity	Type	Rated Flow (gpm)	Rated Head TDH (ft)	Rated Power (hp)	Design Press/Temp (psig/°F)	Code
Pumps							
Waste collector pumps	2	Hor/cent	182	350	40	240/210	Mfg Std
Waste surge pump	1	Hor/cent	182	370	40	240/210	Mfg Std
Floor drain collector pumps	2	Hor/cent	176	350	40	240/210	Mfg Std
Waste neutralizer pumps	2	Hor/cent	176	55	5	170/210	Mfg Std
Concentrator feed pumps	2	Hor/cent	40	100	5	150/210	Mfg Std
Concentrated waste pump	2	Hor/cent	50	180	15	170/210	Mfg Std
Chemical waste pump	1	Hor/cent	176	150	20	170/210	Mfg Std
Decontamination conc waste pump	1	Hor/cent	50	140	7.5	150/210	Mfg Std
Detergent drain pumps	2	Hor/cent	25	175	7.5	150/210	Mfg Std
Waste sample pumps	2	Hor/cent	450	375	75	200/210	Mfg Std
Floor drain sample pumps	2	Hor/cent	176	310	30	240/210	Mfg Std
Waste evaporator dist transfer pumps	2	Hor/cent	50	67	5	170/210	Mfg Std
Waste evaporator conc waste transfer pumps	2	Hor/cent	50	12	1	150/210	Mfg Std
Waste evaporator recycle pumps	2	Hor/cent	50	13.5	1	150/210	Mfg Std
Decontamination solution evap conc waste transfer pump	1	Hor/cent	50	3.6	1	150/210	Mfg Std
Decontamination solution evap recycle pump	1	Hor/cent	50	13.8	1	150/210	Mfg Std

TABLE 3.5-16 (Continued)

Component	Quantity	Type	Rated Flow (gpm)	Rated Head TDH (ft)	Rated Power (hp)	Design Press/Temp (psig/°F)	Code
Pumps (Continued)							
Waste evaporator condensate return pumps	2	Hor/cent	200	120	15	150/210	Mfg Std
Decontamination solution evap condensate return pumps	2	Hor/cent	10	140	1	150/210	Mfg Std
Waste evaporator recirculation pumps	2	Hor/cent	9000	35	150		

TABLE 3.5-16 (Continued)

Component	Quantity	Type Diam/Height (ft and in.)	Material Type/Number	Rated Flow Each (gpm)	Equipment Parameter(4)	Design Press/Temp (psig/°F)	Code
Processing Equipment							
Waste filter	1	Precoat, 3' 6"/10'	Wedge wire element 304 L SS, 52 ea vessel SA 240, 304L	180	Filter surface area = 188 ft^2 Precoat load max 1 lb/ft^2	150/220	ASME, Sect. VIII Div. I
Floor drain filter detergent drain filter	1	Precoat, 3' 6"/10'	Wedge wire element 304 L SS, 52 ea vessel SA 240, 304L	180	Filter surface area = 188 ft^2	150/220	ASME, Sect. VIII Div. I
	1	Cartridge 25 pairs	ASME SA 516 Gr 65	25	Precoat load max 1 lb/ft^2 25 pairs Replaceable Cartridge	150/212	ASME, Sect. VIII Div. I
Waste demineralizer	1	Mixed bed 7'/10'	CS ASME SA 516/rubber-lined	180	190 ft^3 Cat/an 1:1	150/150	ASME, Sect. VIII Div. I
Floor drain demineralizer	1	Mixed bed 7'/10'	CS ASME SA 516/rubber-lined	180	190 ft^3 Cat/an 1:1	150/150	ASME, Sect. VIII Div. I
Waste evaporator	2	Forced Circulation Vapor body: 7'x2"x9" 6'/20' 0" Heater	ASME SA-240 316 L SS	40	Na_2SO_4 conc to 25% SW External HX	30/274	ASME, Sect. VIII Div. I
Decontamination solution evaporator	1	Natural circulation Vertical HX (No passes) 4'x17'	ASME SA-240 316 L SS	3	Internal HX Bottom conc 10%	30/274	ASME, Sect. VIII Div. I TEMA Class C

(4) 1 pound = 0.454 kilogram.

TABLE 3.5-16 (Continued)

Component	Quantity	Type Diam/Height (ft and in.)	Material Type/Number	Rated Flow Each (gpm)	Equipment Parameter	Design Press/Temp (psig/°F)	Code
Processing Equipment (Continued)							
Radwaste demineralizer regeneration system	1	-	-	-	One complete regeneration per 7 hours	-	ASME, Sec.. VIII
Cation vessel	1	7'/10' Vert/cyl	CS SA-515 Gr. 70/rubber-lined	-	-	125/150	ASME, Sect. VIII Div. I
Anion vessel	1	7'/10' Vert/cyl	CS SA-515 Gr. 70/rubber-lined	-	-	125/150	ASME, Sect. VIII Div. I
Caustic dilution hot water tank	1	4'/10' Vert/cyl	CS SA-515 Gr. 70	-	-	150/200	ASME, Sect. VIII Div. I

TABLE 3.5-17

EXPECTED YEARLY ACTIVITY RELEASED FROM LIQUID WASTE MANAGEMENT SUBSYSTEMS
FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10 CFR 50 (Ci)

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing Stream	Subtotal	Adjusted Total	Detergent Wastes	Total
CORROSION AND ACTIVATION PRODUCTS							
Na-24	3.5E-3	1.3E-4	4.5E-3	8.2E-3	1.2E-2	0	1.2E-2
P-32	1.1E-4	6.9E-6	3.5E-4	4.6E-4	6.8E-4	0	6.8E-4
Cr-51	3.4E-3	2.1E-4	1.1E-2	1.5E-2	2.2E-2	0	2.2E-2
Mn-54	4.0E-5	2.6E-6	1.5E-4	1.9E-4	2.8E-4	1.0E-3	1.3E-3
Mn-56	3.4E-3	8.9E-5	2.6E-3	6.1E-3	8.8E-3	0	8.8E-3
Fe-55	5.7E-4	3.7E-5	2.2E-3	2.8E-3	4.1E-3	0	4.1E-3
Fe-59	1.7E-5	1.1E-6	6.0E-5	7.8E-5	1.1E-4	0	1.1E-4
Co-58	1.1E-4	7.2E-6	4.2E-4	5.4E-4	7.8E-4	4.0E-3	4.8E-3
Co-60	2.3E-4	1.5E-5	8.8E-4	1.1E-3	1.6E-3	8.7E-3	1.0E-2
Ni-65	2.0E-5	5.3E-7	1.6E-5	3.6E-5	5.2E-5	0	5.2E-5
Cu-64	9.8E-3	3.5E-4	1.2E-2	2.2E-2	3.2E-2	0	3.2E-2
Zn-65	1.1E-4	7.3E-6	4.3E-4	5.5E-4	8.1E-4	0	8.1E-4
Zn-69m	6.8E-4	2.5E-5	8.4E-4	1.5E-3	2.2E-3	0	2.2E-3
Zn-69	7.1E-4	2.6E-5	8.8E-4	1.6E-3	2.4E-3	0	2.4E-3
Zr-95	0	0	0	0	0	1.4E-3	1.4E-3
Nb-95	0	0	0	0	0	2.0E-3	2.0E-3
W-187	1.3E-4	5.5E-6	2.0E-4	3.3E-4	4.8E-4	0	4.8E-4
Np-239	3.5E-3	1.9E-4	7.5E-3	1.1E-2	1.6E-2	0	1.6E-2
FISSION PRODUCTS							
Br-83	2.3E-4	6.0E-6	1.8E-4	4.1E-4	5.9E-4	0	5.9E-4
Br-84	8.8E-6	3.6E-7	6.7E-6	1.6E-5	2.3E-5	0	2.3E-5
Sr-89	5.7E-5	3.7E-6	2.1E-4	2.7E-4	3.9E-4	0	3.9E-4
Sr-90	4.0E-6	2.6E-7	1.5E-5	2.0E-5	2.9E-5	-	2.9E-5
Y-90	4.5E-7	6.2E-8	7.8E-6	8.3E-6	1.2E-5		1.2E-5
Sr-91	1.1E-3	3.5E-5	1.2E-3	2.3E-3	3.3E-3	0	3.3E-3
Y-91m	7.0E-4	2.2E-5	7.4E-4	1.5E-3	2.1E-3	0	2.1E-3

TABLE 3.5-17 (Continued)

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing System	Subtotal	Adjusted Total	Detergent Wastes	Total
FISSION PRODUCTS (Continued)							
Y-91	3.1E-5	2.2E-6	1.3E-4	1.6E-4	2.4E-4	0	2.4E-3
Sr-92	7.3E-4	1.9E-5	5.7E-4	1.3E-3	1.9E-3	0	1.9E-3
Y-92	1.7E-3	4.4E-5	1.4E-3	3.1E-3	4.6E-3	0	4.6E-3
Y-93	1.1E-3	3.7E-5	1.2E-3	2.4E-3	3.5E-3	0	3.5E-3
Zr-95	4.5E-6	2.9E-7	1.7E-5	2.1E-5	3.1E-5	0	3.1E-5
Nb-95	4.5E-6	2.9E-7	1.7E-5	2.2E-5	3.2E-5	0	3.2E-5
Nb-98	2.9E-5	9.4E-7	2.2E-5	5.1E-5	7.5E-5	0	7.5E-5
Mo-99	1.0E-3	5.6E-5	2.3E-6	3.4E-3	4.9E-3	0	4.9E-3
Tc-99m	4.4E-3	1.5E-4	5.4E-3	9.9E-3	1.4E-2	0	1.4E-2
Ru-103	1.1E-5	7.2E-7	4.0E-5	5.2E-5	7.5E-5	1.4E-4	2.3E-4
Rh-103m	1.1E-5	7.2E-7	4.0E-5	5.2E-5	7.5E-5	0	7.5E-5
Tc-104	8.4E-6	5.3E-7	6.3E-6	1.5E-5	2.2E-5	0	2.2E-5
Ru-105	2.8E-4	7.3E-6	2.3E-4	5.1E-4	7.4E-4	0	7.4E-4
Rh-105m	2.8E-4	7.3E-6	2.3E-4	5.1E-4	7.5E-4	0	7.5E-4
Rh-105	9.4E-5	5.3E-6	2.1E-4	3.1E-4	4.5E-4	0	4.5E-4
Ru-106	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.2E-5	2.4E-3	2.4E-3
Rh-106	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.2E-5	0	1.2E-5
Ag-110m	5.7E-6	3.6E-8	2.2E-6	2.8E-6	4.0E-6	4.4E-4	4.4E-4
Te-129m	2.2E-5	1.4E-6	7.8E-5	1.0E-4	1.5E-4	0	1.5E-4
Te-129	1.4E-5	9.2E-7	5.0E-5	6.6E-5	9.5E-5	0	9.5E-5
Te-131m	4.4E-5	2.1E-6	7.8E-5	1.2E-4	1.8E-4	0	1.8E-4
Te-131	8.1E-6	3.8E-7	1.4E-5	2.3E-5	3.3E-5	0	3.3E-5
I-131	1.0E-3	6.1E-5	6.6E-2	6.7E-2	9.8E-2	6.2E-5	9.8E-2
Te-132	5.2E-6	2.9E-7	1.2E-5	1.7E-5	2.5E-5	0	2.5E-5
I-132	2.1E-3	5.7E-5	1.7E-4	3.8E-3	5.6E-3	0	5.6E-3
I-133	1.0E-2	4.3E-4	2.4E-2	3.4E-2	5.0E-2	0	5.0E-2
I-134	5.8E-4	1.9E-5	4.4E-4	1.0E-3	1.5E-3	0	1.5E-3

TABLE 3.5-17 (Continued)

	High Purity Waste Processing Stream	Low Purity Waste Processing Stream	Chemical Waste Processing System	Subtotal	Adjusted Total	Detergent Wastes	Total
FISSION PRODUCTS (CONTINUED)							
Cs-134	1.7E-4	5.5E-5	5.7E-5	2.8E-4	4.1E-4	1.3E-2	1.3E-2
I-135	5.7E-3	1.6E-4	5.2E-3	1.1E-2	1.6E-2	0	1.6E-2
Cs-136	4.4E-4	1.4E-4	1.3E-4	7.1E-4	1.0E-3	0	1.0E-3
Cs-137	1.1E-4	3.7E-5	3.8E-5	1.9E-4	2.7E-4	2.4E-2	2.4E-2
Ba-137m	1.1E-4	3.4E-5	3.6E-5	1.8E-4	2.6E-4	0	2.6E-4
Cs-138	1.7E-4	3.4E-5	1.3E-5	2.1E-4	3.1E-4	0	3.1E-4
Ba-139	2.2E-4	6.5E-6	1.7E-4	4.0E-4	5.9E-4	0	5.9E-4
Ba-140	2.2E-4	1.4E-5	6.8E-4	9.1E-4	1.3E-3	0	1.3E-3
La-140	3.9E-5	4.9E-6	3.6E-4	4.1E-4	5.9E-4	0	5.9E-4
La-141	1.0E-4	2.7E-6	8.3E-5	1.9E-4	2.8E-4	0	2.8E-4
Ce-141	1.9E-5	1.2E-6	6.7E-5	8.7E-5	1.3E-4	0	1.3E-4
La-142	1.6E-4	4.6E-6	1.2E-4	2.9E-4	4.2E-4	0	4.2E-4
Ce-143	1.4E-5	6.5E-6	2.5E-5	3.9E-5	5.7E-5	0	5.7E-5
Pr-143	2.3E-5	1.4E-6	7.2E-5	9.6E-5	1.4E-4	0	1.4E-4
Ce-144	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.2E-5	5.2E-3	5.2E-3
Pr-144	1.7E-6	1.1E-7	6.5E-6	8.3E-6	1.2E-5	0	1.2E-5
ALL OTHERS	1.4E-5	1.4E-6	1.9E-5	3.4E-5	5.0E-5	0	5.0E-5
TOTAL (Except Tritium)	6.0E-2	2.6E-3	1.6E-1	2.2E-1	3.2E-1	6.2E-2	3.8E-1
Tritium Release							26

TABLE 3.5-18 (Page 1 of 3)

EXPECTED ACTIVITY CONCENTRATIONS (uCi/ml)
FOR EVALUATION OF RADIOACTIVE RELEASES TO THE
DELAWARE RIVER

Isotope	Concentration (uCi/ml)(1)	MPC (uCi/ml) 10CFR20 Table II, Col. 2	Fraction of MPC
Na-24	4E-9	2E-4	2E-5
P-32	2E-10	2E-5	1E-5
Cr-51	7E-9	2E-3	4E-6
Mn-54	4E-10	1E-4	4E-6
Mn-56	3E-9	1E-4	3E-5
Fe-55	1E-9	8E-4	1E-6
Fe-59	4E-11	6E-5	7E-7
Co-58	2E-9	1E-4	2E-5
Co-60	3E-9	5E-5	6E-5
Ni-65	2E-11	1E-4	2E-7
Cu-64	1E-8	3E-4	3E-5
Zn-65	3E-10	1E-4	3E-6
Zn-69m	7E-10	7E-5	1E-5
Zn-69	8E-10	2E-3	4E-7
W-187	2E-10	7E-5	3E-6
Np-239	5E-9	1E-4	5E-5
Br-83	2E-10	3E-6	7E-5
Br-84	8E-12	3E-6	3E-6
Sr-89	1E-10	3E-6	3E-5
Sr-90	1E-11	3E-7	3E-5
Y-90	4E-12	2E-5	2E-7
Sr-91	1E-9	7E-5	1E-5
Y-91m	7E-10	3E-3	2E-7
Y-91	8E-10	3E-5	3E-5
Sr-92	6E-10	7E-5	9E-6
Y-92	2E-9	6E-5	3E-5
Y-93	1E-9	3E-5	3E-5
Zr-95	5E-10	6E-5	8E-6
Nb-95	7E-10	1E-4	7E-6
Nb-98	2E-11	3E-6	7E-6
Mo-99	2E-9	2E-4	1E-5

(1)See page 3.

TABLE 3.5-18 (Continued) (Page 2 of 3)

Isotope	Concentration (uCi/ml)[1]	MPC (uCi/ml) 10CFR20 Table II, Col. 2	Fraction of MPC
Tc-99m	5E-9	6E-3	8E-7
Ru-103	7E-11	8E-5	9E-7
Rh-103m	2E-11	1E-2	2E-9
Tc-104	7E-12	3E-6	2E-6
Ru-105	2E-10	1E-4	2E-6
Rh-105m	2E-10	3E-6	7E-5
Rh-105	1E-10	1E-4	1E-6
Ru-106	8E-10	1E-5	8E-5
Rh-106m	4E-12	3E-6	1E-6
Ag-110m	1E-10	3E-5	3E-6
Te-129m	5E-11	3E-5	2E-6
Te-129	3E-11	8E-4	4E-8
Te-131m	6E-11	6E-5	1E-6
Te-131	1E-11	3E-6	3E-6
I-131	3E-8	3E-7	1E-1
Te-132	8E-12	3E-5	3E-7
I-132	2E-9	8E-6	3E-4
I-133	2E-8	1E-6	2E-2
I-134	5E-10	2E-5	3E-5
Cs-134	4E-9	9E-6	4E-4
I-135	5E-9	4E-6	1E-3
Cs-136	3E-10	9E-5	3E-6
Cs-137	8E-9	2E-5	4E-4
Ba-137m	9E-11	3E-6	3E-5
Cs-138	1E-10	3E-6	3E-5
Ba-139	2E-10	3E-6	7E-5
Ba-140	4E-10	2E-5	2E-5
La-140	2E-10	2E-5	1E-5
La-141	9E-11	3E-6	3E-5
Ce-141	4E-11	9E-5	4E-7
La-142	1E-10	3E-6	3E-5
Ce-143	2E-11	4E-5	5E-7
Pr-143	5E-11	5E-5	1E-6
Ce-144	2E-9	1E-5	2E-4
Pr-144	4E-12	3E-6	1E-6
All Others	2E-11	-	-
Total	1E-7	-	-
H3	9E-6	3E-3	3E-3

TABLE 3.5-18 (Continued) (Page 3 of 3)

(1) Annual average concentration after dilution by the minimum monthly flow of 7.2E4 liters per minute (1.9E4 gallons per minute) cooling tower blowdown, adjusted for an 80 percent capacity factor. Concentrations have also been adjusted to reflect the fact that the releases presented in Table 3.5-19 are based on 50,000 microcuries per second noble gas offgas rate (at 30 minute delay). The concentrations in this table are based on a 500,000 microcurie per second rate.

TABLE 3.5-19 (Page 1 of 4)

INPUT DATA FOR AQUATIC DOSE CALCULATIONS

HOPE CREEK GENERATING STATION - LIQUID DOSE CALCULATIONS

1 42.3 1.0 1

5.97E06

HCGS SOURCE TERM - ONE UNIT WITH MULTIPLIER OF 1.0

H 3	26.0
NA24	0.012
P 32	0.00068
CR51	0.022
MN54	0.0013
MN56	0.0088
FE55	0.0041
FE59	0.00011
CO58	0.0048
CO60	0.01
NI65	0.000052
CU64	0.032
ZN65	0.00081
ZN69M	0.0022
ZN69	0.0024
W 187	0.00049
NP239	0.016
BR83	0.00059
BR84	0.000023
SR89	0.00039
SR90	0.000028
Y 90	0.000012
SR91	0.0033
Y 91M	0.0021
Y 91	0.0024
SR92	0.0019
Y 92	0.0046
Y 93	0.0035
ZR95	0.0014
NB95	0.002
NB98	0.000075
MO99	0.0049
TC99M	0.014
RU103	0.00022
RH103M	0.000075
TC104	0.000022
RU105	0.00074
RH105M	0.00075
RH105	0.00045
RU106	0.0024
RH106	0.000012

TABLE 3.5-19 (Continued) (Page 2 of 4)

AG110M	0.00044
TE129M	0.00015
TE129	0.000095
TE131M	0.00018
TE131	0.000033
I 131	0.098
TE132	0.000025
I 132	0.0056
I 133	0.05
I 134	0.0015
CS134	0.013
I 135	0.016
CS136	0.001
CS137	0.024
BA137M	0.00026
CS138	0.00031
BA139	0.00059
BA140	0.0013
LA140	0.00059
LA141	0.00028
CE141	0.00013
LA142	0.00042
CE143	0.000057
PR143	0.00014
CE144	0.0052
PR144	0.000012

1	0.2	10.0	10.0	10.0	10.0	0.0
21.0	5.0	0.0	0.0	12.0	100.0	100.0
16.0	3.8	0.0	0.0	67.0	100.0	100.0
6.9	1.7	0.0	0.0	14.0	100.0	100.0

1862.0	33820	206.7
3453.0	147.0	160.4
4522.0	101.0	122.5
6118.0	11.0	66.9
9310.0	3.9	22.3
11704.0	3.5	16.9
19950.0	6.0	47.4
46284.0	74.0	100.8
77938.0	2289.0	164.0
84854.0	1175.0	232.9
5530.0	33820.0	206.7
10270.0	147.0	160.4
13430.0	101.0	122.5
18170.0	11.0	66.9
27650.0	3.9	22.3

TABLE 3.5-19 (Continued) (Page 3 of 4)

34760.0	3.5	16.9		
59250.0	6.0	47.4		
137460.0	74.0	100.8		
231470.0	2289.0	164.0		
252010.0	1175.0	232.9		
273.0	33820.0	206.7		
507.0	147.0	160.4		
663.0	101.0	122.5		
897.0	11.0	66.9		
1365.0	3.9	22.3		
1716.0	3.5	16.9		
2925.0	6.0	47.4		
6786.0	74.0	100.8		
11427.0	2289.0	164.0		
12441.0	1175.0	232.9		
11200.0	33820.0	206.7		
20800.0	147.0	160.4		
27200.0	101.0	122.5		
36800.0	11.0	66.9		
56000.0	3.9	22.3		
70400.0	3.5	16.9		
120000.0	6.0	47.4		
278400.0	74.0	100.8		
468800.0	2289.0	164.0		
510400.0	1175.0	232.9		
368000.0	33820.0	206.7	0.2	REGION U5
340000.0	147.0	160.4	0.2	REGION U4
368000.0	101.0	122.5	0.2	REGION U3
368000.0	11.0	66.9	0.2	REGION U2
400000.0	3.9	22.3	0.2	REGION U1
340000.0	3.5	16.9	0.2	REGION D1
460000.0	6.0	47.4	0.2	REGION D2
364000.0	74.0	100.8	0.2	REGION D3
436000.0	2289.0	164.0	0.2	REGION D4
556000.0	1175.0	232.9	0.2	REGION D5
202400.0	33820.0	206.7	REGION U5	
187000.0	147.0	160.4	REGION U4	
202400.0	101.0	122.5	REGION U3	
202400.0	11.0	66.9	REGION U2	
220000.0	3.9	22.3	REGION U1	
187000.0	3.5	16.9	REGION D1	
253000.0	6.0	47.4	REGION D2	
202000.0	74.0	100.8	REGION D3	
239800.0	2289.0	164.0	REGION D4	
305800.0	1175.0	232.9	REGION D5	

TABLE 3.5-19 (Continued) (Page 4 of 4)

6720.0	33820.0	206.7	REGION U5
12480.0	147.0	160.4	REGION U4
16320.0	101.0	122.5	REGION U3
22080.0	11.0	66.9	REGION U2
33600.0	3.9	22.3	REGION U1
42240.0	3.5	16.9	REGION D1
72000.0	6.0	47.4	REGION D2
167040.0	74.0	100.8	REGION D3
281280.0	2289.0	164.0	REGION D4
306240.0	1175.0	232.9	REGION D5

TABLE 3.5-20 (Page 1 of 2)

LIVE VOLUME CAPACITIES OF TANKS AND DESIGN OF PROCESS EQUIPMENT CONSIDERED IN THE CALCULATION OF HOLDUP TIMES

I. Tanks	Number	Live Volume Capacity (gal)(1)
Waste Collector Tank	2	29,000
Floor Drain Collector Tank	2	15,000
Waste Surge Tank	1	67,500
Waste Neutralizer Tank	2	25,000
Concentrated Waste Tank	2	10,550
Decontamination Solution Concentrated Waste Tank	1	600
Chemical Waste Tank	1	4,000
Waste and Floor Drain Sample Tanks	4	15,550
Waste Evaporator Distillate Storage Tank	1	1,100
Decontamination Solution Evaporator Condensate Return Tank	1	30

II. Pumps	Number	Flow Rate (gpm)
Waste Collector Tank Pump	2	182
Waste Surge Tank Pump	1	182
Floor Drain Collector Tank Pump	2	176
Concentrator Feed Pump	2	40
Concentrated Waste Pump	2	50
Chemical Waste Pump	1	176
Decontamination Concentrated Waste Pump	1	50
Waste Sample Tank Pump	2	450
Floor Drain Sample Tank Pump	2	176
Crystallizer Recirculation Pump	1	30
Waste Evaporator Distillate Transfer Pump	2	50
Waste Evaporator Concentrated Waste Transfer Pump	2	50

III. Filters	Number	Flow Rate (gpm)
Waste Filter	1	180
Floor Drain Filter	1	180

(1) 1 gallon = 3.785 liters.

TABLE 3.5-20 (Continued) (Page 2 of 2)

IV. Demineralizers	Number	Flow Rate (gpm)
Waste Demineralizer	1	180
Floor Drain Demineralizer	1	180

V. Evaporators	Number	Flow Rate (gpm)
Decontamination Solution Evaporator	1	5
Waste Evaporators	2	40

HCGS OLER

TABLE 3.5-21

FLOWSHEET DATA

POINT	PRESSURE (psig)	TEMPERATURE (^{O}F(^{O}C))	H_2 (pph/scfm)	O_2 (pph/scfm)	AIR (pph/scfm)	H_2O VAPOR (pph/scfm)	TOTAL (pph/scfm)
1	11	114 (238)	44/154	339/77	337/70	10847/4017	11567/4318
2	11	105 (221)	44/154	339/77	344/75	10847/4017	11574/4323
3	125	178 (353)	-	-	-4.1	338/125	338/125
4	10.2	132 (270)	44/154	339/77	344/75	10847/4017	11574/4323
5	9.2	367 (693)	-	-	344/75	11244/4164	11574/4239
6	7.8	49 (120)	-	-	344/75	25/8	369/83
7	7.4	45 (113)	-	-	344/75	18/6	362/81
8	1.6	93 (200)	-	-	344/75	18/6	362/81
9	1.4	4 (40)	-	-	344/75	1.6/0.6	345/75
10	1.38	18 (65)	-	-	344/75	1.6/0.6	345/75
11	1.18	18 (65)	-	-	344/75	1.6/0.6	345/75
12	0.62	18 (65)	-	-	344/75	1.6/0.6	345/75
13	0.5	18 (65)	-	-	344/75	1.6/0.6	345/75

TABLE 3.5-22 (Page 1 of 3)

EXPECTED ANNUAL ACTIVITY RELEASED FROM GASEOUS WASTE MANAGEMENT SYSTEMS
FOR EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10 CFR 50 (Ci)

NUCLIDE	REACTOR BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	STEAM JET AIR EJECTOR	MECHANICAL VACUUM PUMP	TOTAL ANNUAL RELEASE
H-3	2.6E1(1)	2.6E1	-	-	-	-	5.2E1
C-14	-	-	-	-	-	-	9.5E0
Ar-41	1.5E1	0	0	0	0	0	1.5E1
Kr-83m	0	0	0	0	0	0	0
Kr-85m	1.0E0	2.5E1	3.0E0	0	0	0	2.9E1
Kr-85	0	0	0	0	2.2E2	0	2.2E2
Kr-87	0	6.1E1	2.0E0	0	0	0	6.3E1
Kr-88	1.0E0	9.1E1	3.0E0	0	0	0	9.5E1
Kr-89	0	5.8E2	2.0E0	2.9E1	0	0	6.1E2
Xe-131m	0	0	0	0	7.0E0	0	6.7E0
Xe-133m	0	0	0	0	0	0	0
Xe-133	2.7E1	1.5E2	8.3E1	2.2E2	6.5E1	1.3E3	1.8E3
Xe-135m	1.5E1	4.0E2	4.5E1	5.3E2	0	0	9.9E2
Xe-135	3.3E1	3.3E2	9.4E1	2.8E2	0	5.0E2	1.2E3
Xe-137	4.5E1	1.0E3	1.4E2	8.3E1	0	0	1.3E3

(1) $2.6E1 = 2.6X10^{1}$

TABLE 3.5-22 (Continued)

NUCLIDE	REACTOR BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	STEAM JET AIR EJECTOR	MECHANICAL VACUUM PUMP	TOTAL ANNUAL RELEASE
Xe-138	2.0E0	1.0E3	6.0E0	2.0E0	0	0	1.0E3
I-131	1.1E-2	1.2E-1	2.2E-2	3.4E-3	0	8.7E-2	2.4E-1
I-133	1.6E-1	1.7E0	3.1E-1	4.8E-2	0	9.7E-1	3.2E0
Cr-51	2.0E-6	9.0E-4	9.0E-6	7.0E-6	-	1.0E-6	9.2E-4
Mn-54	4.0E-6	6.0E-4	1.0E-5	4.0E-5	-	0	6.5E-4
Co-58	1.0E-6	1.0E-3	2.0E-6	2.0E-6	-	0	1.0E-3
Fe-59	9.0E-7	1.0E-4	3.0E-6	3.0E-6	-	0	1.1E-4
Co-60	1.0E-5	1.0E-3	4.0E-5	7.0E-5	-	5.6E-7	1.1E-3
Zn-65	1.0E-5	6.0E-3	4.0E-5	3.0E-6	-	3.4E-7	6.1E-3
Sr-89	3.0E-7	6.0E-3	2.0E-7	0	-	0	6.0E-3
Sr-90	3.0E-8	2.0E-5	7.0E-8	0	-	0	2.0E-5
Nb-95	1.0E-5	6.0E-6	9.0E-5	4.0E-8	-	0	1.1E-4
Zr-95	3.0E-6	4.0E-5	7.0E-6	8.0E-6	-	0	5.8E-5
Mo-99	6.0E-5	2.0E-3	6.0E-4	3.0E-8	-	0	2.7E-3
Ru-103	2.0E-6	5.0E-5	4.0E-5	1.0E-8	-	0	9.2E-5

TABLE 3.5-22 (Continued)

NUCLIDE	REACTOR BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	STEAM JET AIR EJECTOR	MECHANICAL VACUUM PUMP	TOTAL ANNUAL RELEASE
Ag-110m	4.0E-9	0	2.0E-8	0	-	0	2.4E-8
Sb-124	2.0E-7	1.0E-4	3.0E-7	7.0E-7	-	0	1.0E-4
Cs-134	7.0E-6	2.0E-4	4.0E-5	2.4E-5	-	3.2E-6	2.7E-4
Cs-136	1.0E-6	1.0E-4	4.0E-6	0	-	1.9E-6	1.1E-4
CS-137	1.0E-5	1.0E-3	5.0E-5	4.0E-5	-	8.9E-6	1.1E-3
Ba-140	2.0E-5	1.0E-2	2.0E-4	4.0E-8	-	1.1E-5	1.0E-2
Ce-141	2.0E-6	1.0E-2	7.0E-6	7.0E-8	-	0	1.0E-2

TABLE 3.5-23

OFFGAS SYSTEM MAJOR EQUIPMENT DESCRIPTION

Equipment	Equipment Numbers	Type	Quantity	Material	Capacity[1]	Size[1]	Design Pressure Temp psig/°F [2]
Preheater	00E305 10E305	Shell and straight tube	2	Shell, channel, Sheet: carbon steel (CS) Tubes: stainless steel (SS)	263,600 Btu/h	182.7 ft^2 effective area	Shell side: 273/400 Tube side: 940/400
Cooler condenser	00E306 10E306	Shell and straight tube	2	Shell, Sheet, Channel: CS Tubes: SS	16.07×10^6 Btu/h	904.1 ft^2 effective area	Shell side: 780/800 Tube side: 225/250
Recombiner	00S312 10S312	Spherical shell	2	Shell: SS Internals: Catalyst support Assembly: SS Catalyst: Palladium-coated, ceramic-base, pellet-type	2200 lb Catalyst	Vessel I.D. 78 in. Catalyst: 78 in. dia., 16 in. deep	450/900 (Vessel)
Holdup pipe	-	Straight pipe	8	CS	-	24 in. dia. x 55 ft long	400/850
Outlet HEPA filter	00F327	Vertical cylinder	1	Vessel: CS Internals: C-size filter element	150 scfm at 1.2 psi	Vessel: 54 in. high, 14 in. dia. Cartr.: 13 in. high, 11.25 in. dia.	445/150

[1] 1 BTU = 0.252 Kcal; 1 pound = 0.454 kilogram; 14.223 psi = 1 kg/cm^2; 3.28 ft = 1 m; 0.394 in. = 1 cm.
[2] (°F-32) x 0.555 = °C.

TABLE 3.5-23 (Continued)

Equipment	Equipment Numbers	Type	Quantity	Material	Capacity	Size	Design Pressure Temp psig/°F
Glycol cooler condenser	00S309	Shell and circular tube	1	Glycol vessel: CS Process tubes: SS Freon tubes: Copper	56,700 Btu/h	Glycol vessel: 72 in. dia., 96 in. high 193 ft^2 Effective area (freon coil) 280 ft^2 Effective area (process gas)	Shell side: 0/150 Tube side: 655/150
Guard bed vessel	00S310	Vertical cylinder	1	CS	200 lb charcoal	31 in. dia. x 80 in. high	280/150
Charcoal adsorber vessel	00T384	Vertical cylinder	10	CS	32,200 lb charcoal each	96 in. dia. x 312 in. high	410/150
Charcoal bed	-	Sutcliffe Speakman 203C	322,000 lb	Activated charcoal	Adsorb. coeff. at design temp. Xe: 733 Kr: 31.8	Mesh size 8 by 16	-
Refrigeration units (glycol)	0AS346 0BS346	Open	2	Freon 22 refrigerant	64,400 Btu/h	-	-
Refrigeration units (compartment cooling)	0AS348 0BS348	Open	2	Freon 22 refrigerant	127,00 Btu/h	-	-

TABLE 3.5-24

OFFGAS SYSTEM EQUIPMENT MALFUNCTIONS ANALYSIS

Equipment Item	Malfunction	Consequences	Design Precautions
Piping from SJAE to and including holdup pipe	Pressure boundary leakage	Increased local airborne radioactivity levels and increased releases from plant ventilation	Ventilation releases will be monitored and alarmed. The vent gas will then be filtered by the radwaste exhaust system. Low pressure system, radiographed welds, and system is designed to withstand hydrogen detonation.
Recombiner preheater	Steam leak from shell side into tube side	Increased preheater outlet temperature - increased quantity of steam in process steam	Temperature elements at preheater outlet regulate steam flow to preheater - additional steam flow is condensed in the cooler condenser and returned to the main condenser.
	Steam failure	Recombiner preheater cools down, increasing the moisture level in the recombiner, reducing catalyst activity and causing hydrogen concentration to rise at the recombiner outlet.	An alarm sounds as recombiner feed temperature drops; alarm also sounds at increase of hydrogen concentration downstream of recombiner (0.3%). Shutdown occurs if hydrogen concentration reaches 0.6%.
Recombiners	Catalyst deteriorates or is wetted.	Recombiner outlet temperature drops - high hydrogen concentration at recombiner outlet.	Recombiner temperature monitors record low temperature, and alarm/analyzers record hydrogen level and actuate alarm at 0.3% and 0.6%; automatic shutdown occurs if hydrogen level reaches 0.6%.

TABLE 3.5-24 (Continued)

Equipment Item	Malfunction	Consequences	Design Precautions
Cooler condenser	Cooling water leak (tube to shell side)	The cooling water leaks to the shell side of the heat exchanger. Liquid level in cooler condenser shell drain rises.	Liquid level instruments actuate alarm on high levels in cooler condenser. Additional liquid automatically drains to CRW.
	Liquid level instrument fails	Cooler condenser shell drain level drops.	Redundant level instrument actuates alarm on low level in cooler condenser - redundant level control valve closes.
	Cooling water failure	Cooler condenser outlet temperature increases.	Temperature element at cooler condenser outlet actuates alarm and shuts down the recombiner system.
Offgas system main process piping	Pressure boundary leakage	Release of offgas mixture to radwaste enclosure	Ventilation monitors in ducts from the offgas area detect leakage from offgas piping.
Glycol cooler condenser	Refrigerator failure	If glycol unit fails, the moisture content of the process steam increases, resulting in decreased adsorption.	The failure of the refrigerator actuates a local panel alarm and the main control room panel system trouble alarm. A redundant glycol refrigeration unit is installed. Moisture instrumentation and temperature instrumentation are provided at the cooler condenser outlet. High outlet temperature and high moisture are alarmed at the local panel and in the main control room. High thermal inertia of glycol bath is provided.

TABLE 3.5-24 (Continued)

Equipment Item	Malfunction	Consequences	Design Precautions
Charcoal adsorbers	Moisture in gas stream	Charcoal adsorption performance deteriorates gradually as charcoal gets wet. Holdup times decrease and plant gaseous releases increase.	Moisture elements detect increasing mositure in inlet stream. Various design precautions are included upstream to preclude moisture from entering adsorbers. Sacrificial guard beds are provided to protect main adsorber vessels.
Charcoal vault air conditioning units	Mechanical failure of refrigeration units or air coolers	If ambient temperature increases, delay efficiency of charcoal beds decreases. Increased releases would occur depending on the fuel leakage rate.	Redundant air conditioning units are provided. A redundant fan and cooler is provided for each cell. High and low ambient temperature alarms in main control room and local panel. Ambient temperature is recorded at the local panel. There is a refrigeration trouble alarm in main control room and local panel. Refrigeration system capacity is oversized for heat load.
Outlet HEPA filter	Plugging of filter media	Increasing differential pressure in HEPA creates higher system back pressure. SJAE bypass valve may open recycling offgas back to main condenser.	Differential pressure is alarmed at the local panel, in main control room and indicated at the local panel. DOP test connections are provided. HEPA filter can be bypassed for servicing.

TABLE 3.5-25

EXPECTED ACTIVITY CONCENTRATIONS (uCi/ml) AT THE SITE BOUNDARY FOR EVALUATION OF GASEOUS RELEASES

Isotope	Concentration (uCi/ml)(1)	MPC (uCi/ml) 10CFR20 Table II, Column 1	Fraction of MPC	Annual External Whole Body Dose (mrem)
I131	2E-14	1E-10	2E-4	6E-5
I133	3E-13	4E-10	8E-4	1E-3
H3	4E-12	2E-7	2E-5	-
C14	7E-13	1E-7	7E-6	-
Ar41	1E-12	4E-8	3E-5	1E-2
Kr85m	2E-12	1E-7	2E-5	3E-3
Kr85	2E-11	3E-7	7E-5	3E-4
Kr87	5E-12	2E-8	3E-4	3E-2
Kr88	7E-12	2E-8	4E-4	1E-1
Kr89	5E-11	3E-6	2E-5	9E-1
Xe131m	5E-13	4E-7	1E-6	8E-5
Xe133	1E-10	3E-7	3E-4	4E-2
Xe135m	8E-11	3E-6	3E-5	3E-1
Xe135	9E-11	1E-7	9E-4	2E-1
Xe137	1E-10	3E-6	3E-5	2E-1
Xe138	8E-11	3E-6	3E-5	7E-1
Cr51	7E-17	8E-8	9E-10	2E-8
Mn54	5E-17	1E-9	5E-8	3E-7
Co58	8E-17	2E-9	4E-8	6E-7
Fe59	9E-18	2E-9	5E-9	8E-8
Co60	9E-17	3E-10	3E-7	2E-6
Zn65	5E-16	2E-9	3E-7	2E-6
Sr89	5E-16	3E-10	2E-6	3E-10
Sr90	2E-18	3E-11	7E-8	-
Nb95	9E-18	3E-9	3E-9	5E-8
Zr95	5E-18	1E-9	5E-9	3E-8
Mo99	2E-16	7E-9	3E-8	2E-7
Ru103	7E-18	3E-9	2E-9	3E-8
Ag110m	2E-21	3E-10	7E-12	4E-11
Sb124	8E-18	7E-10	1E-8	1E-7
Cs134	2E-17	4E-10	5E-8	3E-7
Cs136	9E-18	6E-9	2E-9	2E-7
Cs137	9E-17	5E-10	2E-7	4E-7
Ba140	8E-16	1E-9	8E-7	1E-6
Ce141	8E-16	5E-9	2E-7	4E-7
Total				2E0

(1) Concentrations have been adjusted to reflect the fact that the releases presented in Table 3.5-22 are based on a 50,000 uCi/sec noble gas offgas rate (at 30 minute delay). The concentrations in this table are based on a 500,000 uCi/sec rate.

TABLE 3.5-26 (Page 1 of 7)

INPUT DATA FOR ATMOSPHERIC DOSE CALCULATIONS

(1)
HOPE CREEK GENERATING STATION-AIR DOSE CALCULATIONS
C

640.0 0.5 0.66 0.5 0.33 8.0
YEAR 2010 POPULATION DATA FOR HCGS (HCGS FSAR)
6 10

N	0.0	0.0	0.0	0.0	0.0	455.0
	97200.0	111400.0	117600.0	320500.0		
NNE	0.0	0.0	0.0	0.0	36.0	9802.0
	22600.0	148800.0	1198200.0	1306900.0		
NE	0.0	0.0	0.0	7.0	357.0	2268.0
	8800.0	53000.0	389200.0	602800.0		
ENE	0.0	0.0	0.0	62.0	89.0	1205.0
	7400.0	35300.0	71700.0	47500.0		
E	0.0	0.0	0.0	0.0	0.0	1062.0
	24400.0	59100.0	48300.0	28100.0		
ESE	0.0	0.0	0.0	0.0	0.0	509.0
	13400.0	19800.0	12700.0	27900.0		
SE	0.0	0.0	0.0	0.0	0.0	45.0
	1100.0	1200.0	0.0	33800.0		
SSE	0.0	0.0	0.0	0.0	0.0	191.0
	0.0	200.0	700.0	22000.0		
S	0.0	0.0	0.0	0.0	23.0	369.0
	13500.0	39100.0	13600.0	4800.0		
SSW	0.0	0.0	0.0	15.0	0.0	229.0
	23900.0	14700.0	27200.0	15600.0		
SW	0.0	0.0	0.0	0.0	30.0	691.0
	25700.0	5900.0	15400.0	8700.0		
WSW	0.0	0.0	0.0	0.0	15.0	1151.0
	20100.0	3300.0	10000.0	10500.0		
W	0.0	0.0	0.0	15.0	38.0	4065.0
	16900.0	1300.0	49500.0	259400.0		
WNW	0.0	0.0	0.0	129.0	30.0	534.0
	21400.0	23700.0	46400.0	18100.0		
WW	0.0	0.0	0.0	99.0	220.0	915.0
	67400.0	30100.0	16400.0	31500.0		
NNW	0.0	0.0	0.0	4.0	296.0	2424.0
	62400.0	118700.0	49700.0	41300.0		

HCGS AREA MILK PRODUCTION - DRESDNER 1982 SURVEY
6 10

N	0.0	0.0	0.0	0.0	0.0	0.0
	2.43E6	1.96E6	2.90E4	4.90E4		
NNE	0.0	0.0	0.0	0.0	1.40E4	2.15E6
	8.10E6	3.73E6	2.00E3	4.00E3		
NE	0.0	0.0	0.0	0.0	6.00E3	1.71E6
	8.10E6	2.93E6	1.30E6	2.50E6		
ENE	0.0	0.0	0.0	0.0	0.0	6.83E6
	5.55E6	4.55E6	1.36E6	2.98E6		

TABLE 3.5-26 (Continued) (Page 2 of 7)

E	0.0	0.0	0.0	0.0	0.0	1.43E6
	1.22E6	2.43E6	7.34E5	2.16E5		
ESE	0.0	0.0	0.0	0.0	0.0	0.0
	8.10E5	5.24E5	8.03E5	2.61E5		
SE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	3.00E3		
SSE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	3.26E5		
S	0.0	0.0	0.0	0.0	0.0	0.0
	3.13E6	4.68E6	8.13E6	4.75E6		
SSW	0.0	0.0	0.0	0.0	0.0	7.00E3
	3.90E6	5.33E6	1.20E7	1.39E7		
SW	0.0	0.0	0.0	0.0	7.00E3	4.59E5
	6.71E6	7.40E6	7.52E6	5.13E6		
WSW	0.0	0.0	0.0	0.0	0.0	2.48E6
	6.73E6	3.42E7	9.56E6	1.59E6		
W	0.0	0.0	0.0	0.0	4.45E5	3.48E5
	1.95E6	3.99E6	1.05E7	1.13E7		
WNW	0.0	0.0	0.0	0.0	5.13E5	2.23E6
	2.05E6	1.99E6	1.65E7	3.09E7		
NW	0.0	0.0	0.0	0.0	0.0	1.70E6
	2.00E6	9.97E6	5.70E4	1.26E5		
NNW	0.0	0.0	0.0	0.0	0.0	0.0
	9.72E5	2.94E6	1.97E6	6.90E4		

HCGS AREA MEAT PRODUCTION - DRESDNER 1982 SURVEY (INCLUDES POULTRY)

	6	10				
N	0.0	0.0	0.0	0.0	0.0	0.0
	2.63E5	1.90E6	4.95E6	7.80E6		
NNE	0.0	0.0	0.0	0.0	1.40E3	1.28E5
	1.37E6	8.34E5	6.19E5	8.63E5		
NE	0.0	0.0	0.0	0.0	1.00E2	1.33E5
	2.11E6	7.49E5	8.85E6	3.53E5		
ENE	0.0	0.0	0.0	0.0	0.0	1.26E5
	9.06E5	6.75E5	9.09E5	4.71E5		
E	0.0	0.0	0.0	0.0	0.0	1.09E5
	3.05E5	4.94E5	2.95E5	1.15E5		
ESE	0.0	0.0	0.0	0.0	0.0	1.17E5
	2.42E5	1.57E5	2.88E5	2.05E5		
SE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
SSE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	7.34E5		
S	0.0	0.0	0.0	0.0	0.0	0.0
	1.04E6	1.62E6	3.17E6	4.21E5		
SSW	0.0	0.0	0.0	0.0	0.0	1.50E5
	1.11E6	1.18E6	1.24E5	1.32E6		
SW	0.0	0.0	0.0	0.0	0.0	1.50E5
	9.85E5	5.50E6	5.83E6	1.29E4		

TABLE 3.5-26 (Continued) (Page 3 of 7)

WSW	0.0	0.0	0.0	0.0	0.0	1.58E5
	6.84E5	2.91E5	2.98E4	1.50E3		
W	0.0	0.0	0.0	0.0	1.80E3	1.56E5
	6.98E4	3.80E3	6.00E3	1.03E4		
WNW	0.0	0.0	0.0	0.0	7.00E2	0.0
	6.58E4	9.90E3	2.86E4	3.17E5		
NW	0.0	0.0	0.0	0.0	0.0	0.0
	5.58E4	5.01E6	1.51E7	2.88E7		
NNW	0.0	0.0	0.0	0.0	0.0	0.0
	1.11E4	1.59E5	1.83E5	4.45E6		

HCGS AREA VEGETABLE PRODUCTION - DRESDNER 1982 SURVEY (INCLUDES POTATOES)

6 10

N	0.0	0.0	0.0	0.0	0.0	0.0
	1.51E6	2.84E6	7.53E5	1.27E6		
NNE	0.0	0.0	0.0	0.0	0.0	2.63E5
	2.02E6	1.42E6	1.05E5	3.89E5		
NE	0.0	0.0	0.0	0.0	0.0	2.95E5
	2.04E6	1.49E6	2.38E6	1.52E6		
ENE	0.0	0.0	0.0	0.0	0.0	2.55E5
	3.26E6	2.76E6	5.68E6	3.88E6		
E	0.0	0.0	0.0	0.0	0.0	5.78E5
	2.52E6	3.27E6	5.98E6	4.25E6		
ESE	0.0	0.0	0.0	0.0	0.0	8.62E5
	5.05E5	5.02E5	1.36E6	3.63E6		
SE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	3.24E5	0.0		
SSE	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	1.00E6		
S	0.0	0.0	0.0	0.0	0.0	0.0
	3.03E6	4.55E6	1.16E7	7.06E6		
SSW	0.0	0.0	0.0	0.0	0.0	1.25E5
	3.54E6	5.13E6	1.55E7	1.36E7		
SW	0.0	0.0	0.0	0.0	0.0	1.70E5
	4.59E6	5.32E6	7.06E6	1.30E7		
WSW	0.0	0.0	0.0	0.0	0.0	1.46E5
	3.31E6	6.34E6	3.59E6	9.31E5		
W	0.0	0.0	0.0	0.0	0.0	1.62E5
	2.77E6	1.25E5	1.68E6	1.23E6		
WNW	0.0	0.0	0.0	0.0	0.0	0.0
	2.64E6	5.14E5	2.57E6	3.74E6		
NW	0.0	0.0	0.0	0.0	0.0	0.0
	2.51E6	2.14E5	1.76E6	2.01E6		
NNW	0.0	0.0	0.0	0.0	0.0	0.0
	4.29E5	3.77E6	3.16E6	1.61E6		

TABLE 3.5-26 (Continued) (Page 4 of 7)

HCGS SINGLE UNIT SOURCE TERM WITH MULTIPLIER OF 1.0

	1.0
I 131	2.4E-1
I 133	3.2E00
H 3	5.2E01
C 14	9.5E00
AR41	1.5E01
KR85M	2.9E01
KR85	2.2E02
KR87	6.3E01
KR88	9.50E1
KR89	6.1E02
XE131M	6.7E00
XE133	1.8E03
XE135M	9.9E02
XE135	1.2E03
XE137	1.3E03
XE138	1.0E03
CR51	9.2E-4
MN54	6.5E-4
CO58	1.0E-3
FE59	1.1E-4
CO60	1.1E-3
ZN65	6.1E-3
SR89	6.0E-3
SR90	2.0E-5
NB95	1.1E-4
ZR95	5.8E-5
MO99	2.7E-3
RU103	9.2E-5
AG110M	2.4E-8
SB124	1.0E-4
CS134	2.7E-4
CS136	1.1E-4
CS137	1.1E-3
BA140	1.0E-2
CE141	1.0E-2

HCGS GROUND LEVEL X/Q (NORMAL) - HOPE CREEK SOUTH VENT

	6	10				
N		2.022E-07	1.013E-07	7.193E-08	5.258E-08	4.036E-08	2.261E-08
	1.012E-08	5.148E-09	3.268E-09	2.313E-09			
NNE		1.466E-07	8.138E-08	5.877E-08	4.436E-08	3.391E-08	2.002E-08
	8.916E-09	4.406E-09	2.755E-09	1.937E-09			
NE		1.578E-07	8.700E-08	6.208E-08	4.531E-08	3.515E-08	2.370E-08
	9.282E-09	4.580E-09	2.882E-09	2.011E-09			
ENE		8.646E-08	4.849E-08	3.583E-08	2.666E-08	2.147E-08	1.471E-08
	5.864E-09	2.921E-09	1.834E-09	1.293E-09			
E		6.411E-08	4.248E-08	3.452E-08	2.804E-08	2.497E-08	1.575E-08

TABLE 3.5-26 (Continued) (Page 5 of 7)

6.365E-09	3.200E-09	2.183E-09	1.529E-09			
ESE	5.831E-08	3.387E-08	2.656E-08	2.065E-08	1.666E-08	1.078E-08
4.589E-09	2.674E-09	1.662E-09	1.165E-09			
SE	3.047E-07	1.042E-07	6.771E-08	5.070E-08	3.953E-08	2.620E-08
1.150E-08	5.610E-09	3.498E-09	2.459E-09			
SSE	3.016E-07	1.109E-07	7.418E-08	5.390E-08	4.392E-08	2.95E-08
1.308E-08	6.373E-09	3.974E-09	2.793E-09			
S	2.474E-07	1.096E-07	7.731E-08	5.696E-08	4.400E-08	2.500E-08
1.284E-08	7.016E-09	4.369E-09	3.064E-09			
SSW	2.076E-07	9.256E-08	6.757E-08	5.039E-08	4.021E-08	2.495E-08
1.148E-08	5.757E-09	3.858E-09	2.702E-09			
SW	2.021E-07	1.005E-07	7.433E-08	5.530E-08	4.394E-08	2.687E-08
1.324E-08	6.423E-09	4.004E-09	2.801E-09			
WSW	1.831E-07	8.561E-08	6.157E-08	4.616E-08	3.554E-08	2.199E-08
1.047E-08	5.137E-09	3.223E-09	2.295E-09			
W	3.188E-07	1.376E-07	9.106E-08	6.464E-08	4.887E-08	3.240E-08
1.287E-08	6.309E-09	3.942E-09	2.841E-09			
WNW	3.956E-07	1.539E-07	9.575E-08	6.602E-08	4.920E-08	2.735E-08
1.280E-08	6.155E-09	3.800E-09	2.651E-09			
NW	5.272E-07	1.965E-07	1.203E-07	8.234E-08	6.117E-08	3.248E-08
1.311E-08	6.574E-09	4.143E-09	2.935E-09			
NNW	2.540E-07	1.129E-07	7.415E-08	5.222E-08	3.931E-08	2.131E-08
8.777E-09	4.447E-09	2.817E-09	1.997E-09			

HCGS GROUND LEVEL X/Q (NORMAL) - IN PLACE OF DECAYED X/Q

6	10					
N	2.022E-07	1.013E-07	7.193E-08	5.258E-08	4.036E-08	2.261E-08
1.012E-08	5.148E-09	3.268E-09	2.313E-09			
NNE	1.466E-07	8.138E-08	5.877E-08	4.436E-08	3.391E-08	2.002E-08
8.916E-09	4.406E-09	2.755E-09	1.937E-09			
NE	1.578E-07	8.700E-08	6.208E-08	4.531E-08	3.515E-08	2.370E-08
9.282E-09	4.580E-09	2.882E-09	2.011E-09			
ENE	8.646E-08	4.849E-08	3.583E-08	2.666E-08	2.147E-08	1.471E-08
5.864E-09	2.921E-09	1.834E-09	1.293E-09			
E	6.411E-08	4.248E-08	3.452E-08	2.804E-08	2.497E-08	1.575E-08
6.365E-09	3.200E-09	2.183E-09	1.529E-09			
ESE	5.831E-08	3.387E-08	2.656E-08	2.065E-08	1.666E-08	1.078E-08
4.589E-09	2.674E-09	1.662E-09	1.165E-09			
SE	3.047E-07	1.042E-07	6.771E-08	5.070E-08	3.953E-08	2.620E-08
1.150E-08	5.610E-09	3.498E-09	2.459E-09			
SSE	3.016E-07	1.109E-07	7.418E-08	5.390E-08	4.392E-08	2.952E-08
1.308E-08	6.373E-09	3.974E-09	2.793E-09			
S	2.474E-07	1.096E-07	7.731E-08	5.696E-08	4.400E-08	2.500E-08
1.284E-08	7.016E-09	4.369E-09	3.064E-09			
SSW	2.076E-07	9.256E-08	6.757E-08	5.039E-08	4.021E-08	2.495E-08
1.148E-08	5.757E-09	3.858E-09	2.702E-09			
SW	2.021E-07	1.005E-07	7.433E-08	5.530E-08	4.394E-08	2.687E-08
1.324E-08	6.423E-09	4.004E-09	2.801E-09			
WSW	1.831E-07	8.561E-08	6.157E-08	4.616E-08	3.554E-08	2.199E-08

TABLE 3.5-26 (Continued) (Page 6 of 7)

1.047E-08	5.137E-09	3.233E-09	2.295E-09			
W	3.188E-07	1.376E-07	9.106E-08	6.464E-08	4.887E-08	3.240E-08
1.287E-08	6.309E-09	3.942E-09	2.841E-09			
WNW	3.956E-07	1.539E-07	9.575E-08	6.602E-08	4.920E-08	2.735E-08
1.280E-08	6.155E-09	3.800E-09	2.651E-09			
NW	5.272E-07	1.965E-07	1.203E-07	8.234E-08	6.117E-08	3.248E-08
1.311E-08	6.574E-09	4.143E-09	2.935E-09			
NNW	2.540E-07	1.129E-07	7.415E-08	5.222E-08	3.931E-08	2.131E-08
8.777E-09	4.447E-09	2.817E-09	1.997E-09			

HCGS GROUND LEVEL X/Q (DEPLETED) - HOPE CREEK SOUTH VENT

6	10					
N	1.854E-07	9.337E-08	6.682E-08	4.888E-08	3.746E-08	2.076E-08
8.799E-09	4.284E-09	2.587E-09	1.790E-09			
NNE	1.347E-07	7.553E-08	5.484E-08	4.146E-08	3.162E-08	1.824E-08
6.122E-09	2.739E-09	1.601E-09	1.070E-09			
NE	1.448E-07	8.062E-08	5.785E-08	4.222E-08	3.271E-08	1.857E-08
6.313E-09	2.810E-09	1.638E-09	1.093E-09			
ENE	7.943E-08	4.501E-08	3.349E-08	2.492E-08	2.008E-08	1.172E-08
4.090E-09	1.850E-09	1.088E-09	7.299E-10			
E	5.878E-08	3.990E-08	3.277E-08	2.672E-08	2.383E-08	1.262E-08
4.472E-09	2.046E-09	1.057E-09	6.977E-10			
ESE	5.326E-08	3.158E-08	2.510E-08	1.959E-08	1.583E-08	9.659E-09
3.854E-09	1.401E-09	8.047E-10	5.295E-10			
SE	2.782E-07	9.320E-08	6.095E-08	4.584E-08	3.573E-08	2.000E-08
6.771E-09	2.933E-09	1.690E-09	1.118E-09			
SSE	2.756E-07	9.998E-08	6.725E-08	4.882E-08	3.987E-08	2.271E-08
7.700E-09	3.332E-09	1.916E-09	1.265E-09			
S	2.258E-07	1.002E-07	7.121E-08	5.246E-08	4.041E-08	2.264E-08
8.539E-09	3.704E-09	2.132E-09	1.411E-09			
SSW	1.895E-07	8.459E-08	6.249E-08	4.671E-08	3.731E-08	2.246E-08
7.773E-09	3.519E-09	1.882E-09	1.244E-09			
SW	1.849E-07	9.260E-08	6.923E-08	5.159E-08	4.101E-08	2.450E-08
8.115E-09	3.519E-09	2.010E-09	1.330E-09			
WSW	1.677E-07	7.853E-08	5.696E-08	4.280E-08	3.289E-08	1.991E-08
6.863E-09	3.000E-09	1.667E-09	1.097E-09			
W	2.927E-07	1.257E-07	8.361E-08	5.935E-08	4.479E-08	2.506E-08
8.374E-09	3.646E-09	2.104E-09	1.326E-09			
WNW	3.629E-07	1.393E-07	8.677E-08	5.973E-08	4.438E-08	2.431E-08
7.727E-09	3.304E-09	1.887E-09	1.242E-09			
WW	4.832E-07	1.771E-07	1.085E-07	7.419E-08	5.494E-08	2.872E-08
1.119E-08	5.493E-09	3.385E-09	2.360E-09			
NNW	2.335E-07	1.033E-07	6.804E-08	4.785E-08	3.592E-08	1.920E-08
7.650E-09	3.799E-09	2.356E-09	1.644E-09			

HCGS D/Q CORRECTED FOR DEPLETION - HOPE CREEK SOUTH VENT

6	10					
W	2.639E-09	6.731E-10	3.266E-10	1.846E-10	1.205E-10	4.956E-11
2.196E-11	9.977E-12	5.997E-12	4.038E-12			
NNE	1.850E-09	5.345E-10	2.687E-10	1.522E-10	9.960E-11	4.631E-11

TABLE 3.5-26 (Continued) (Page 7 of 7)

	3.460E-11	1.474E-11	7.611E-12	4.886E-12			
NE		2.043E-09	5.866E-10	2.908E-10	1.644E-10	1.073E-10	8.120E-11
	3.693E-11	1.570E-11	8.087E-12	4.947E-12			
ENE		1.223E-09	3.568E-10	1.799E-10	1.019E-10	6.668E-11	4.674E-11
	2.052E-11	8.730E-12	4.536E-12	2.796E-12			
E		7.618E-10	2.285E-10	1.173E-10	6.664E-11	4.909E-11	4.046E-11
	1.970E-11	8.440E-12	3.330E-12	2.108E-12			
ESE		6.315E-10	1.563E-10	7.583E-11	4.284E-11	2.797E-11	2.039E-11
	9.638E-12	4.817E-12	2.612E-12	1.654E-12			
SE		3.906E-09	8.508E-10	3.900E-10	2.192E-10	1.426E-10	1.043E-10
	3.627E-11	1.480E-11	8.324E-12	5.083E-12			
SSE		3.597E-09	8.975E-10	4.307E-10	2.431E-10	1.587E-10	1.126E-10
	3.962E-11	1.617E-11	8.771E-12	5.553E-12			
S		2.773E-09	7.337E-10	3.640E-10	2.062E-10	1.349E-10	5.585E-11
	5.080E-11	1.578E-11	8.560E-12	5.421E-12			
SSW		2.435E-09	5.754E-10	2.765E-10	1.563E-10	1.021E-10	5.536E-11
	4.601E-11	1.971E-11	7.463E-12	4.728E-12			
SW		2.546E-09	6.353E-10	3.090E-10	1.749E-10	1.144E-10	5.770E-11
	3.680E-11	1.514E-11	8.218E-12	5.225E-12			
WSW		2.630E-09	6.646E-10	3.216E-10	1.818E-10	1.187E-10	5.632E-11
	4.021E-11	1.715E-11	8.658E-12	4.442E-12			
W		4.993E-09	1.167E-09	5.458E-10	3.074E-10	2.002E-10	1.344E-10
	5.892E-11	2.509E-11	1.304E-11	6.598E-12			
WNW		6.687E-09	1.456E-09	6.690E-10	3.763E-10	2.449E-10	1.023E-10
	5.089E-11	2.087E-11	1.136E-11	7.213E-12			
NW		9.216E-09	1.928E-09	8.724E-10	4.901E-10	3.186E-10	1.304E-10
	3.936E-11	1.665E-11	9.763E-12	6.869E-12			
NNW		4.274E-09	1.008E-09	4.748E-10	2.679E-10	1.747E-10	7.170E-11
	2.183E-11	9.369E-12	5.595E-12	4.007E-12			
	1 DAIRY FARM #1	13	4.9	4.433E-08	4.433E-08	4.060E-08	1.731E-10
	1 DAIRY FARM #2	13	4.9	4.433E-08	4.433E-08	4.060E-08	1.731E-11
	1 VEG PLOT #1	15	3.5	8.234E-08	8.234E-08	7.419E-08	4.901E-10
	1 MEAT COW #1	13	4.0	5.581E-08	5.581E-08	5.119E-08	2.447E-10
	1 MEAT COW #1	14	4.0	5.655E-08	5.655E-08	5.108E-08	2.995E-10

TABLE 3.5-27

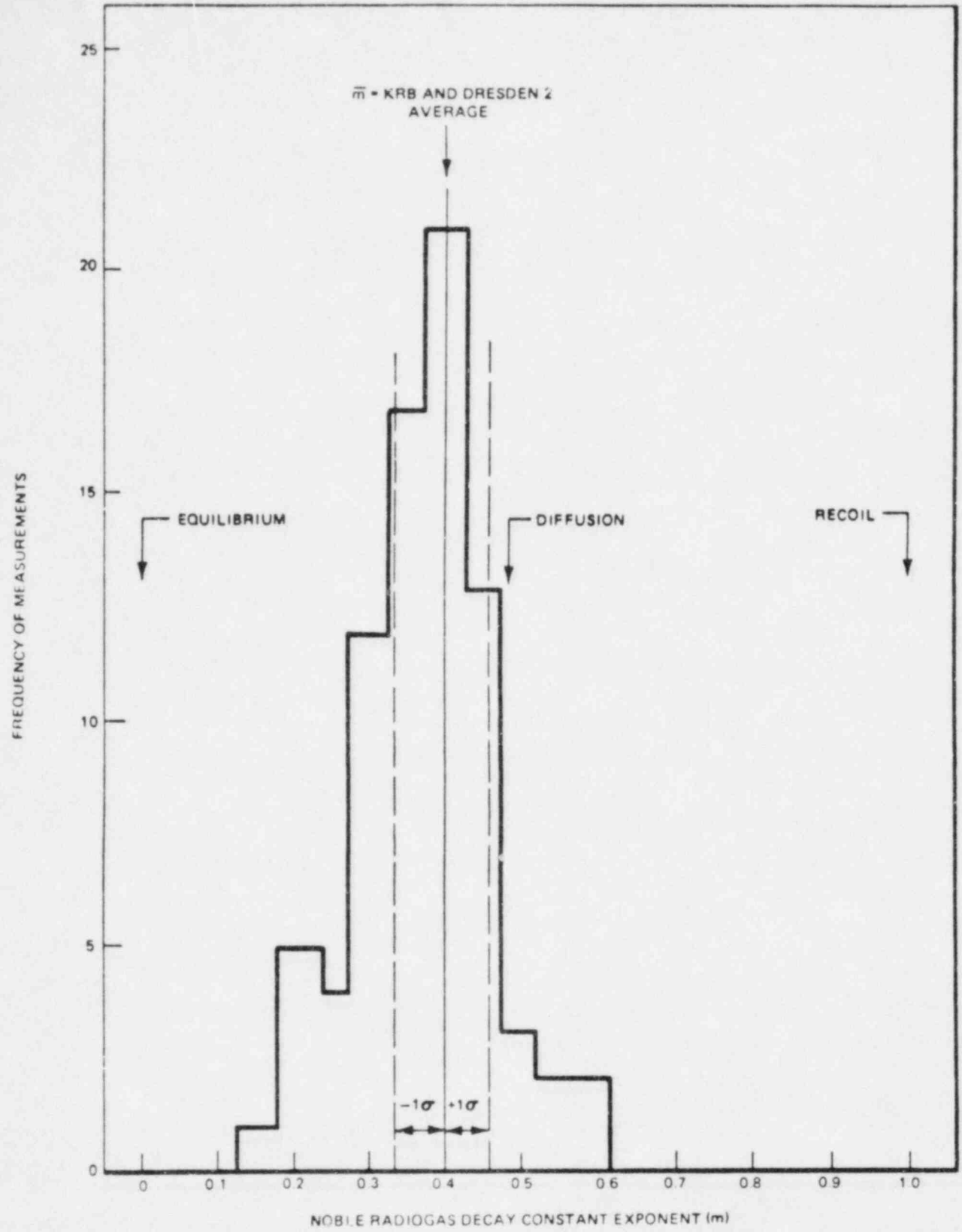
RELEASE POINT DATA

	North Plant Vent	South Plant Vent
Height of release point above grade, m (ft)	35 (115)	35 (115)
Rate of air flow from release point, m^3/min (cfm)	Summer: 4,190 (148,000) Winter: 1,670 (59,000)	Summer: 12,100 (429,000) Winter: 8,690 (307,000)
Heat flow from release point, Kcal/h (Btu/h)	Summer: $4.5X10^5$ ($1.8X10^6$) Winter: $1.4X10^6$ ($5.7X10^6$)	Summer: $1.5X10^6$ ($5.8X10^6$) Winter: $8.1X10^6$ ($3.2X10^7$)
Type and size of release point, m (ft)	Duct Liner 2.4 X 2.4 (8 X 8)	Duct Liner 3.7 X 3.7 (12 X 12)

TABLE 3.5-28

DECONTAMINATION FACTORS ASSUMED AND THE BASES
(Includes Charcoal Adsorbers, HEPA Filters,
and Mechanical Devices)

Parameter	Value
Reactor Building	
Iodine Release Fraction (no charcoal adsorber)	1.0
Particulate Release Fraction (HEPA)	0.01
Auxiliary Building	
Iodine Release Fraction (no charcoal adsorber)	1.0
Particulate Release Fraction (HEPA)	0.01
Turbine Building	
Iodine Release Fraction (no charcoal adsorber)	1.0
Particulate Release Fraction (no HEPA)	1.0
Radwaste Area	
Iodine Release Fraction (no charcoal adsorber)	0.3
Particulate Release Fraction (HEPA)	0.01
Mechanical Vacuum Pump (through the Turbine Building Ventilation System)	
Iodine Release Fraction (no charcoal adsorber)	1.0
Particulate Release Fraction (no HEPA)	1.0

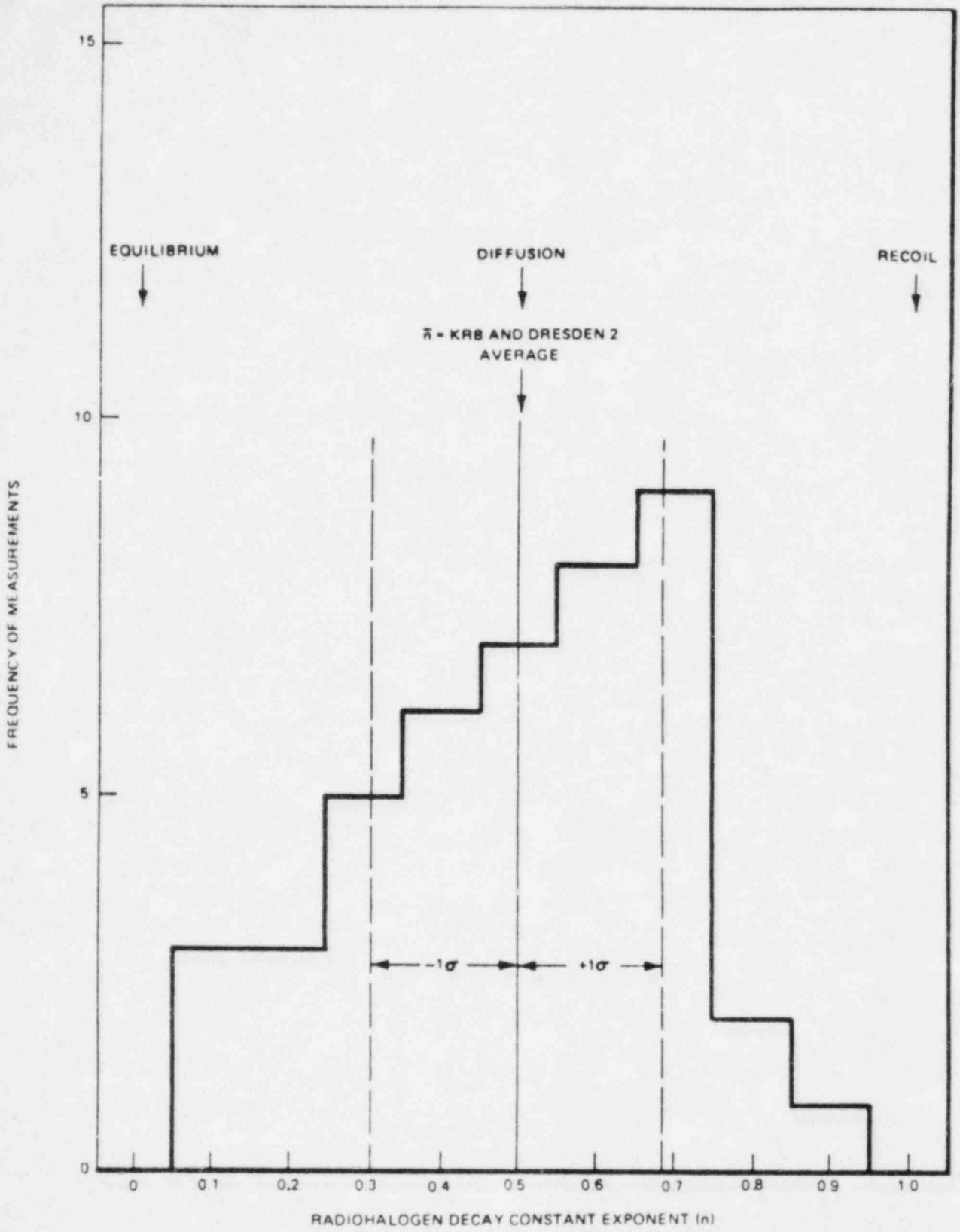


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

NOBLE RADIOGAS DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM

FIGURE 3.5 - 1

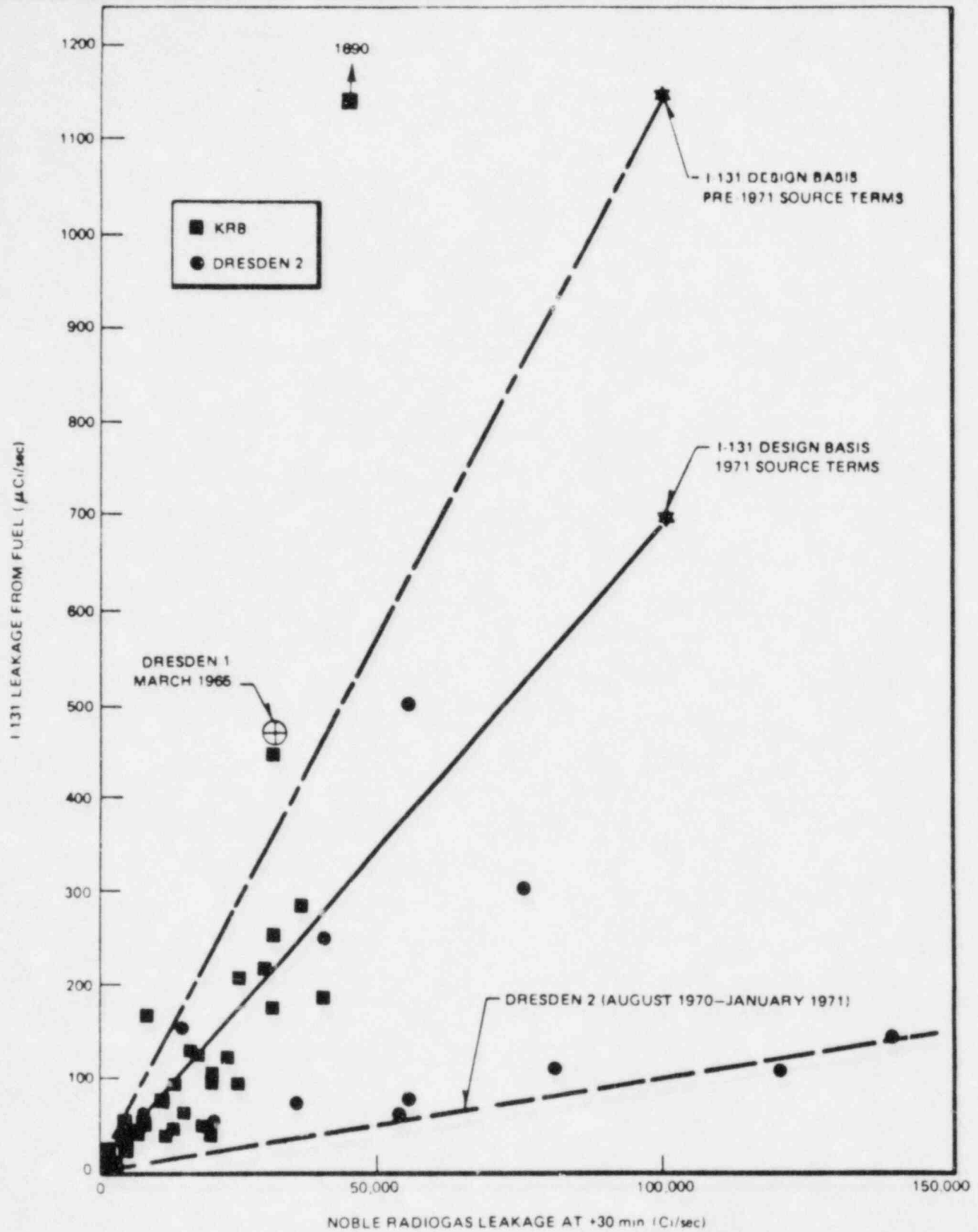


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

RADIOHALOGEN DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM

FIGURE 3.5 - 2

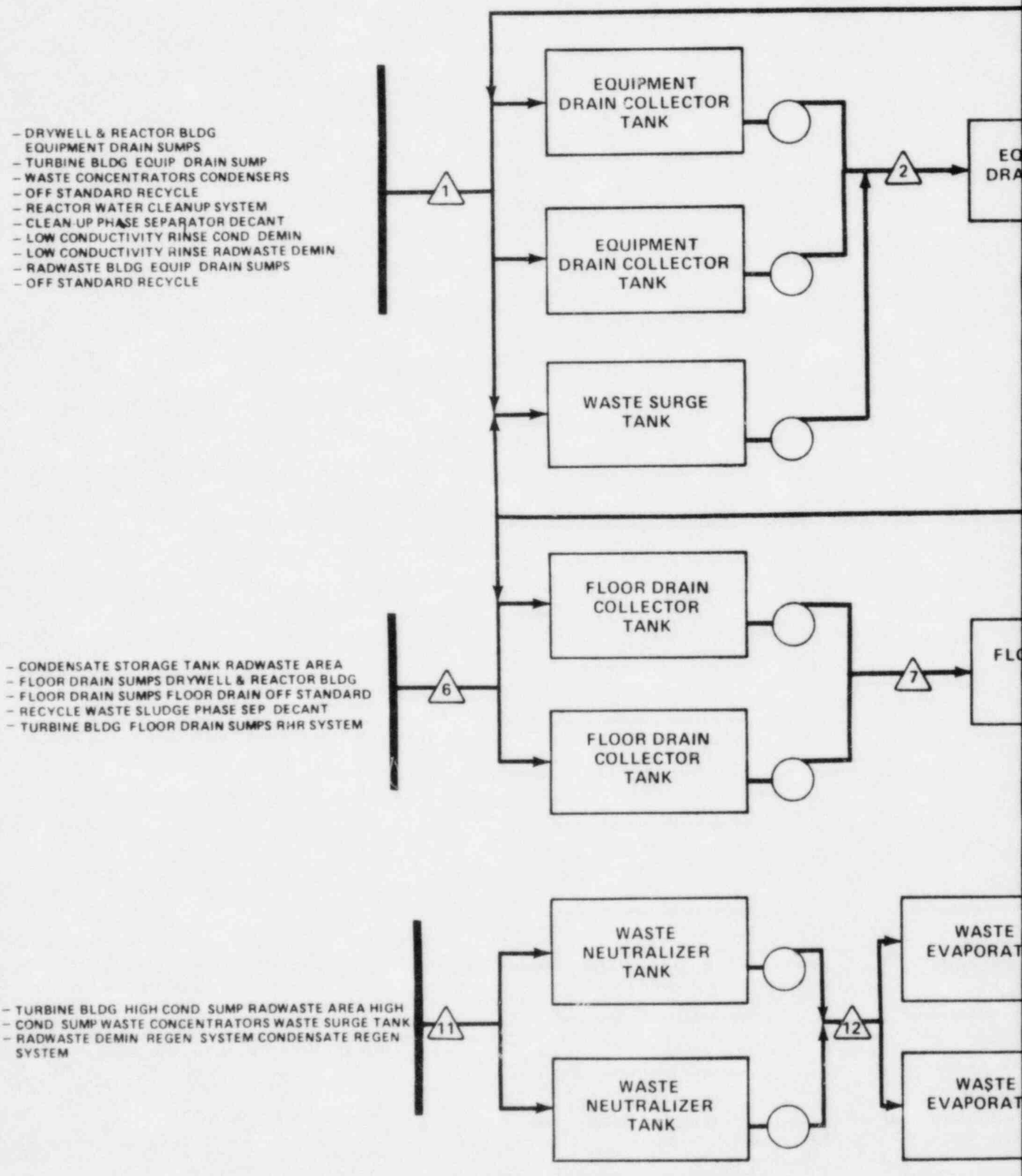


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

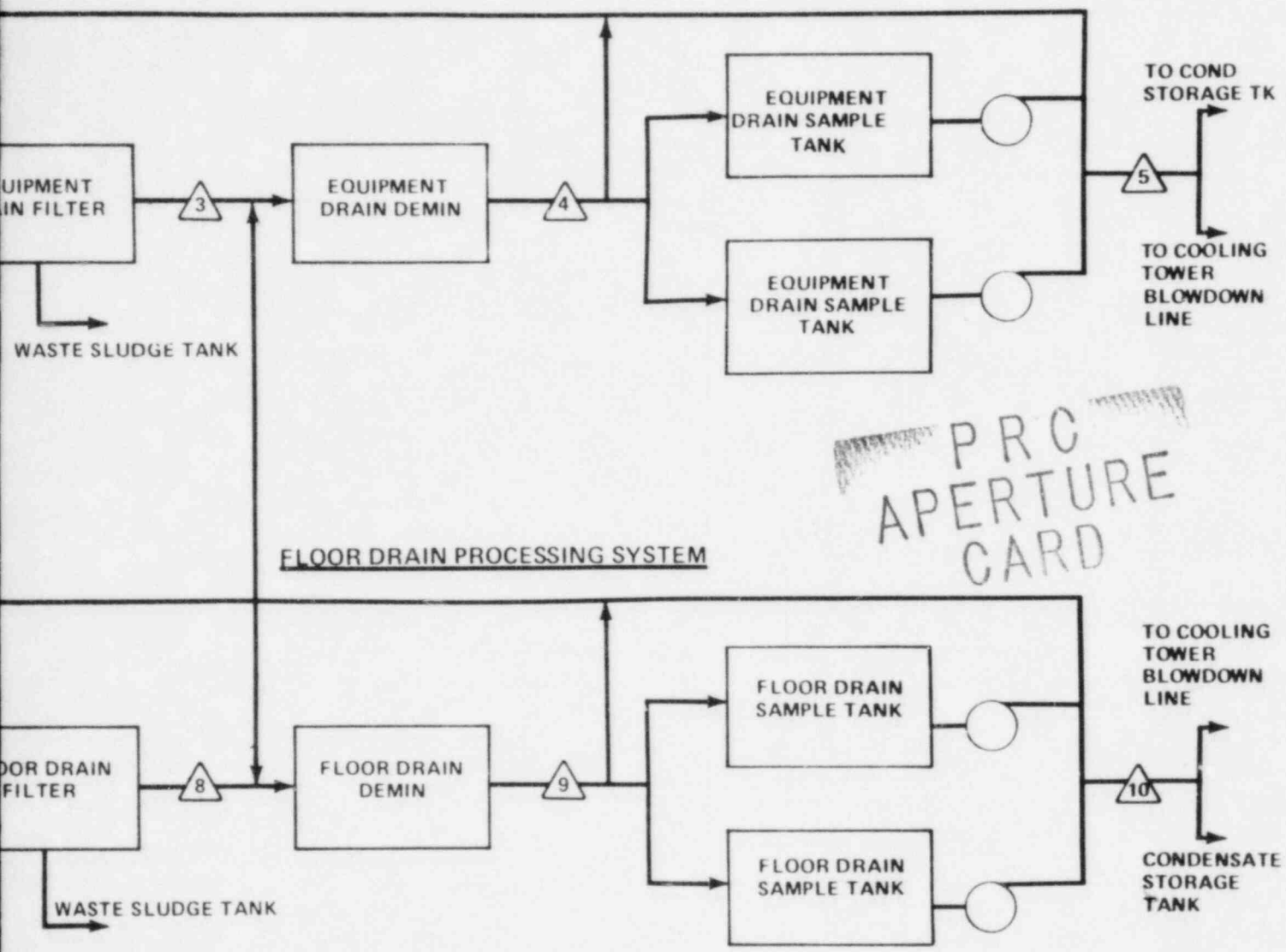
OPERATING LICENSE STAGE

NOBLE RADIOGAS LEAKAGE
VS
I - 131 LEAKAGE

FIGURE 3.5 - 3


– DRYWELL & REACTOR BLDG EQUIPMENT DRAIN SUMPS
– TURBINE BLDG EQUIP DRAIN SUMP
– WASTE CONCENTRATORS CONDENSERS
– OFF STANDARD RECYCLE
– REACTOR WATER CLEANUP SYSTEM
– CLEAN UP PHASE SEPARATOR DECANT
– LOW CONDUCTIVITY RINSE COND DEMIN
– LOW CONDUCTIVITY RINSE RADWASTE DEMIN
– RADWASTE BLDG EQUIP DRAIN SUMPS
– OFF STANDARD RECYCLE
1
EQUIPMENT DRAIN COLLECTOR TANK
EQUIPMENT DRAIN COLLECTOR TANK
WASTE SURGE TANK
2
– CONDENSATE STORAGE TANK RADWASTE AREA
– FLOOR DRAIN SUMPS DRYWELL & REACTOR BLDG
– FLOOR DRAIN SUMPS FLOOR DRAIN OFF STANDARD
– RECYCLE WASTE SLUDGE PHASE SEP DECANT
– TURBINE BLDG FLOOR DRAIN SUMPS RHR SYSTEM
6
FLOOR DRAIN COLLECTOR TANK
FLOOR DRAIN COLLECTOR TANK
7
– TURBINE BLDG HIGH COND SUMP RADWASTE AREA HIGH
– COND SUMP WASTE CONCENTRATORS WASTE SURGE TANK
– RADWASTE DEMIN REGEN SYSTEM CONDENSATE REGEN SYSTEM
11
WASTE NEUTRALIZER TANK
WASTE NEUTRALIZER TANK
12
WASTE EVAPORAT
WASTE EVAPORAT

QUIPMENT DRAIN PROCESSING SYSTEM



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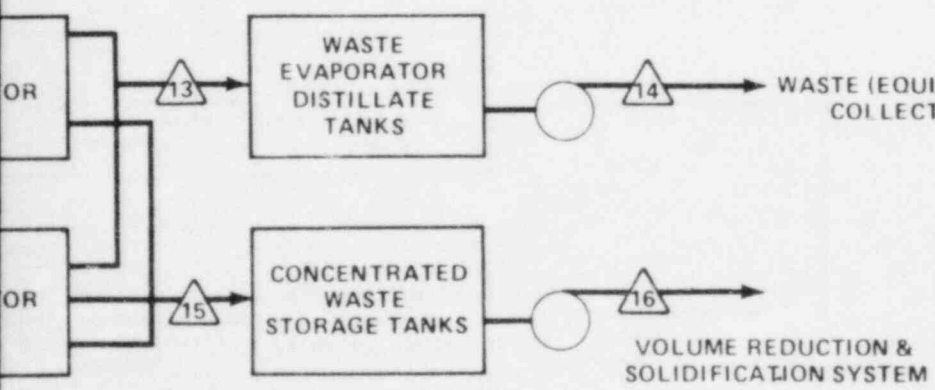
FLOOR DRAIN PROCESSING SYSTEM

REGENERANT WASTE PROCESSING SYSTEM



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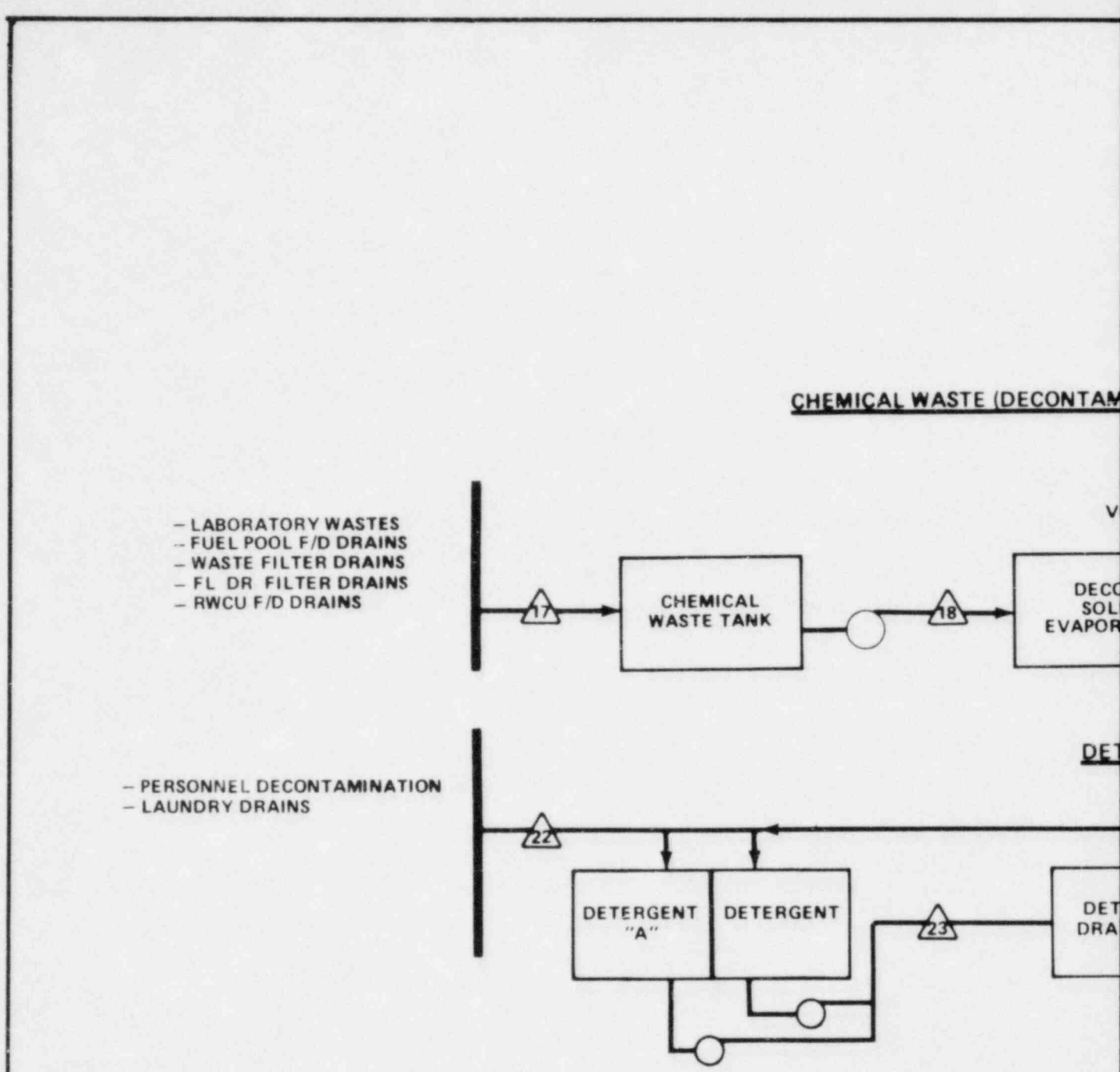
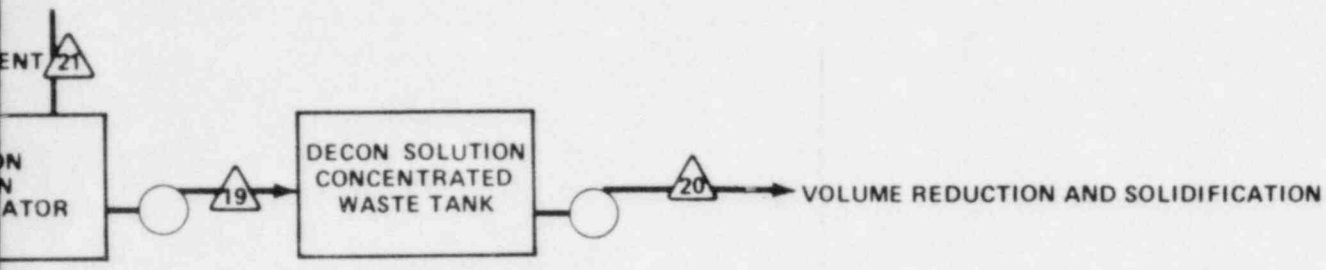
OPERATING LICENSE STAGE

LIQUID WASTE MANAGEMENT PROCESS FLOW DIAGRAM

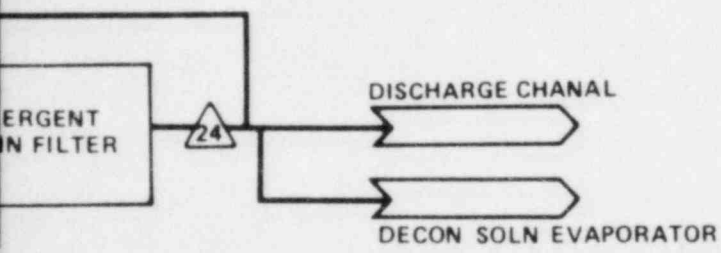
FIGURE 3.5 - 4A


CHEMICAL WASTE (DECONTAM
– LABORATORY WASTES
– FUEL POOL F/D DRAINS
– WASTE FILTER DRAINS
– FL DR FILTER DRAINS
– RWCU F/D DRAINS
17
CHEMICAL WASTE TANK
18
DECO SOL EVAPOR
– PERSONNEL DECONTAMINATION
– LAUNDRY DRAINS
22
DETERGENT "A"
DETERGENT
23
DET DRA

INATION SOLUTION) PROCESSING SYSTEM



TERGENT WASTE PROCESSING SYSTEM



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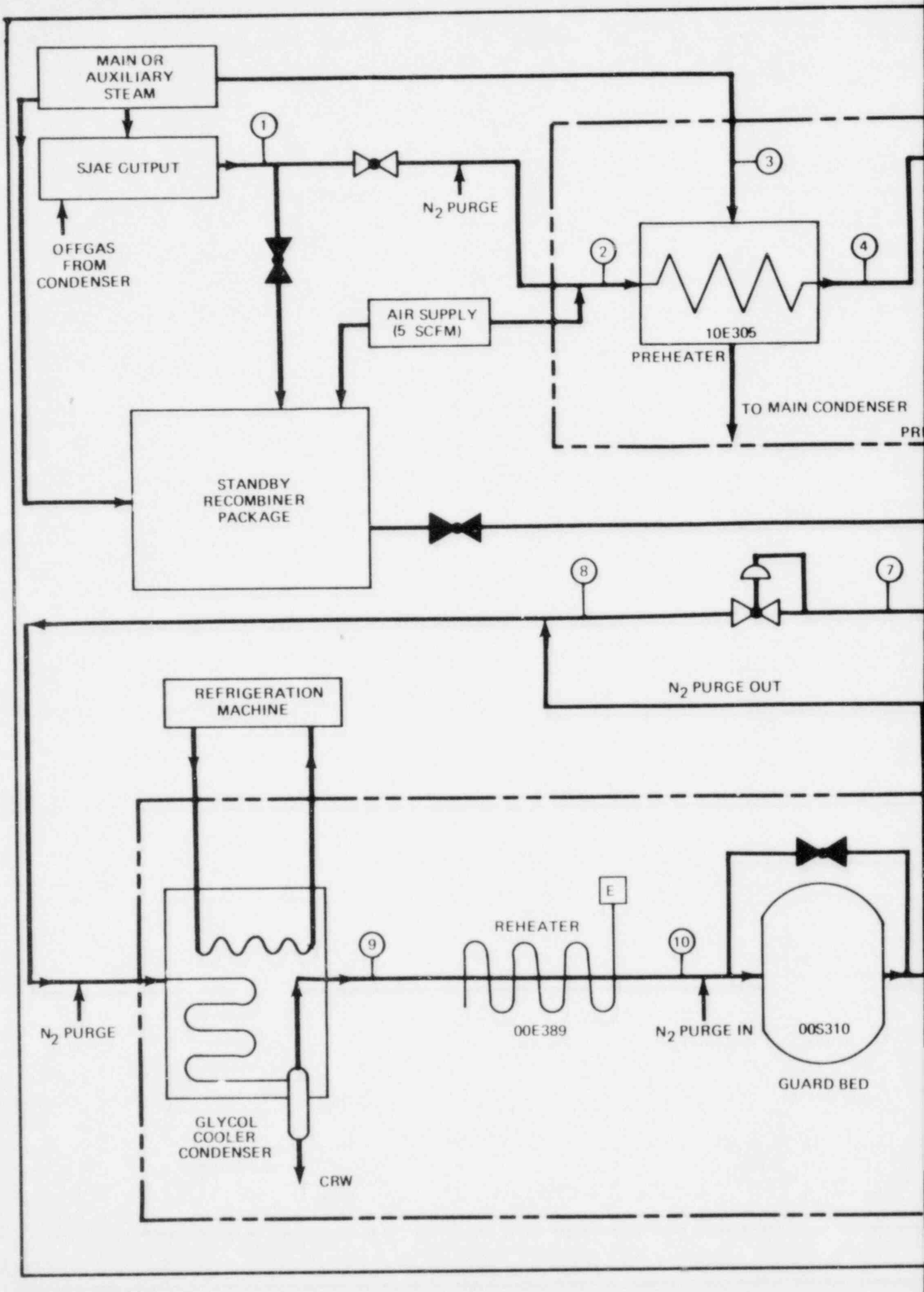
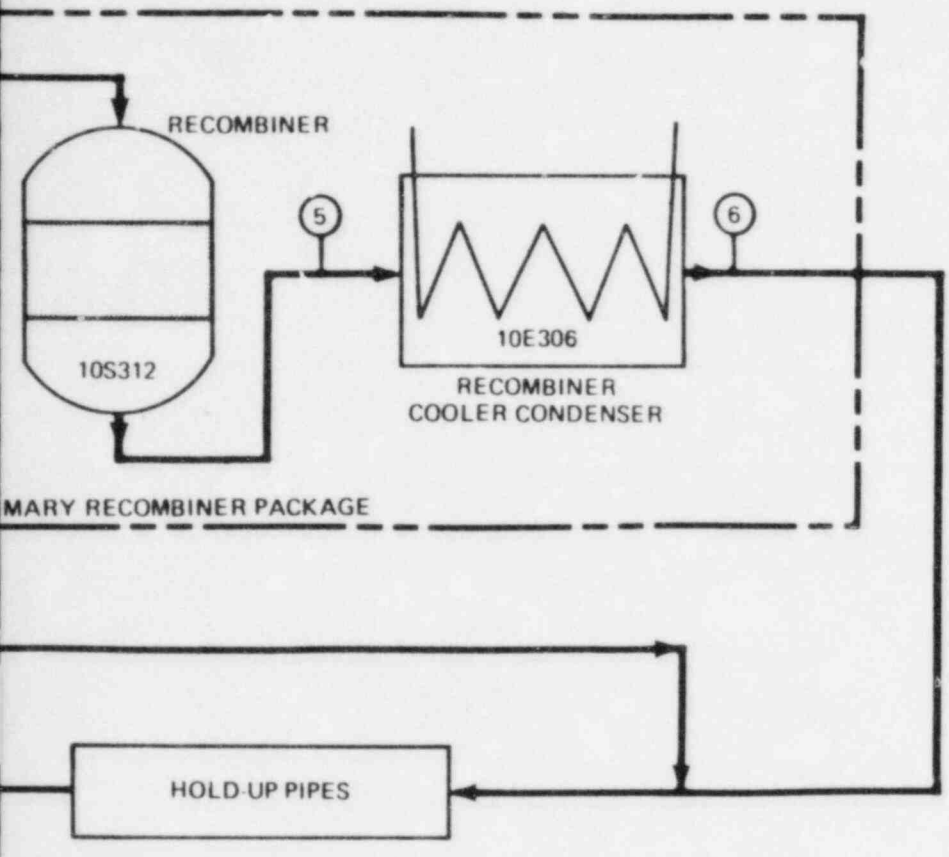
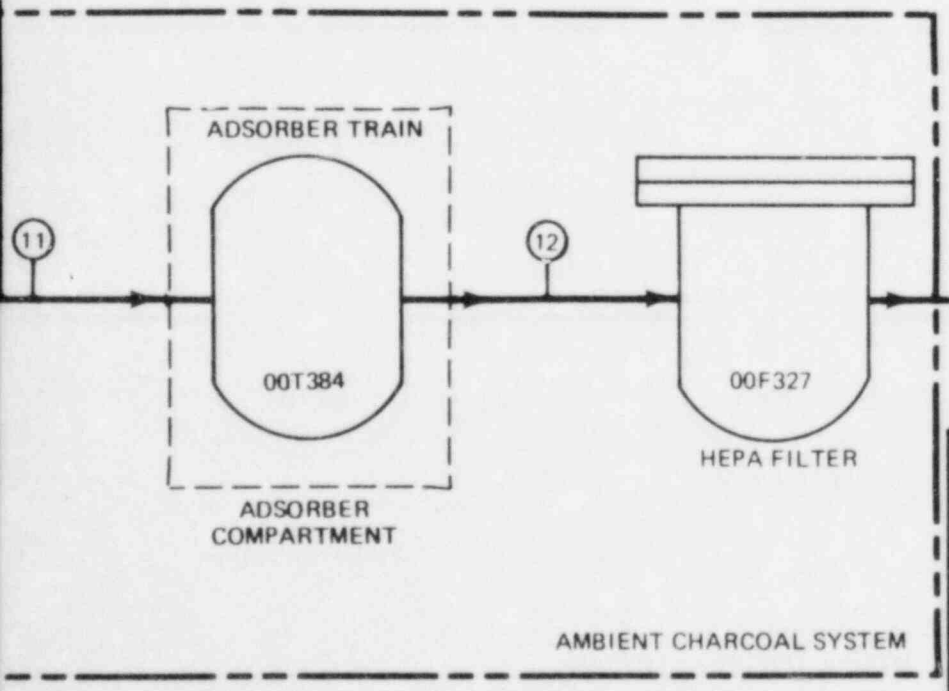
LIQUID WASTE
MANAGEMENT PROCESS
FLOW DIAGRAM

FIGURE 3.5 - 4B


MAIN OR AUXILIARY STEAM
SJAE OUTPUT
OFFGAS FROM CONDENSER
1
N_2 PURGE
3
2
4
AIR SUPPLY (5 SCFM)
10E305
PREHEATER
TO MAIN CONDENSER
STANDBY RECOMBINER PACKAGE
8
7
N_2 PURGE OUT
REFRIGERATION MACHINE
E
REHEATER
9
10
N_2 PURGE
00E389
N_2 PURGE IN
00S310
GUARD BED
GLYCOL COOLER CONDENSER
CRW





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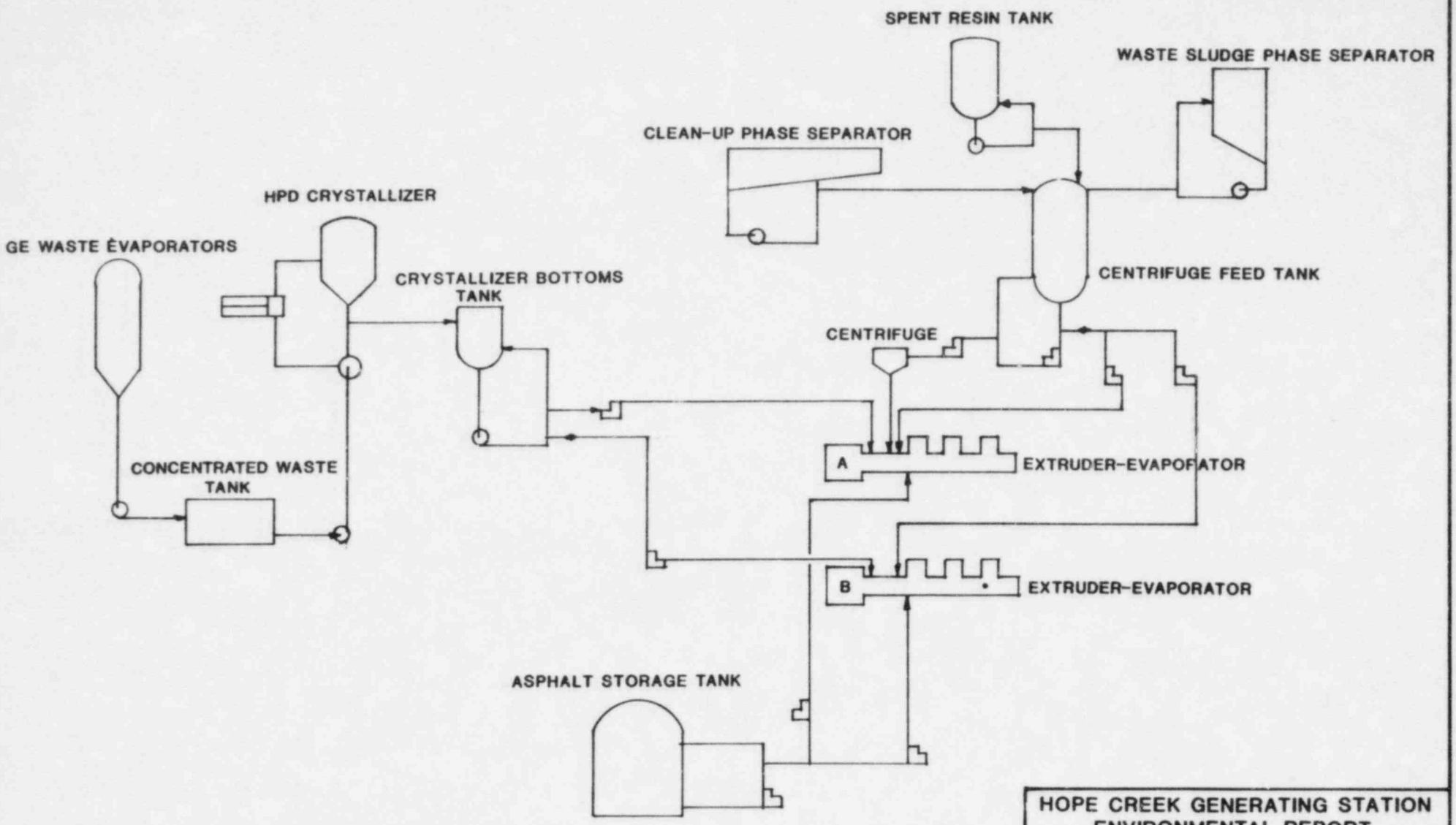
OFFGAS SYSTEM -
PROCESS FLOW DIAGRAM

FIGURE 3.5 - 5

8306290435 - 46



HOPE CREEK GENERATING STATION
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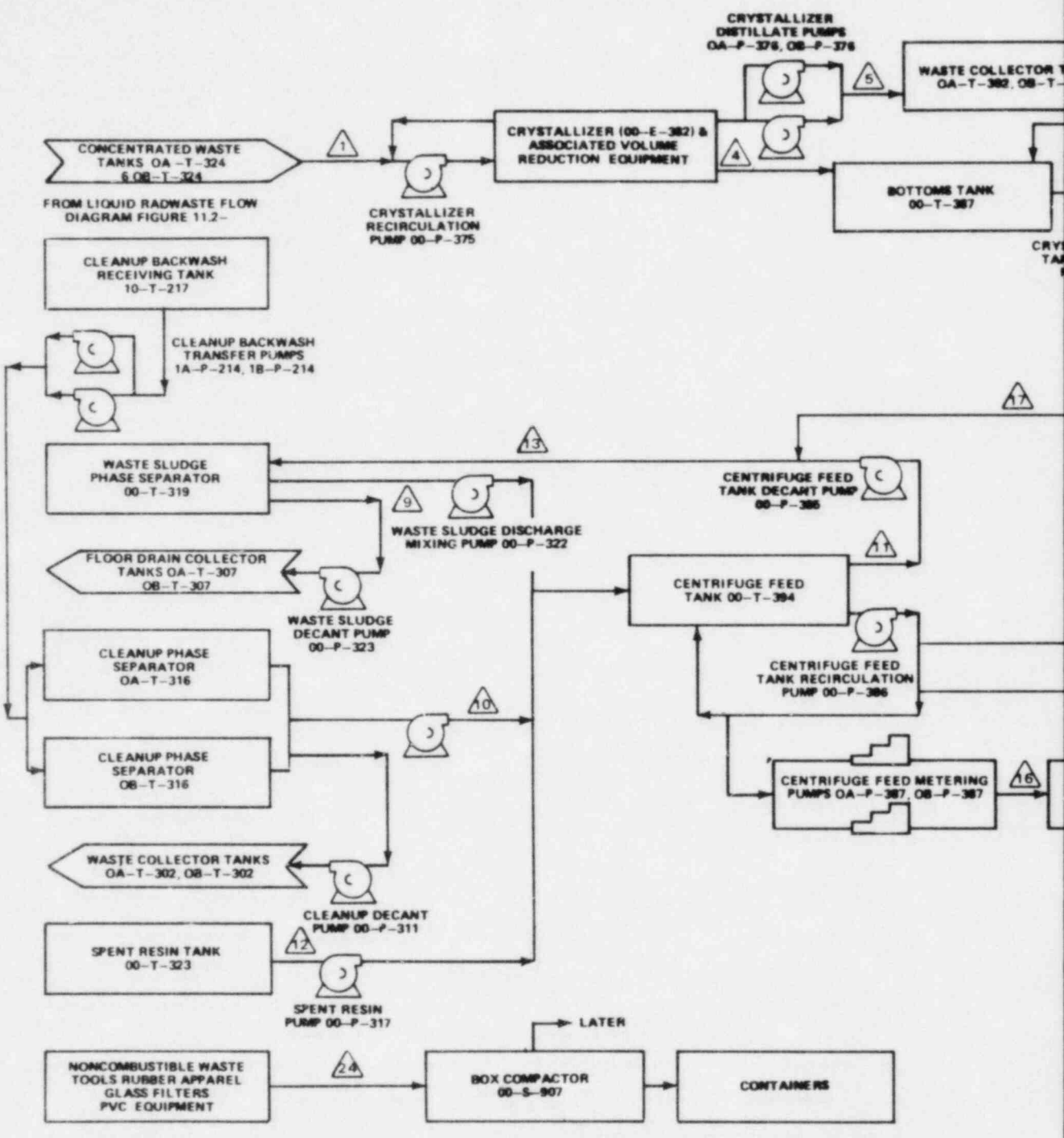
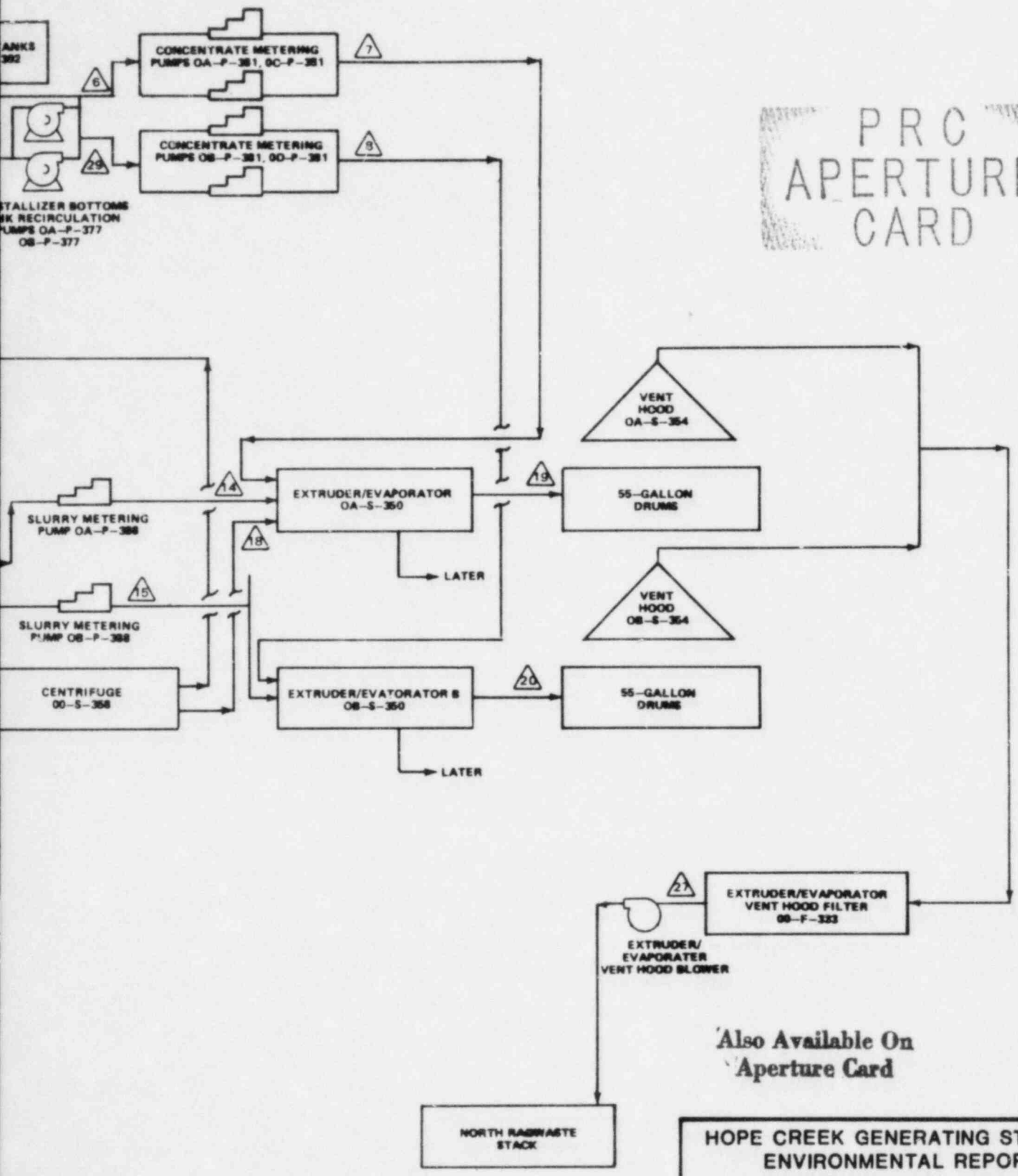
RADWASTE VOLUME REDUCTION AND SOLIDIFICATION SYSTEM

PROCESS FLOW DIAGRAM

FIGURE 3.5 - 6


CRYSTALLIZER DISTILLATE PUMPS OA-P-376, OB-P-376
WASTE COLLECTOR T
OA-T-302, OB-T-
CONCENTRATED WASTE TANKS OA-T-324 & OB-T-324
FROM LIQUID RADWASTE FLOW DIAGRAM FIGURE 11.2-
CRYSTALLIZER (00-E-382) & ASSOCIATED VOLUME REDUCTION EQUIPMENT
BOTTOMS TANK 00-T-387
CRYSTALLIZER RECIRCULATION PUMP 00-P-375
CRY
TA
CLEANUP BACKWASH RECEIVING TANK 10-T-217
CLEANUP BACKWASH TRANSFER PUMPS 1A-P-214, 1B-P-214
WASTE SLUDGE PHASE SEPARATOR 00-T-319
CENTRIFUGE FEED TANK DECANT PUMP 00-P-386
WASTE SLUDGE DISCHARGE MIXING PUMP 00-P-322
FLOOR DRAIN COLLECTOR TANKS OA-T-307 OB-T-307
WASTE SLUDGE DECANT PUMP 00-P-323
CENTRIFUGE FEED TANK 00-T-394
CLEANUP PHASE SEPARATOR OA-T-316
CENTRIFUGE FEED TANK RECIRCULATION PUMP 00-P-386
CLEANUP PHASE SEPARATOR OB-T-316
CENTRIFUGE FEED METERING PUMPS OA-P-387, OB-P-387
WASTE COLLECTOR TANKS OA-T-302, OB-T-302
CLEANUP DECANT PUMP 00-P-311
SPENT RESIN TANK 00-T-323
SPENT RESIN PUMP 00-P-317
LATER
NONCOMBUSTIBLE WASTE TOOLS RUBBER APPAREL GLASS FILTERS PVC EQUIPMENT
BOX COMPACTOR 00-S-907
CONTAINERS



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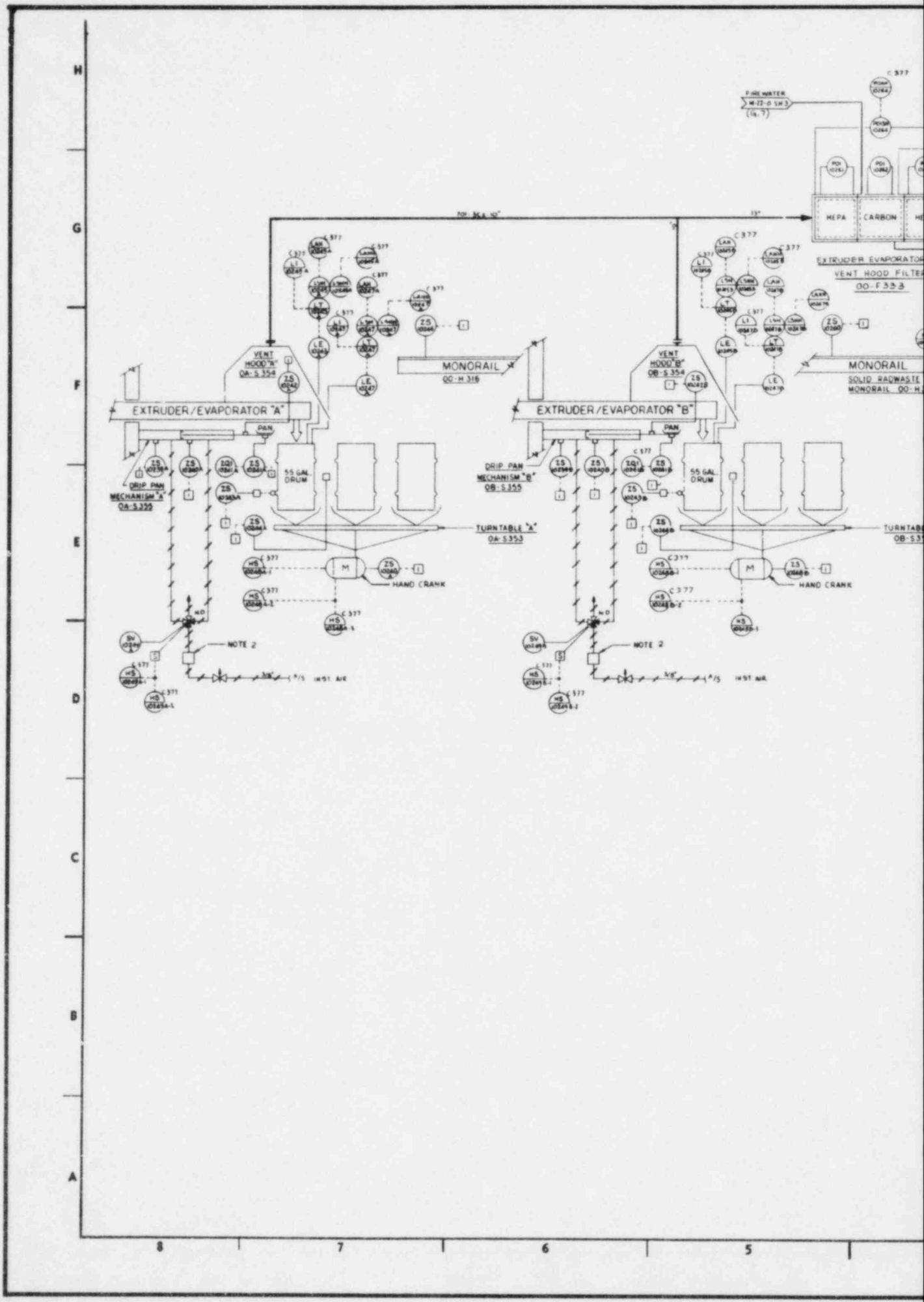
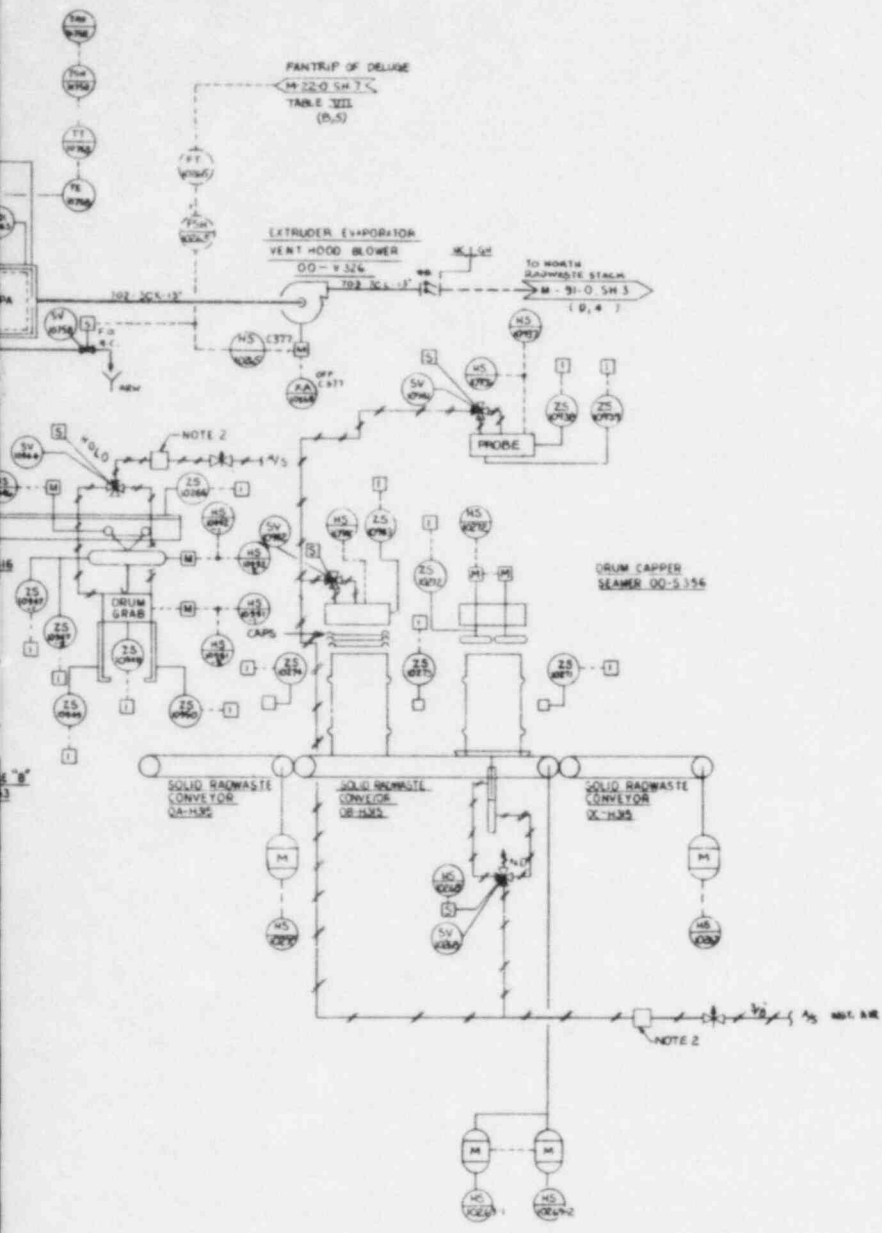
SOLID WASTE MANAGEMENT SYSTEM
PROCESS FLOW DIAGRAM

FIGURE 3.5 - 7


FIRE WATER
HEPA
CARBON
EXTRUDER EVAPORATOR
VENT HOOD FILTER
00-F333
MONORAIL
00-H 316
VENT HOOD "A"
OA-S 354
VENT HOOD "B"
OB-S 354
EXTRUDER/EVAPORATOR "A"
EXTRUDER/EVAPORATOR "B"
PAN
DRIP PAN MECHANISM "A"
OA-S 355
DRIP PAN MECHANISM "B"
OB-S 355
55 GAL DRUM
TURNTABLE "A"
OA-S 353
HAND CRANK
NOTE 2
INST AIR
8
7
6
5
H
G
F
E
D
C
B
A



NOTES:

1. THIS P&ID CONTAINS SYSTEMS OR PORTIONS OF SYSTEMS
   HC - SOLID RADWASTE
   GR - AIR BLDG RADWASTE AREA SUPPLY AND EXHAUST HVAC SYSTEM
2. FILTER REGULATOR/LUBRICATOR
3. ALL VALVES AND INSTRUMENTATION ON THIS SHEET ARE FURNISHED BY THE VENDOR UNLESS DESIGNATED BY A B, THEN BECHTEL SUPPLIED.

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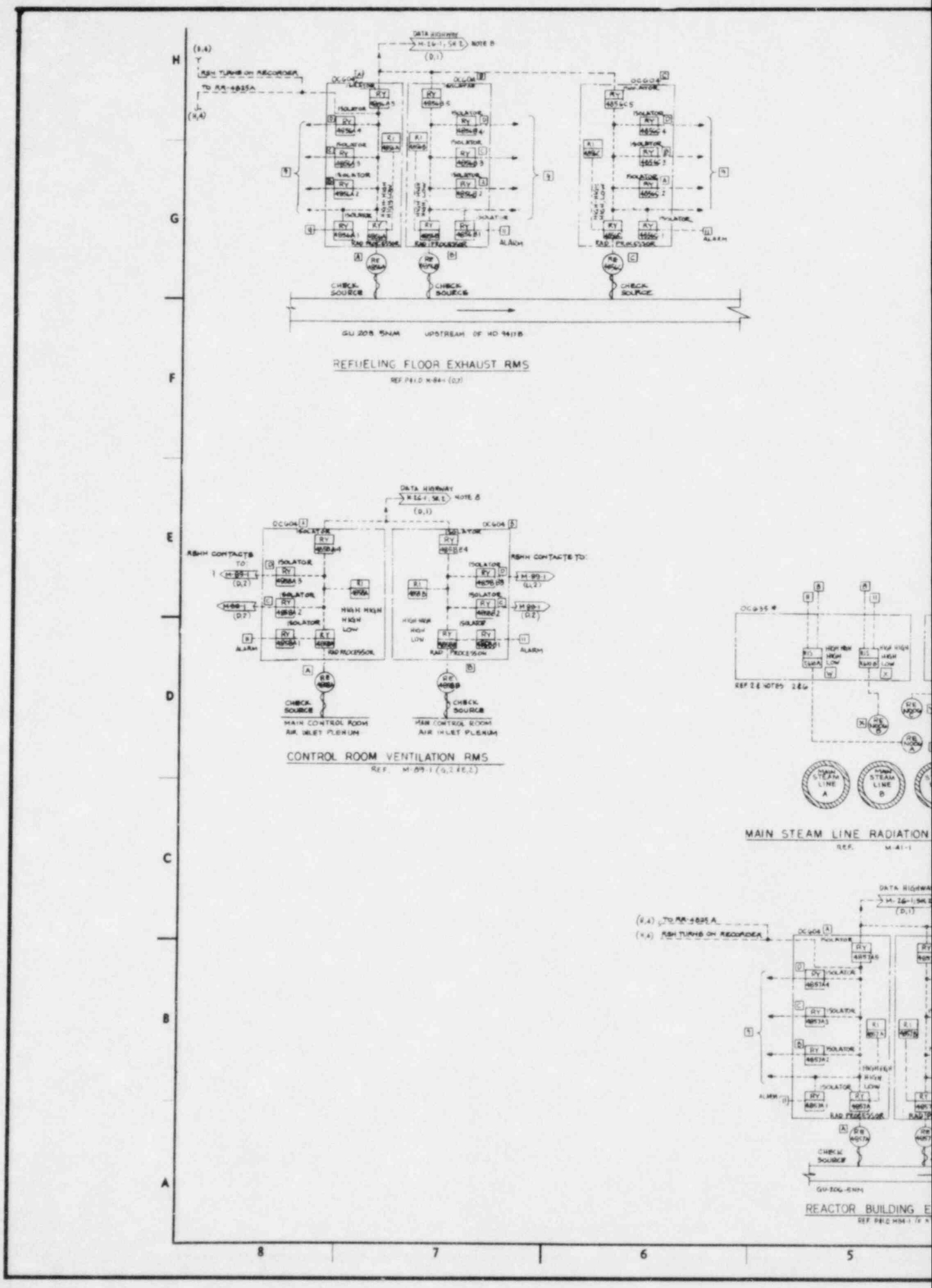
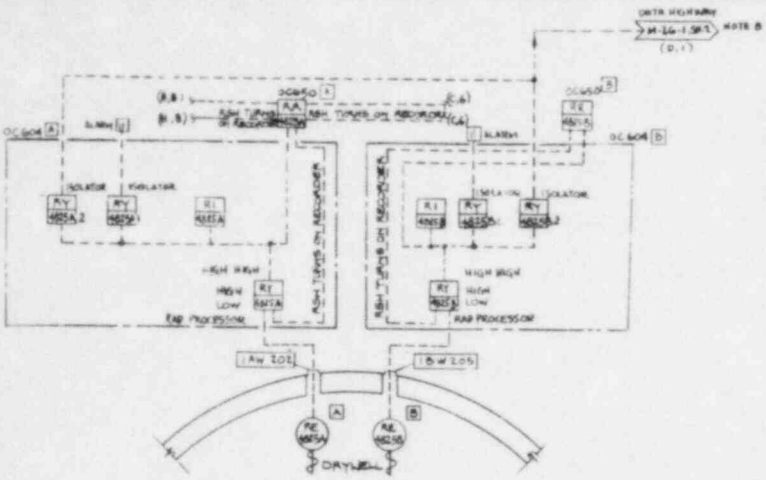
P&ID
SOLID RADWASTE PACKAGING

FIGURE 3.5 - 8

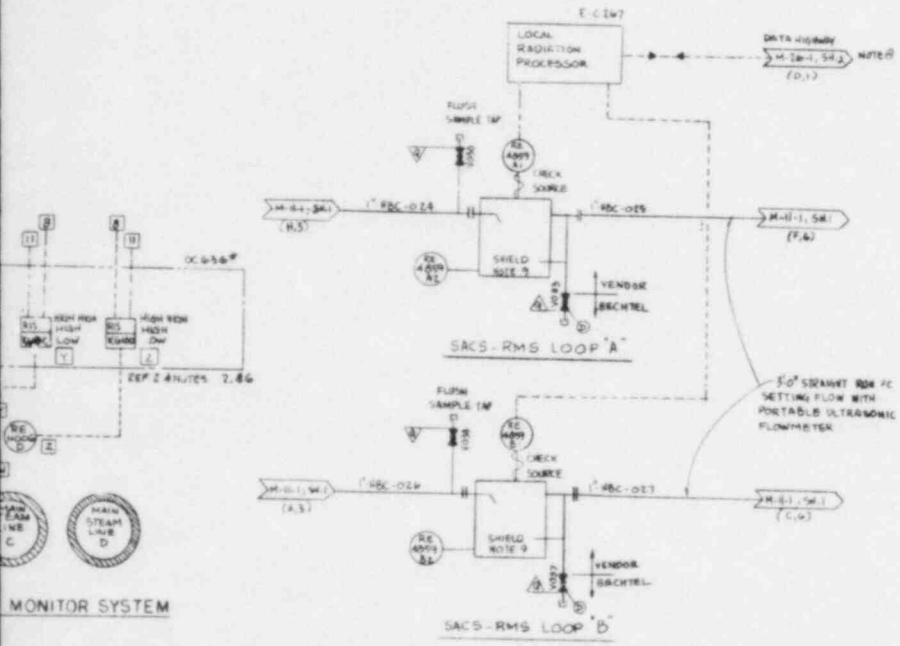
8306290435 -48



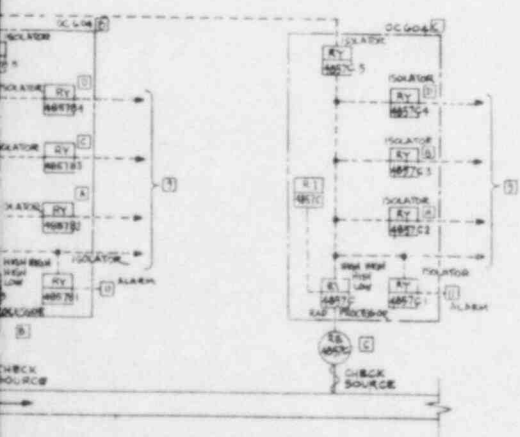
REFUELING FLOOR EXHAUST RMS
CONTROL ROOM VENTILATION RMS
MAIN STEAM LINE RADIATION
REACTOR BUILDING E
DATA HIGHWAY
RSH TURNS ON RECORDER
TO RR-4825A
CHECK SOURCE
ALARM
RAD PROCESSOR
ISOLATOR
HIGH HIGH
HIGH
LOW
RSHH CONTACTS TO:
MAIN CONTROL ROOM AIR INLET PLENUM
MAIN STEAM LINE A
MAIN STEAM LINE B



DRYWELL ATMOSPHERE
POST ACCIDENT (LOCA) RMS



MONITOR SYSTEM



KHAUST RMS

NOTES:

1. THIS FIG ALSO CONTAINS PORTIONS OF THE FOLLOWING SYSTEMS:
   - RI-SAFETY & TURBINE AUXILIARIES COOLING
   - RT-ELECTRO HYDRAULIC CONTROL
   - RX-RADWASTE
   - RD-AREA RADIATION MONITORING
2. THE DETECTORS (RE04) SHALL BE LOCATED WITHIN THE STEAM LINE TUNNEL AS CLOSE AS PRACTICAL TO THE PRIMARY CONTAINMENT. THE DETECTORS ARE ARRANGED SO THAT EACH DETECTOR VIEWS ALL STEAM LINES WITH APPROXIMATELY THE SAME RESPONSE. THE DETECTOR ASSEMBLY IS FASTENED TO A JIG AND IN-SERTED INTO SEALED PIPE WELLS FROM OUTSIDE THE STEAM TUNNEL. CABLES ARE TO BE ROUTED TO MINIMIZE HEAT EXPOSURE. CABLE LENGTHS ARE SUFFICIENT FOR REMOVING THE DETECTOR AND PLACING THEM INTO A PORTABLE CALIBRATION ASSEMBLY.
3. DELETED.
4. DELETED.
5. OTHER RMS ARE LOCATED AS FOLLOWS:

FAID	SYSTEM NAME
M-09-0 SH 2 (B,7)	TURBINE BLDG CIRCULATING WATER RMS. RE 4857
M-15-0 SH 2 (F,1)	COOLING TOWER BLOWDOWN RMS RE 4817
M-25-1 SH 1 (C,2)	DRYWELL LEAK DETECTION RMS.
M-43-0 SH 1 (C,2)	LIQUID RADWASTE RMS RE 4861
M-44-0 (B,5)	HEATING STEAM CONDENSATE (WASTE) RMS RE3428
M-45-0 SH 2 (C,3)	HEATING STEAM CONDENSATE (DRYDN) RMS RE3534
M-48-0 SH 1 (F,2)	RADWASTE DRUM RADIATION MONITOR, RE10705
M-70-0 SH 2 (C,5)	GASEOUS RADWASTE AMBIENT CHARCOAL TREATMENT SYSTEM, D-RE4281 AND D-RE4282.

6. THE QE MASTER PARTS LIST IS DII FOR THE MAIN STEAM LINE RMS.
7. DELETED.
8. THE REDUNDANT COMMUNICATIONS LOOP INCLUDES ALL LOCAL RADIATION PROCESSORS, TYPICAL ISOLATION DEVICES, TYPICAL RADIATION PROCESSOR CHANNEL (In This case) Class 1E
9. ONLY THE PRESSURE BOUNDARY OF THE SACS RMS IS QUALIFIED SEISMICALLY (QA).

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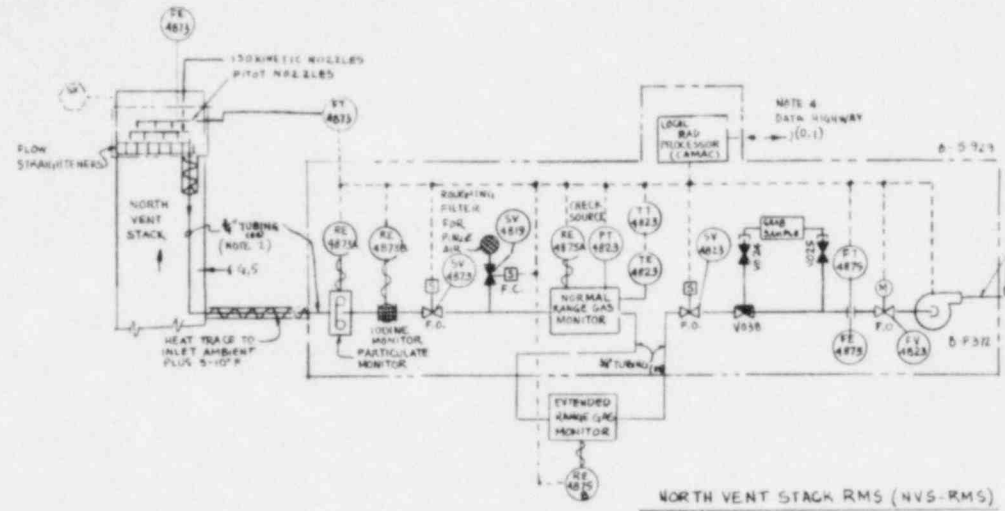
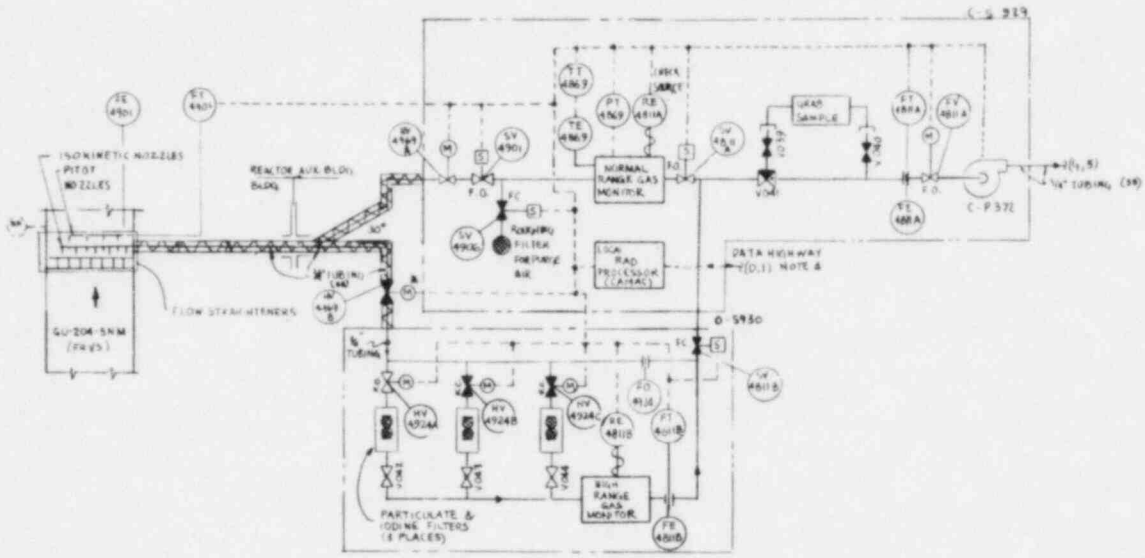
RADIOLOGICAL
MONITORING
SYSTEMS (RMS)

FIGURE 3.5 - 9A



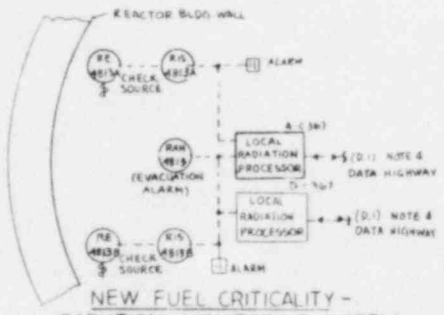
NORTH VENT STACK RMS (NVS-RMS)

P&ID M-91-0, SH. 3 & M-92-0, SH. 2



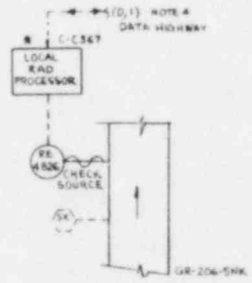
FILTRATION RECIRCULATION & VENT SYSTEM - RMS (FRVS - RMS)

REF. P & ID M-84-1 (A, 3)



NEW FUEL CRITICALITY - RADIATION MONITORING SYSTEM

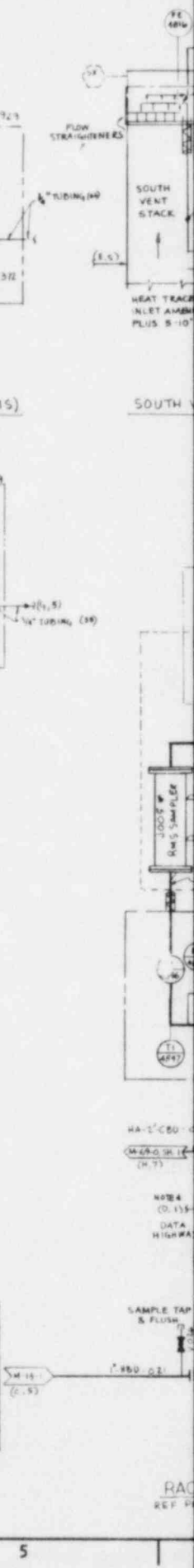
(ADJACENT TO NEW FUEL STORAGE VAULT)



REACTOR BLDG. VENT SYS. EXHAUST DUCT MOUNTED RMS SCHEDULE

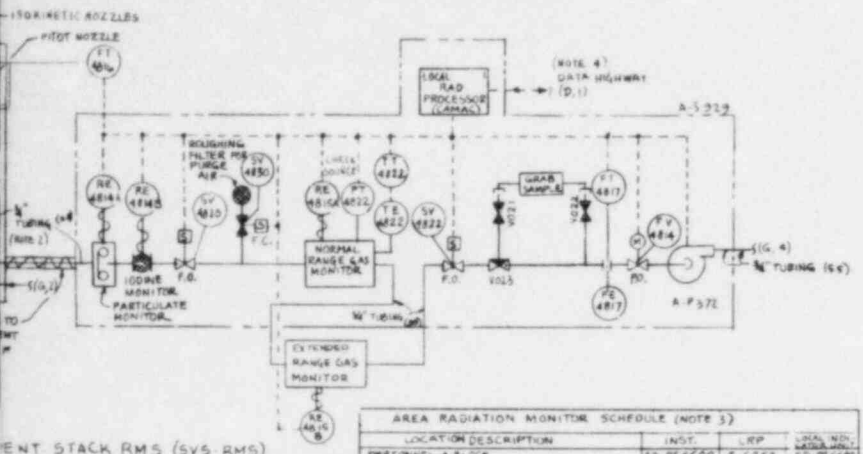
(TYPICAL OF 7)

SYSTEM DESCRIPTION	DETECTOR	LRP	DUCT	REF. 10855-
REACT. BLDG. VENT. SYSTEM EXHAUST	RE4826	1C-C367	GR-206-5NK	M-84-1 (F, 4)
TURBINE BLDG. EXHAUST	RE4827	1A-C167	GE-102-5NK	M-82-1, SH. 1 (F, 8)
RADWASTE EXHAUST SYSTEM	RE4812	0D-C367	GH-550-5NK	M-92-0, SH. 1 (D, 8)
GASEOUS RADWASTE AREA EXHAUST	RE4828	0E-C367	GH-374-5NK	M-91-8, SH. 1 (B, 7)
TURBINE BLDG. COMPARTMENT EXHAUST	RE4456	1C-C167	GE-127-5NK	M-82-1, SH. 1 (G, 3)
RADWASTE AREA EXHAUST	RE4457	0H-C367	GH-353-5NK	M-92-0 (C, 5)
TECHNICAL SUPPORT CENTER INLET	RE4868	0G-C367	INLET PLENUM	M-93-0, SH. 2 (D, 7)



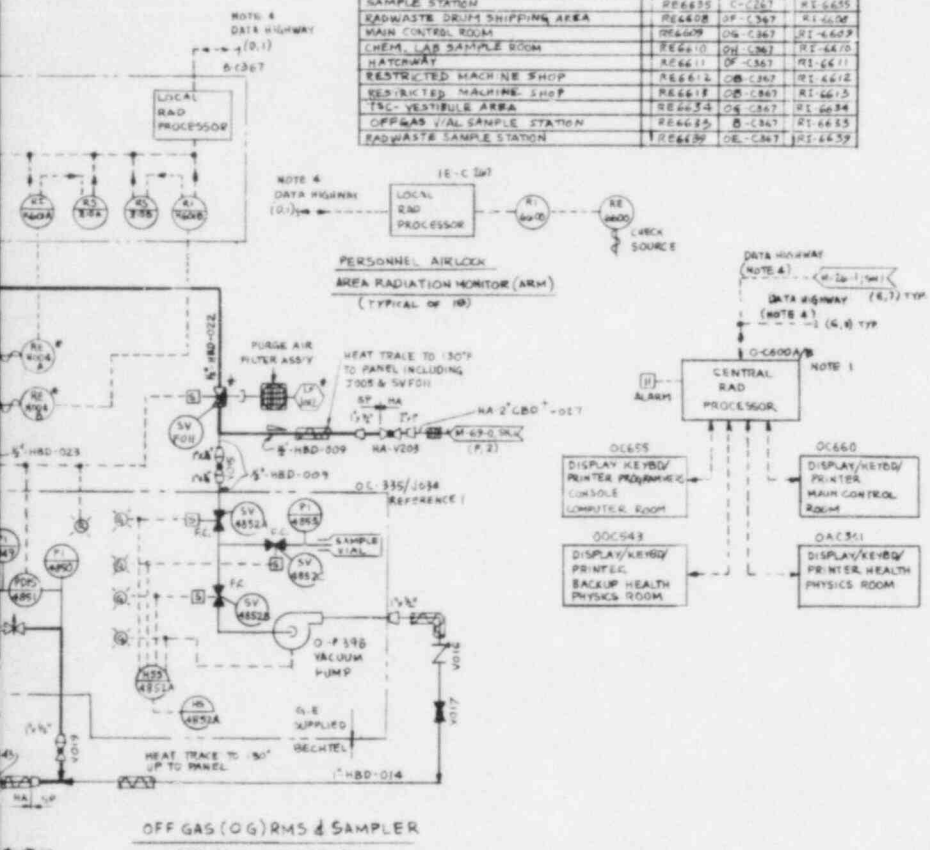
NOTES:

1. FUNCTIONS IN CENTRAL RADIATION PROCESSOR INCLUDE ALL RADIATION INDICATION, ALARM INDICATION, DATA STORAGE AND REQUIRED CONTROL FUNCTION IMPLEMENTATION.
2. THE SVS-RMS AND NVS-RMS SAMPLE LINES ARE LOCATED INSIDE VNE STACKS.
3. AREA RADIATION MONITORS (DETECTORS AND LIU) ARE WALL MOUNTED APPROXIMATELY 4 FEET ABOVE THE FLOOR LEVEL.
4. THE REDUNDANT COMMUNICATIONS LOOP INCLUDES ALL LOCAL RADIATION PROCESSORS AND TWINAX ISOLATION DEVICES THE CENTRAL RADIATION PROCESSING SHOWN ON 10855-M-26-1 SH 1.

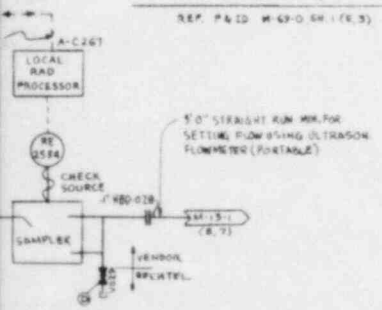


ENT STACK RMS (SVS-RMS)
P&ID M-84-1, (E,3)

AREA RADIATION MONITOR SCHEDULE (NOTE 3)			
LOCATION DESCRIPTION	INST.	LRP	LOCAL IND. (AREA RAD.)
PERSONNEL AIRLOCK	SD-RE6600	E-C267	SD-RI6600
MOTORIZED EQUIP. HATCH	RE6601	F-C267	RI-6601
OPERL EQUIP. HATCH	RE6602	F-C267	RI-6602
SPENT FUEL POOL & DEMIN. EQUIP.	RE6603	F-C267	RI-6603
SAFEGUARD INSTRUMENT ROOM	RE6604	A-C267	RI-6604
EQUIPMENT AIRLOCK	RE6605	C-C267	RI-6605
CLEANUP DEMIN. SYSTEM EQUIP.	RE6606	C-C267	RI-6606
SPENT FUEL POOL	RE6607	D-C267	RI-6607
SAMPLE STATION	RE6635	C-C267	RI-6635
RADWASTE DRUM SHIPPING AREA	RE6608	DF-C347	RI-6608
MAIN CONTROL ROOM	RE6609	DG-C367	RI-6609
CHEM. LAB SAMPLE ROOM	RE6610	DH-C367	RI-6610
HATCHWAY	RE6611	DF-C367	RI-6611
RESTRICTED MACHINE SHOP	RE6612	DB-C367	RI-6612
RESTRICTED MACHINE SHOP	RE6618	DB-C367	RI-6613
TSC- VESTIBULE AREA	RE6634	DG-C367	RI-6634
OFFGAS V/AL SAMPLE STATION	RE6636	B-C367	RI-6635
RADWASTE SAMPLE STATION	RE6639	DE-C347	RI-6639



OFF GAS (OG) RMS & SAMPLER
REF. P&ID M-69-0, SH.1 (E,3)



S RMS
ID M-13-1 (C,5 & 6,1)

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RADIOLOGICAL MONITORING SYSTEMS (RMS)

FIGURE 3.5 - 9B

8306290435 -50

3.6 CHEMICAL AND BIOCIDE WASTES

3.6.1 BIOCIDE SYSTEM

The sodium hypochlorite injection systems are consistent with construction permit stage plans. There are two points of biocide injection to assure adequate residuals: one in the service water system and one in the circulating water system. Although the cold water bypass has been eliminated (see Section 3.3), free available chlorine residuals produced in the cooling tower blowdown do not exceed anticipated values nor New Jersey and DRBC standards. The system selection resulted, in part, from chlorination studies (see Chapter 13). The system is described below.

The plant neither uses nor stores any bulk elemental chlorine. Sodium hypochlorite is used for chlorination of the service and circulating water systems to control organic fouling.

Each injection system consists of two storage tanks; these tanks contain a 13 percent sodium hypochlorite solution, two metering injection pumps, one diffuser manifold, one local control panel, and associated piping valves, alarms and miscellaneous instrumentation. The injection systems control biological growth by injecting a diluted (one percent) solution of sodium hypochlorite through the respective service water and circulating water sodium hypochlorite diffuser manifolds.

A 0 to 60 minute timer, normally set for 30 minute intervals, controls the injection of sodium hypochlorite; injection occurs three times each day. Injection points are located at the service water pump pits downstream of the traveling screens (to avoid chlorinating impinged organisms) and at the circulating water pump pits. Chlorine residual is monitored just prior to the point where service water enters the circulating water system, at the outlet of the main condensers, and in the cooling tower blowdown line (see Figure 3.4-3). The dosage rate is controlled to maintain a chlorine residual of 0.2 milligram per liter as an instantaneous maximum with a 0.2 milligram per liter average in the service and circulating water systems, and 0.5 milligram per liter instantaneous maximum with a 0.2 milligram per liter average in the cooling tower blowdown line.

Chlorination at the above intervals and durations requires approximately 92?,000 liters per year (243,900 gallons per year) of 13 percent sodium hypochlorite solution, or 113,700 kilograms (304,800 pounds) of chlorine as Cl_2 (see Table 3.6-1).

3.6.2 SCALE CONTROL SYSTEM

As planned at the construction permit stage, calcium carbonate scale is controlled by adding sulfuric acid to the circulating water system. Concentrated sulfuric acid is stored as a 93 percent solution (66° Baume'), and is diluted with service water to a one percent solution prior to injection at the circulating water pump pits (see Figure 3.4-3). Circulating water pH is maintained at the pH of saturation (pHs) in order to attain stability according to the Langelier Index. The quantity of sulfuric acid used is 175,000 kilograms per month (380,000 pounds per month).

3.6.3 COOLING TOWER BLOWDOWN

As Section 3.4.4 describes, the station utilizes a natural draft cooling tower as a major component of the heat dissipation and circulating water systems. The service water system supplies makeup water at an approximate rate of 32,000 gallons per minute (121,200 liters per minute). The cooling tower blowdown consists of river water concentrated approximately two times per water cycle. Flow is approximately 19,000 gallons per minute (71,900 liters per minute).

Sulfuric acid and sodium hypochlorite are added to the circulating water to control pH and biological growth, respectively (see Section 3.6.2). Section 3.4.5 describes the discharge of the cooling tower blowdown.

3.6.4 MAKEUP DEMINERALIZERS

Two trains of ion exchange demineralizers satisfy the station's high purity makeup water requirements, as was planned at the construction permit stage.

The two trains are parallel, each sized to produce 570 liters per minute (150 gallons per minute) of demineralized water. A train consists of one strong acid cation vessel, one vacuum degasifier (common to both trains), one strong base anion vessel and one mixed bed vessel. Each cation/anion train produces 820,000 liters (217,000 gallons) of demineralized water between regenerations, while each mixed bed produces 3,780,000 liters (999,000 gallons) of demineralized water between regenerations. Each demineralizer train normally requires regeneration once every three days, except for the mixed beds, which are normally regenerated once every 15 days.

At the construction permit stage it was estimated that daily regeneration of each train would require 240 kilograms (520 pounds) of 66° Baume' sulfuric acid and 140 kilograms (300

pounds) of sodium hydroxide. Cancellation of Unit 2 and the revised regeneration scheme detailed above result in the following chemical usage per regeneration:

	60° Be' H_2SO_4	NaOH
Cation/anion train	332 kg 732 lb	139 kg 307 lb
Mixed bed	65 kg 144 lb	65 kg 144 lb

Demineralizer regenerant effluent is stored in one 190,000-liter (50,000-gallon) capacity tank prior to discharge to the oily water and low volume wastewater system.

3.6.5 AUXILIARY BOILERS

The station is equipped with three auxiliary boilers to provide building heating, process testing steam and auxiliary steam to the turbine building. The boiler feedwater is treated with ammonia to maintain a pH in the range of 8.5 to 9.0. Daily ammonia consumption is anticipated to be approximately 0.5 kilogram per day (1.1 pounds per day). Hydrazine, a dissolved oxygen scavenger, is also used to treat the feedwater. A daily consumption of approximately 0.8 kilogram per day (1.8 pounds per day) is anticipated. The chemical feed systems for each solution are identical; they consist of a 190-liter (50-gallon) tank and two 14.4 liter per hour (3.8 gallon per hour) chemical feed pumps.

A single atmospheric blowdown tank is provided for the continuous blowdown of the three boilers. During normal operation, one boiler operates, while one remains in a standby mode; normal operation results in a blowdown of 64 liters per minute (17 gallons per minute). During plant start-up, a maximum of two boilers operate; the resulting blowdown is expected to be 128 liters per minute (34 gallons per minute). Composition of the blowdown is expected to be as follows:

Parameter	Daily Average	Maximum Anticipated
TSS (mg/l)	0	100
Oil and grease (mg/l)	0	20
Copper, total (mg/l)	<1	1.0
Iron, total (mg/l)	1.0	1.0

The auxiliary boiler blowdown discharges to the oily water and low volume wastewater system.

3.6.6 OILY WATER AND LOW VOLUME WASTEWATER SYSTEM

The oily water and low volume waste collection system is designed to encompass the following waste streams:

a. Turbine building emergency sumps
b. Switchyard and transformer drains
c. Make-up demineralizer wastes
d. Auxiliary boiler blowdown and drains
e. Circulating water chemical storage and water treatment
f. Diesel generator and control room drains

During the construction permit stage, PSE&G planned to construct and operate a treatment facility to accommodate these wastes. Publication of revised effluent limitations (Table 5.1.2) on November 19, 1982, has prompted PSE&G to reevaluate the system along with several alternatives. Collection of wastes in a barge for transport to an off-site treatment facility is one such alternative. The final method of treatment and/or disposal has not been determined.

3.6.7 METAL CLEANING WASTES

During the start-up process, various HCGS systems are flushed to insure their integrity. Well water followed by demineralized water comprise the only flushing agents. These wastes accumulate in a lined 4.9-million liter (1.3-million gallon) capacity surface impoundment to allow particulate settlement. Upon verification that the contents meet the NJPDES and the DRBC effluent limitations, the water is discharged to the Delaware River.

TABLE 3.6-1

LIST OF CHEMICALS TO BE USED AT HCGS

CHEMICAL	SYSTEM/ USE	FREQUENCY OF USE	CONSUMPTION			
			MAXIMUM ANNUAL		AVERAGE (ANNUAL)	
			Metric	English	Metric	English
Sodium Hypochlorite[1]	Service water/ biocide	30 minutes - 3 times daily	8,400 kg	22,600 lb	6,200 kg	16,700 lb
	Circulating water/ biocide	30 minutes - 3 times daily	145,600 kg	390,000 lb	107,500 kg	288,100 lb
Sulfuric Acid	Cation/anion train regeneration	Every 3 days	60,600 kg	133,590 lb	40,400 kg	89,060 lb
	Mixed bed/regeneration	Every 15 days	2,400 kg	5,250 lb	1,600 kg	3,500 lb
	Circulating water/ pH-scale control	As required	2,109,190 kg	4,650,000 lb	703,000 kg	1,500,000 lb
Ammonia	Auxiliary boilers/ pH control	As required	360 kg	800 lb	190 kg	412 lb
Hydrazine	Auxiliary boilers/ D. O. control	As required	590 kg	1,300 lb	300 kg	657 lb
Sodium Hydroxide	Cation/anion train regeneration	Every 3 days	25,500 kg	56,100 lb	17,000 kg	37,400 lb
	Mixed bed/regeneration	Every 15 days	2,380 kg	5,250 lb	1,600 kg	3,500 lb

[1] Chlorine as CL_2.

3.7 SANITARY AND OTHER WASTE SYSTEMS

3.7.1 SANITARY WASTE

Two wells supply water for domestic use at HCGS (see Section 2.4.2 and 3.3). This supply is chlorinated to meet the chemical and bacteriological requirements of the Federal Safe Drinking Water Act as administered by the NJDEP.

Potable and sanitary wastes discharge to the HCGS sewage treatment facility. A temporary system for use during construction, consisting of septic tanks to be pumped out and trucked away periodically, was planned during the construction permit stage; however, Amendment No. 4 to the Construction Permit (Reference 3.7-1) authorized the installation of the extended aeration system that exists today and which will continue in use during operation.

Figure 3.7-1 depicts the layout of the treatment system in use during station construction. This facility consists of three complete package plants: two 30,200 liter per day (8,000 gallon per day) units and one 132,500 liter per day (35,000 gallon per day) unit. Station operation utilizes all three package plants.

Two lift stations collect domestic wastes originating from plumbing fixtures such as toilets, showers, sinks and related floor drains. During normal operation, the sewage is pumped to an air ejector type lift station located within the sewage treatment facility. This lift station pumps the waste to a 75,700 liter (20,000 gallon) surge tank, which contains a bar screen and comminutor. One, two, or three of the package plants then receive sewage, depending upon actual flows (demand on system).

The PSE&G Nuclear Department Facility on Artificial Island also uses the HCGS sewage treatment system. This addition, combined with increased HCGS staff size, increases normal operations personnel normally served from 390 to 1320. During refueling, the number of people using the system is approximately 2320. The resulting increase in system loading necessitates occasional use of all three package plants.

All three package facilities are of the extended aeration - activated sludge type. The facility surge tank acts as an hydraulic buffer, thereby ensuring that each package plant provides a minimum 24-hour aeration time. Following aeration, settling tanks ensure a 4-hour detention time. The activated sludge and other residue that settle out during these processes are diverted to a waste sludge holding tank. Here, the

solids are aerated to provide further stabilization prior to off-site removal by a licensed waste disposal contractor.

Liquid discharge from the settling tanks is diverted to the chlorine contact chamber, where there is a minimum 30-minute mixing period. Contact time is based on 24-hour flow at nominal plant rating. A sodium hypochlorite solution is metered into the chambers according to net plant flow. The system adds approximately 272 kilograms (600 pounds) of chlorine per 3,785,000 liters (1,000,000 gallons) of settled waste water.

Sewage plant effluent discharges to the Delaware River via the storm drainage system.

The treatment facilities provide, as a minimum, the level of treatment and effluent quality required by federal standards for secondary treatment contained in 40 CFR 133. They operate in accordance with limitations imposed by the NJDEP (NPDES permit No. NJ0025411, Discharge No. 62B) and the DRBC. Table 3.7-1 characterizes required sewage system effluent quality and quantity.

3.7.2 LAUNDRY AND DECONTAMINATION WASTES

Section 3.5.2 discusses laundry and other liquid radwaste treatment systems. Section 3.5.4 describes solid radwaste treatment.

3.7.3 DIESEL GENERATOR AND BOILER EXHAUST

At the construction permit stage, PSE&G planned to use eight diesel generators and two auxiliary boilers. With the cancellation of HCGS Unit 2, PSE&G reduced the number of diesel generators to four. Design development resulted in the addition of a third boiler; however, only a maximum of two will be in operation at any time.

HCGS uses auxiliary steam boilers (32,100 kilograms per hour (86,000 pounds per hour) saturated steam) to supply heating and process steam. Diesel generators rated at 4430 kilowatts provide station emergency power.

Fuel for all units is No. 2 fuel oil with the following average analysis:

a.	Carbon	86.5%
b.	Hydrogen	13.2%
c.	Nitrogen	<0.1%
d.	Sulfur	0.2%

e. High Heating Value 10,832 kcal/kg (19,500 Btu/lb)
f. Density 120.2 kg/m^3 (7.5 lb/ft^3)

Table 3.7-2 lists projected use and fuel consumption of both boilers and diesel generators. Stack exhaust is vented at least 18 meters (60 feet) above grade. Each of the units has an air pollution control permit from the NJDEP Bureau of Air Pollution Control (see Chapter 12). Table 3.7-3 lists the quantities of various pollutants found in boiler and generator stack gases.

REFERENCES

3.7-1 U.S. Atomic Energy Commission, Construction Permit for the Hope Creek Generating Station, November 8, 1974.

3.7-2 U.S. Environmental Protection Agency, Process Design Manual - Wastewater Treatment Facilities for Sewered Small Communities, (EPA-625/1-77-009), October, 1977.

3.7-3 Delaware River Basin Commission, Docket No. D-73-193CP, June 17, 1975.

TABLE 3.7-1

SEWAGE TREATMENT PLANT
EFFLUENT LIMITATIONS(1)

	Minimum	Average	Instantaneous Maximum
Flow(2)	36,300 lpd (9600 gpd)	110,500 lpd (29,200 gpd)	607,900 lpd (160,600 gpd)
pH	6.5	NA	8.5
BOD^5	Effluent BOD^5 must represent a 90% reduction from influent concentration as a minimum.	25 mg/l as 30 day avg.	40 mg/l
	1.5 kilograms (4 pounds) of carbonaceous oxygen demand allowed each day as a maximum (Reference 3.7-3).		
Total Suspended Solids (TSS)	Effluent TSS must represent a 90% reduction from influent concentration as a minimum.	30 mg/l as 30 day avg.	40 mg/l
Chlorine	1.0 mg/l	2.0 mg/l	2.5 mg/l

(1) Based on strictest of DRBC, USEPA (NPDES) and NJDEP (operating license) limitations.

(2) Minimum and Maximum values based on "Minimum 24 hour" and "Peak on Maximum Day" ratios in Reference 3.7-2.

TABLE 3.7-2

BOILER/GENERATOR USE DATA

BOILERS

	Metric	English
On-Line Time	13,600 boiler hr/yr	Same
Fuel Consumption	2,839 l/hr-boiler	750 gal/hr-boiler
Fuel Allocation	40,878,000 l/yr	10,800,000 gal/yr
Fuel Use	2,091 kg/hr-boiler	5,601 lb/hr-boiler
Fuel Density	120.2 kg/m^3	7.5 lb/ft^3

DIESEL GENERATORS

	Metric	English
On-Line Time	1,200 engine hr/yr	Same
Fuel Consumption	1,136 l/hr-engine	300 gal/hr-engine
Fuel Allocation	1,419,375 l/yr	375,000 gal/yr
Fuel Use	858 kg/hr-engine	2,300 lb/hr-engine
Fuel Density	120.2 kg/m^3	7.5 lb/ft^3

TABLE 3.7-3

BOILER/GENERATOR STACK EMISSIONS

BOILERS (1)

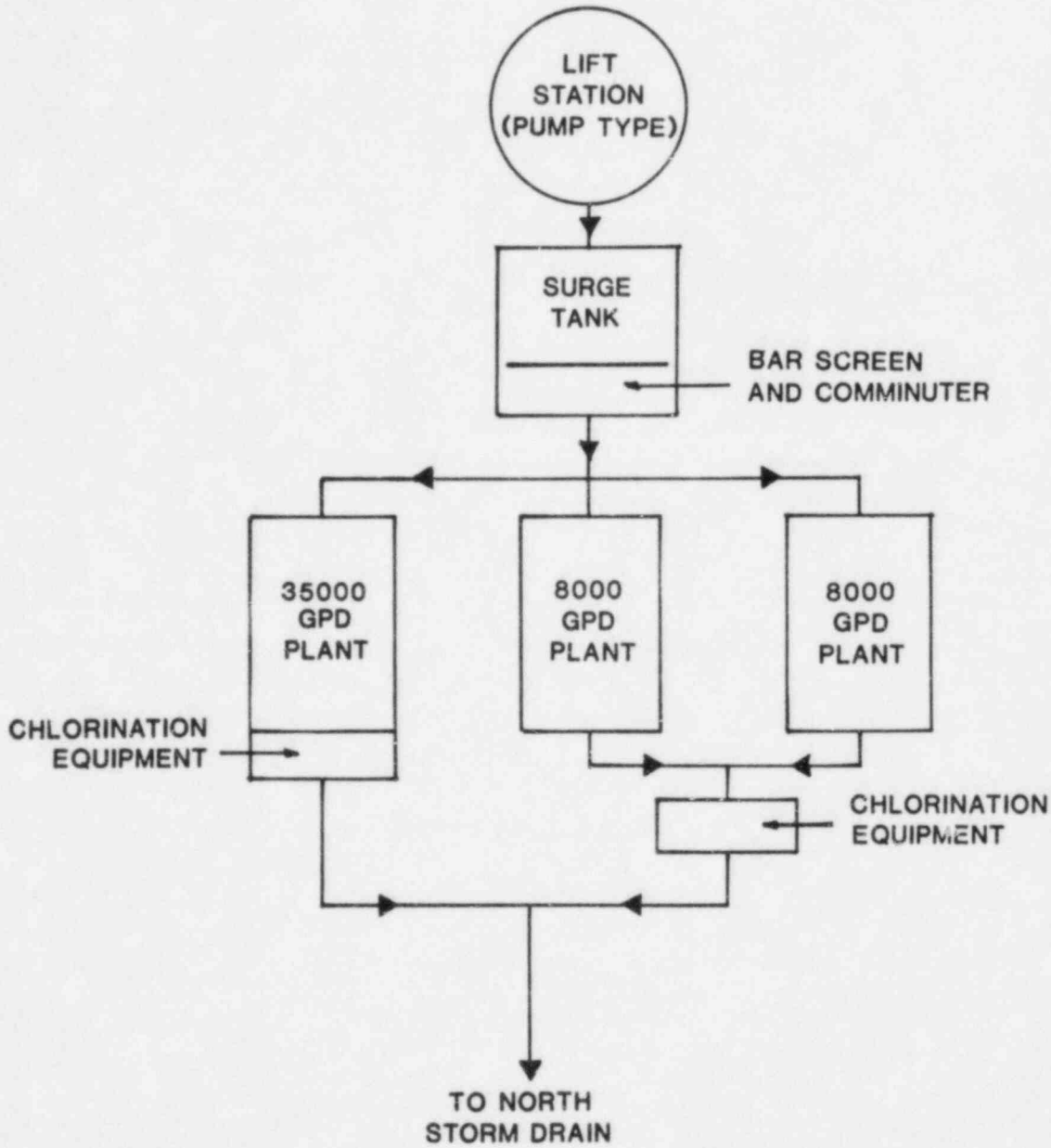
Pollutant	Metric	English
Particulates	10,000 kg/yr	11 tons/yr
SO_2	217,700 kg/yr	240 tons/yr
NO_x	163,300 kg/yr	180 tons/yr
CO	23,600 kg/yr	26 tons/yr
Hydrocarbons	4,900 kg/yr	5.4 tons/yr

DIESEL GENERATORS (2)

Pollutant	Metric	English
Particulates	300 kg/yr	0.37 ton/yr
SO_2	3,800 kg/yr	4.2 tons/yr
NO_x	32,700 kg/yr	36 tons/yr
CO	800 kg/yr	0.9 ton/yr
Hydrocarbons	1,300 kg/yr	1.4 tons/yr

(1) Totals for annual boiler operation (1 or 2 boilers in operation at any given time).

(2) Totals for 4 generator operation (testing).



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

SEWAGE TREATMENT
FACILITY

FIGURE 3.7 - 1

3.8 REPORTING OF RADIOACTIVE MATERIAL MOVEMENT

10 CFR 51.20 specifies the detailed requirements for the analysis of the environmental impact involved with the transportation of radioactive material to and from HCGS. Table S-4 of 10 CFR 51 (see Table 3.8-1) evaluates the environmental impact of radioactive material transportation; the material contained in Table S-4 applies to HCGS since the following conditions are met:

a. HCGS is a light water reactor with a power level which does not exceed 3800 mWt.

b. The enriched fuel does not contain U-235 in excess of four percent by weight.

c. The average level of irradiation of the fuel does not exceed 33,000 megawatt-days per metric ton.

d. Waste is shipped from the reactor in the form of packaged waste.

e. Unirradiated fresh fuel is shipped to the reactor by truck, rail or barge, and waste other than irradiated fuel is shipped from the reactor by truck or rail.

Since HCGS satisfies these conditions, the environmental analyses provided in 10 CFR 51.20 are valid for HCGS.

TABLE 3.8-1

ENVIRONMENTAL IMPACT OF TRANSPORTATION OF FUEL AND WASTE TO AND FROM ONE LIGHT-WATER-COOLED NUCLEAR POWER REACTOR [1]
(FROM TABLE S-4 OF 10 CFR 51)

NORMAL CONDITIONS OF TRANSPORT

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

EXPOSED POPULATION	ESTIMATED NUMBER OF PERSONS EXPOSED	RANGE OF DOSES TO EXPOSED INDIVIDUAL[2] PER REACTOR YEAR	CUMULATIVE DOSE TO EXPOSED POPULATION PER REACTOR YEAR [3]
Transportation workers	200	0.01 to 300 mrem	4 man-rem
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	3 man-rem

ACCIDENTS IN TRANSPORT

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

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

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

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

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

3.9 TRANSMISSION FACILITIES

PSE&G discussed HCGS transmission facilities during the construction permit stage, and described them in the Final Environmental Statement (FES). Section 3.9 combines construction permit stage material with updated information concerning the transmission facilities.

PSE&G proposed two entirely new 500 kilovolt transmission lines, originating at Artificial Island, during the construction permit stage. The 121 kilometer (75 mile) line, which would have run from HCGS to Tuckerton, New Jersey, over a new ROW, was subsequently cancelled. The 69 kilometer (42.9 mile) line, which would have run between HCGS and the New Freedom switching station along a pre-existing 106 meter (350 foot) ROW, has been constructed, but is connected instead to Salem Generating Station. Since this line connects with a pre-existing line running beyond New Freedom to the Deans switching station, it is referred to as the Salem - Deans line (see Section 3.9.2) (Figure 3.9-5). HCGS has been connected to New Freedom through a pre-existing line (see Section 3.9-1). This arrangement does not occupy or disturb any off-site areas not anticipated during the construction permit stage.

Since the construction permit stage, the manner in which HCGS is connected to PSE&G's 500 kilovolt transmission system facilities has been changed to involve two additional transmission lines. One line runs from HCGS to the Keeney switching station (see Section 3.9.3), and the other connects HCGS with Salem Generating Station (see Section 3.9.4).

3.9.1 HOPE CREEK - NEW FREEDOM 500 KILOVOLT TRANSMISSION LINE

HCGS has been connected to the pre-existing 69 kilometer (42.9 mile) Salem - New Freedom North line. The line, which was originally built for and connected to Salem Generating Station, is now redesignated Hope Creek - New Freedom (see Figure 3.9-5).

The line is physically identical to and located alongside a portion of the Salem - Deans line, between Salem Generating Station and the New Freedom switching station. The physical and right-of-way (ROW) descriptions given for the Salem - Deans line portion are applicable to the Hope Creek - New Freedom line (see Section 3.9.2).

3.9.2 SALEM - DEANS 500 KILOVOLT TRANSMISSION LINE (SALEM - NEW FREEDOM PORTION)

Figure 3.9-1 illustrates the lattice type steel and aluminum towers used for the transmission line portion. The towers have a typical base dimension of 6 by 12 meters (20 by 40 feet) as illustrated in Figure 3.9-2.

The stranded 54/37 aluminum (ACAR) conductors are 12.6 square centimeters (2.0 square inches) in cross section, with an outside diameter of 4.6 centimeters (1.8 inches). Conductors on V-string insulator assemblies are bundled two per phase and held 46 centimeters (18 inches) apart by supporting hardware on the towers (see Figure 3.9-1). The ruling spans between towers range from 427 meters (1400 feet) near HCGS to 305 meters (1000 feet) as the line approaches the New Freedom switching station. The minimum conductor clearance to the ground is 10 meters (33 feet) at 100°C (212°F), which meets the National Electric Safety Code (NESC), Section 23, requirement (Reference 3.9-1). The 500 kilovolt, single circuit Salem-Deans transmission line portion has a normal summer capacity of 2730 MVA and emergency (maximum) summer capacity of 3220 MVA. The normal winter capacity is 2960 MVA, and the emergency (maximum) winter capacity is 3980 MVA.

The typical maximum electric field strength beneath the spans at one meter (three feet) above the ground is five kilovolts per meter, and at the edge of the ROW is two kilovolts per meter. The generated magnetic fields typically do not exceed 0.05 gauss. Since PSE&G anticipates balanced line loading, a nominal ground current should not occur. Audible sound levels from the transmission line are approximately 50 dbA at the edge of the ROW, as stipulated in New Jersey law (NJSA 13:161-23) and the New Jersey Administrative Code (NJAC 7:29-1.2a).

The line occupies approximately 53 meters (175 feet) of the total 106 meter (350 foot) wide ROW. The other 53 meter (175 foot) portion of the ROW is occupied by the Hope Creek - New Freedom line (see Section 3.9-1). The length of the transmission line portion from Salem to New Freedom is approximately 69 kilometers (42.9 miles); the line occupies 368 hectares (910 acres) of the ROW. Table 3.9-1 lists the land types crossed by the line. The present and future use of these lands follows individual county-wide land use trends and projections as indicated below (References 3.9-2 and 3.9-3).

At present, a majority of the land in Salem County is composed of farms, meadows, woods, and vacant areas. The remaining land is predominantly residential. Projected use for prime agricultural land, as classified by the U.S. Department of Agriculture, is that it will remain as such; secondary agricultural land, woods and vacant areas are to give way to urbanization and open land projects. In Salem County the transmission line portion traverses less than 60 hectares (150 acres) of prime agricultural land. The well-drained, slightly sloped soils contained in this area are Mattapex, Othello, Woodstown and Chillum silt loams. Section 5.5 discusses operating and maintenance effects of the line portion.

Within Salem County the transmission line portion crosses two transmission ROW's owned by the Atlantic City Electric Company. The Deepwater - Sherman 138 kilovolt ROW is located between towers 16/1-17/1 on Figure 3.9-3C, and the Monroe - Lewis 138 kilovolt ROW and the Deepwater - Lewis 138 kilovolt ROW are found between towers 19/1-20/1 on Figure 3.9-3C. The line crosses a Conrail railroad corridor between towers 24/1-25/1 on Figure 3.9-3D, and a South Jersey Gas Company 51 centimeter (20 inch) diameter natural gas pipeline between towers 16/1-17/1 on Figure 3.9-3C. Major roadways crossed are Routes 49, 77, and 40, located between towers 11/1-12/1 on Figure 3.9-3B, towers 20/1-21/1 on Figure 3.9-3C, and towers 23/1-24/1 on Figure 3.9-3D, respectively.

In Gloucester County a portion of the land has been developed into residential, commercial and industrial areas; the remaining lands are used for agricultural purposes or are undeveloped. Projected land use trends for Gloucester County call for prime agricultural land to remain as such. Additional lands will be used for commercial, industrial, and open space areas. The transmission line portion passes over less than 12 hectares (30 acres) of prime agricultural land consisting of Aura, Downer and Sassafras loams, which are well drained, and slope in a 15 to 40 percent range. Section 5.5 discusses operating and maintenance effects of the line portion.

In Gloucester County the transmission line portion crosses two Atlantic City Electric Company ROW's. The Monroe - Landis 138 kilovolt ROW is located between towers 32/1-33/1 on Figure 3.9-3E. The Monroe - Hammonton 69 kilovolt ROW is located between towers 36/1-37/1 on Figure 3.9-3E. Two South Jersey Gas Company natural gas pipelines are within Gloucester County; a 41 centimeter (16 inch) diameter line is between towers 30/1-31/1 on Figure 3.9-3D, and a 30 centimeter (12 inch) diameter line is between towers 37/1-38/1 on Figure

3.9-3E. The line crosses a Conrail railroad corridor between towers 29/1-30/1 on Figure 3.9-3D. Major roadways crossed are Route 322, located between towers 37/1-38/1 on Figure 3.9-3E, and Route 538, located between towers 28/1-29/1 on Figure 3.9-3D.

The last three miles of the transmission line portion extends into Camden County and connects to the New Freedom - Deans portion of the line at the New Freedom switching station. Most of the transmission line portion in Camden County lies within the jurisdiction of the Pinelands Commission, which has designated the area as a protection area. The New Brooklyn County Park occupies a small portion of land crossed by the line portion and contiguous with the New Freedom switching station. Projected land use for these sections of the county will remain, for the most part, unchanged. There are no prime agricultural lands traversed by the transmission line portion in Camdem County. Section 5.5 discusses operating and maintenance effects of the line portion.

Within Camden County the transmission line crosses an American Telephone and Telegraph Company underground cable between towers 42/1-43/1 on Figure 3.9-3F. The line crosses only one major roadway, the Atlantic City Expressway, between towers 40/1-41/1 on Figure 3.9-3F.

Maintenance practices for the line portion and ROW consist of conducting patrols at least five times each year to ensure the physical integrity of transmission line supports, hardware, insulators and conductors. These periodic checks are conducted by helicopter and ground patrols. Climbing inspections of structures are performed at least every three years (see Section 5.5).

Figures 3.9-3A through F identify historic, archeological and cultural areas within two kilometers (1.2 miles) of either side of the transmission line portion. These sites are listed in Section 2.6.

3.9.3 HOPE CREEK - KEENEY 500 KILOVOLT TRANSMISSION LINE

PSE&G has connected HCGS to an pre-existing 48 kilometer (30.1 mile) 500 kilovolt transmission line running to the Keeney switching station near Newark, Delaware. The former Salem - Keeney line, which was originally built for and connected to Salem Generating Station, has been redesignated Hope Creek - Keeney (see Figures 3.9-4 and 3.9-5). The Delmarva Power and Light Company operates the portion of the line located in Delaware (see Figure 3.9-5).

3.9.4 HOPE CREEK - SALEM 500 KILOVOLT TRANSMISSION LINE

PSE&G has run a transmission line approximately 305 meters (1000 feet) in length that connects the HCGS and Salem Generating Station switchyards (see Figure 3.9-5).

3.9.5 NEW FREEDOM SWITCHING STATION

The New Freedom switching station in Winslow Township, Camden County, New Jersey is located on an irregularly-shaped plot of land off Chews Landing-New Brooklyn Road. The station consists of a 230 and 500 kilovolt switchyard and a control house. The control house measures 22 meters (72 feet) in a north-south direction and 18 meters (59 feet) in an east-west direction. The building, which is at an elevation of approximately 154 feet above MSL, is finished with exposed aggregate panels separated by concrete beams, and bordered by aluminum flashings.

REFERENCES

3.9-1 ANSI, National Electric Safety Code, Institute of Electrical and Electronics Engineer, Inc., N.Y., N.Y., pp. 138-217.

3.9-2 B. B. Friedlander, T. A. Clark, Rev. 1, Master Plan Lower Alloways Creek Township, New Jersey, December, 1978.

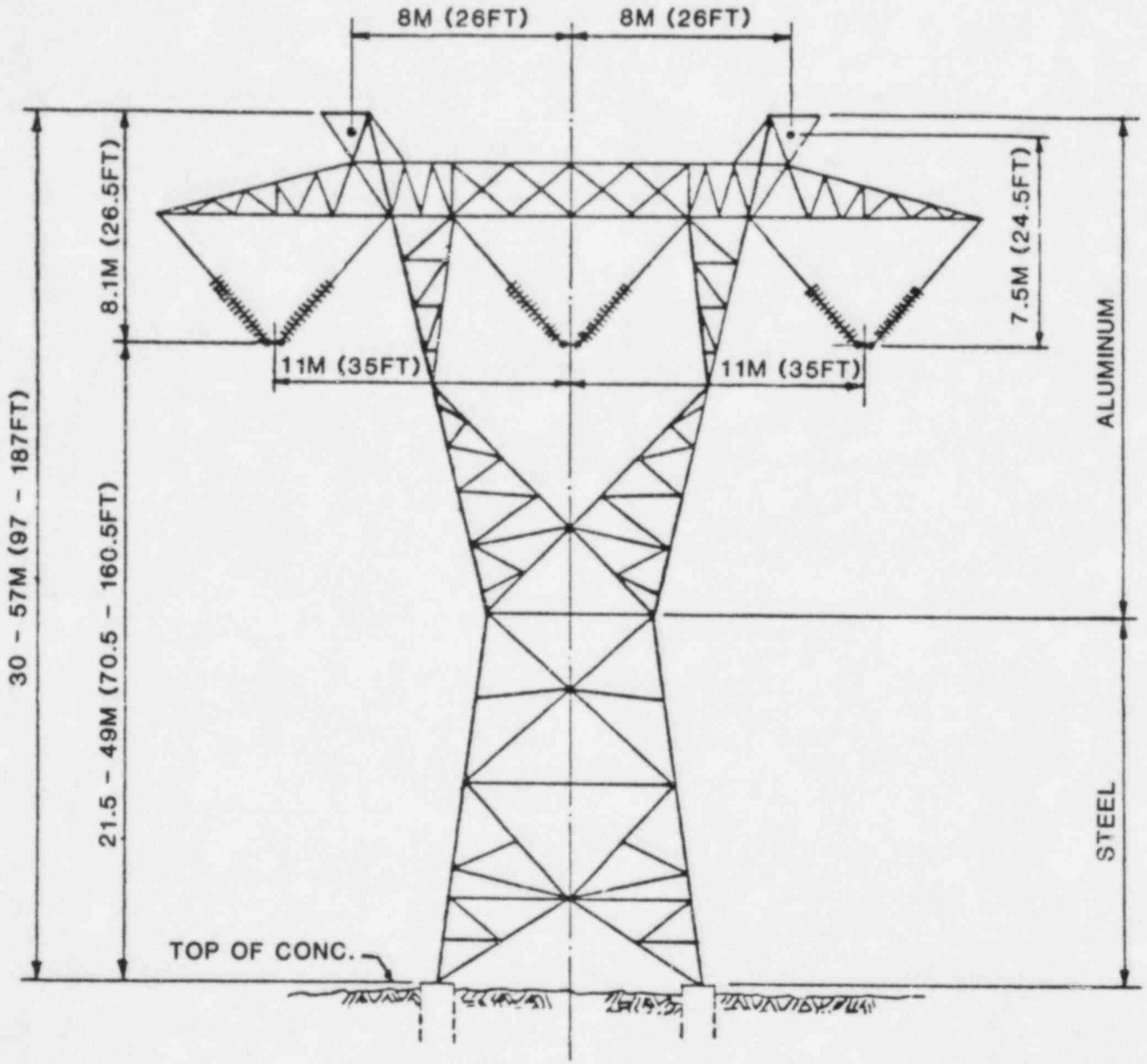
3.9-3 Salem County Planning Board, A Plan for Comprehensive Development, November, 1970.

TABLE 3.9-1

LAND TYPES CROSSED BY THE
SALEM - NEW FREEDOM PORTION OF THE SALEM-DEANS
RIGHT-OF-WAY[1]

DISTANCE FROM SITE km/(mi)	COUNTIES	NONFORESTED WETLANDS	FORESTED WETLANDS	MIXED FOREST	CROPLAND/ PASTURE[2]	EVERGREENS	RESIDENTIAL
0-8/(0-5)	Salem	X			X		
8-16/(5-10)	Salem	X		X	X		
16-24/(10-15)	Salem			X	X		
24-32/(15-20)	Salem			X	X		
32-40/(20-25)	Salem		X	X	X		
40-48/(25-30)	Salem Gloucester		X	X	X		
48-56/(30-35)	Gloucester		X	X	X	X	
56-64/(35-40)	Gloucester				X	X	X
64-69/(40-43)	Camden		X	X		X	

(1) Land types taken from New Jersey Department of Environmental Protection land use maps.
(2) Soil types for prime agricultural areas are listed in Section 3.9.



TRANSVERSE VIEW

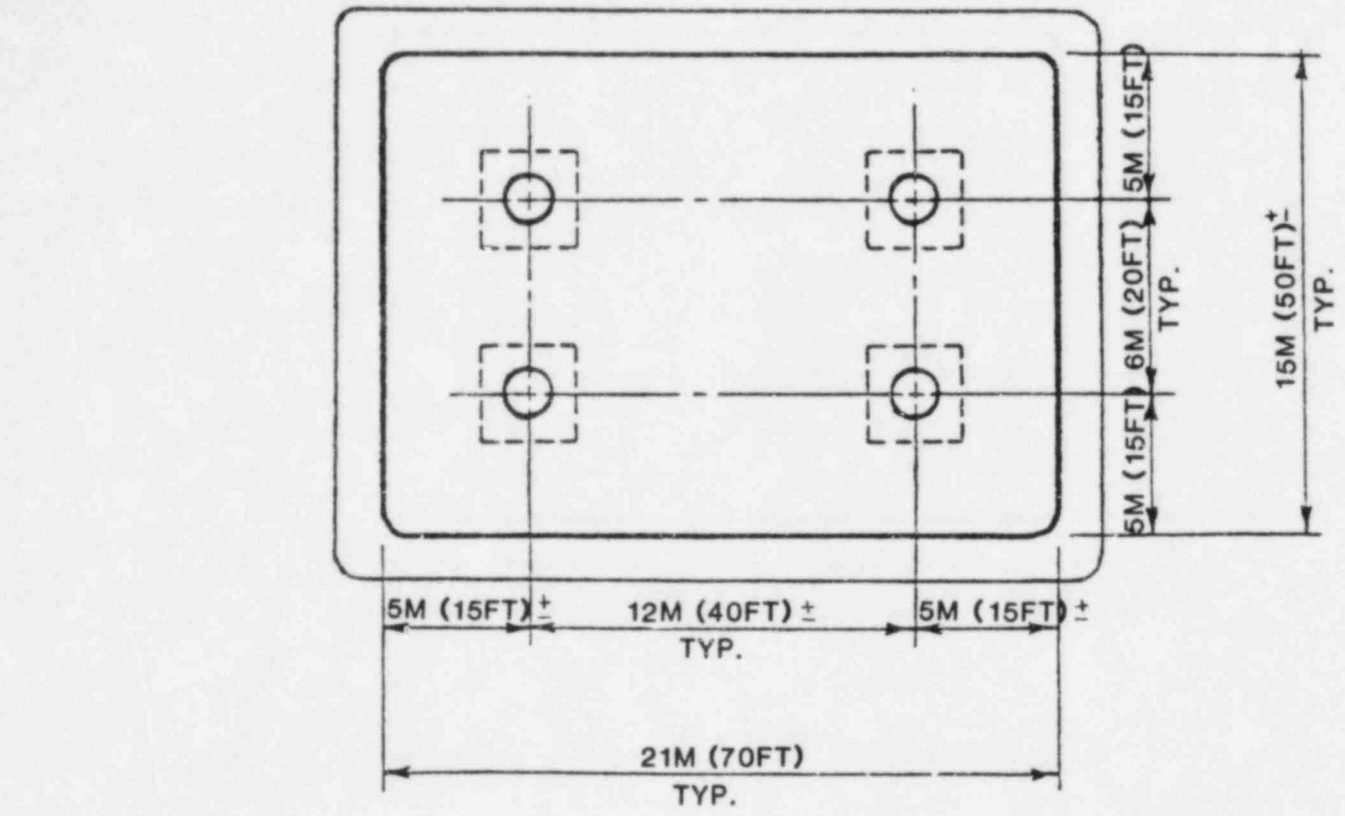
TYPE FMT TOWER

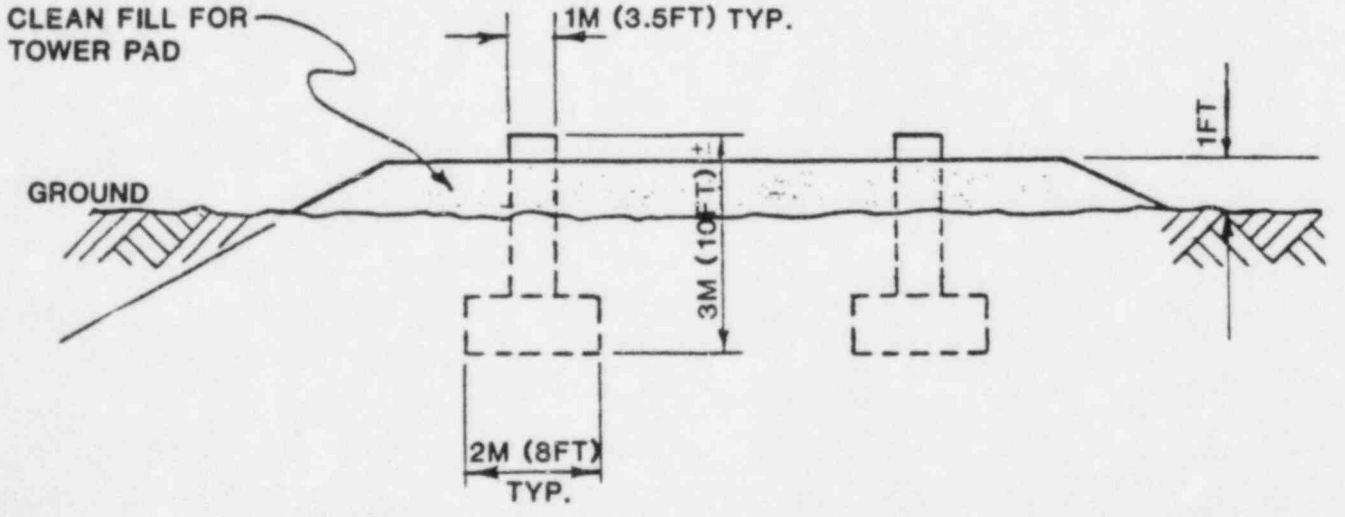
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

TYPICAL 500KV STANDARD
COMPOSITE TOWER

FIGURE 3.9 - 1



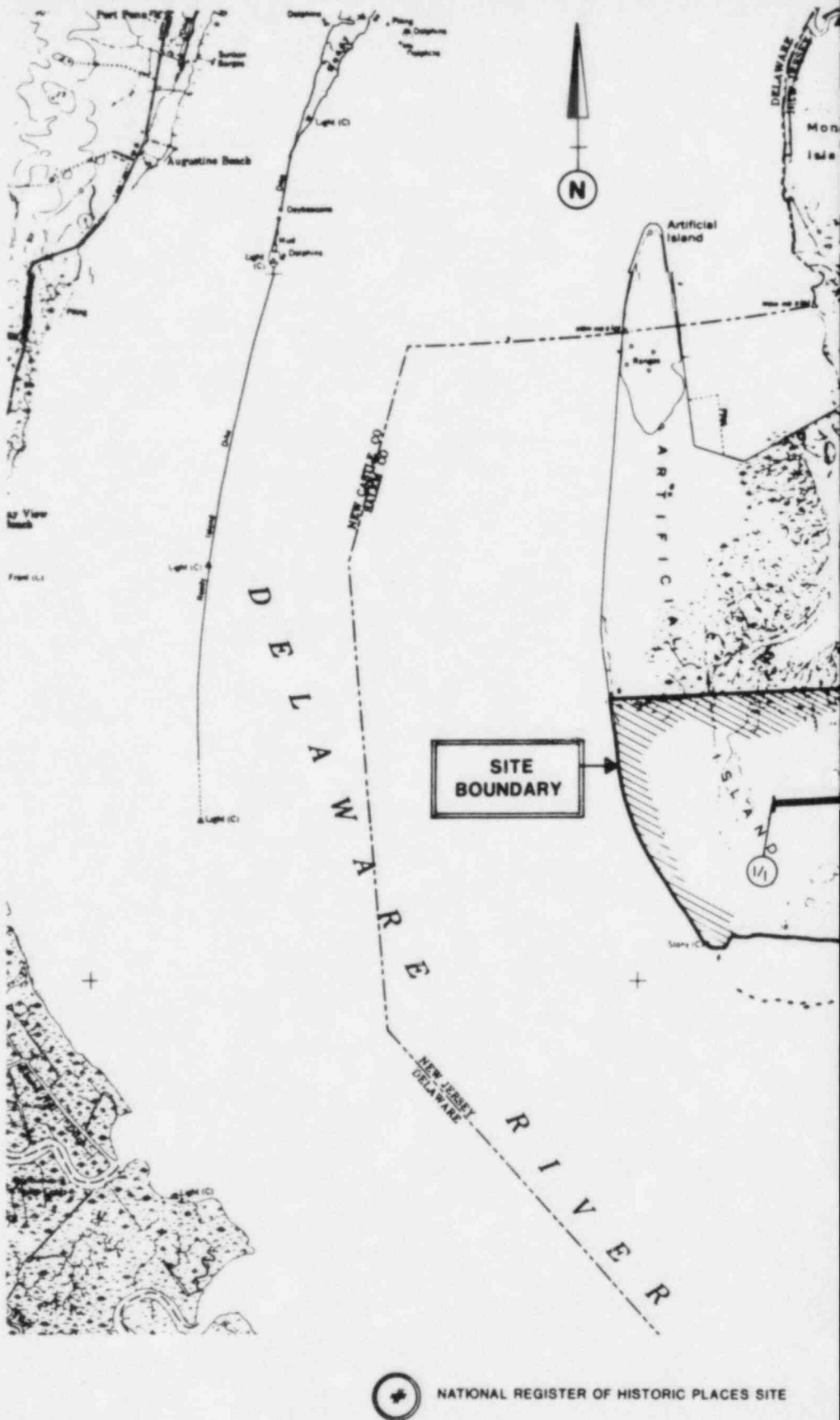


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

TYPICAL 500KV
TRANSMISSION TOWER BASE

FIGURE 3.9 - 2


N
Artificial Island
SITE BOUNDARY
DELAWARE RIVER
NEW JERSEY
DELAWARE
Augustine Beach
NATIONAL REGISTER OF HISTORIC PLACES SITE

TOWER NUMBER

1 0 1 MILE

1 0 1 KILOMETER

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

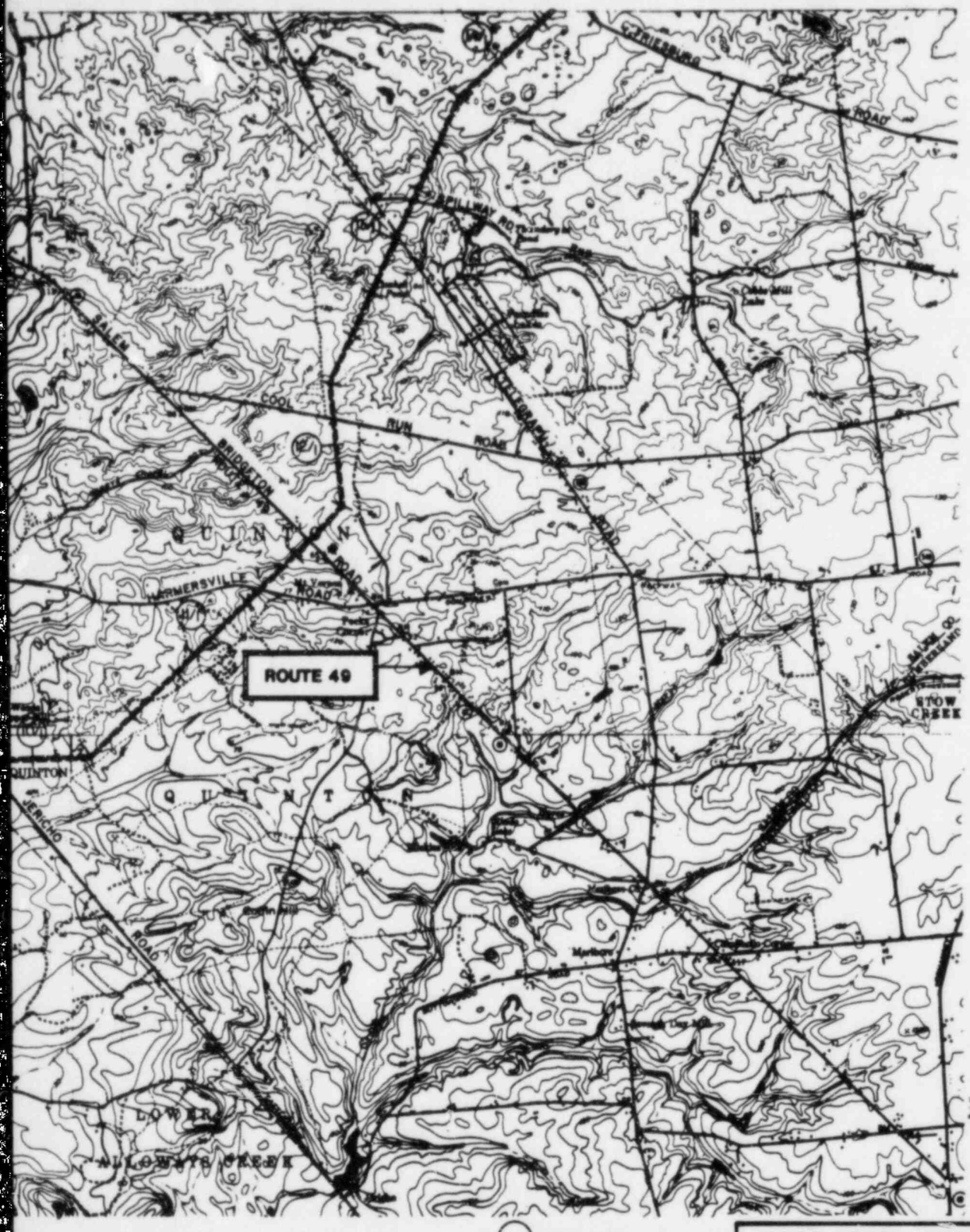
SALEM - DEANS
(HOPE CREEK - NEW FREEDOM
PORTION) ROW

FIGURE 3.9 - 3A

PRC APERTURE CARD

Also Available On Aperture Card

NATIONAL REGISTER OF HISTORIC PLACES SITE



PRC APERTURE CARD

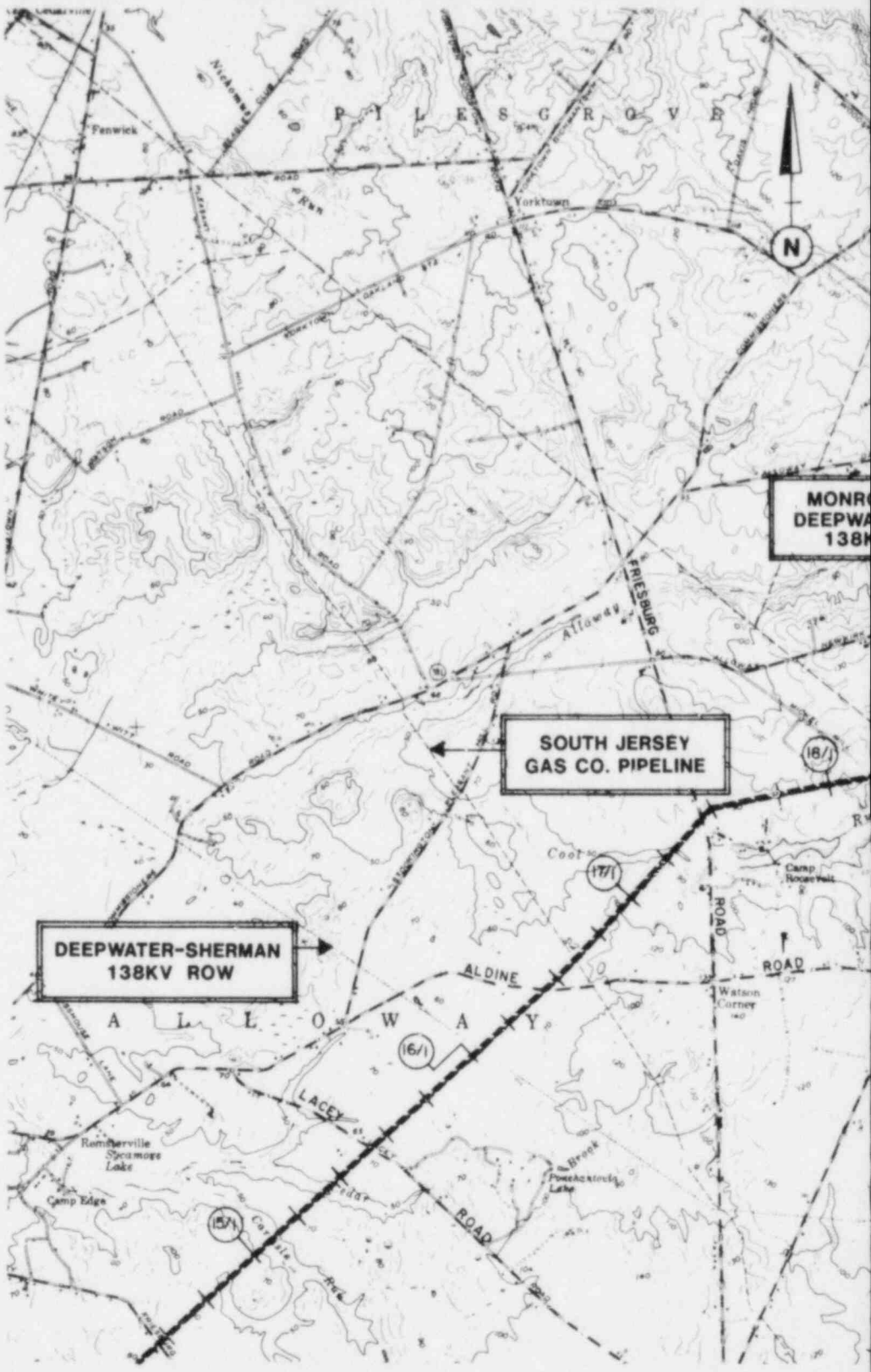
Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

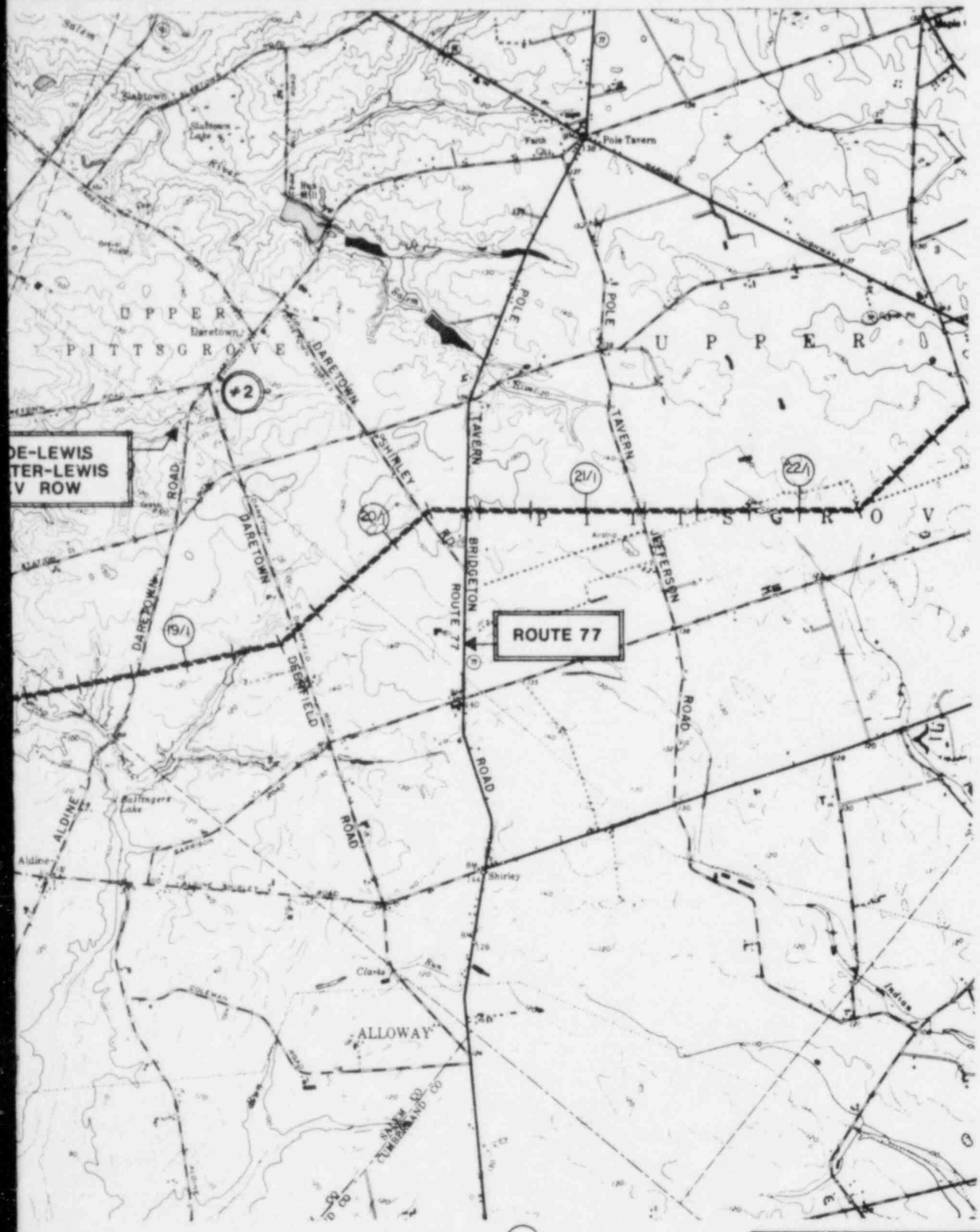
SALEM - DEANS
(HOPE CREEK - NEW FREEDOM PORTION) ROW

FIGURE 3.9 - 3B



JOIN TO FIGURE 3.9 - 3B

NATIONAL REGISTER OF HISTORIC PLACES SITE



JOIN TO FIGURE 3.9 - 3D

TOWER NUMBER

1 0 1 MILE

1 0 1 KILOMETER

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

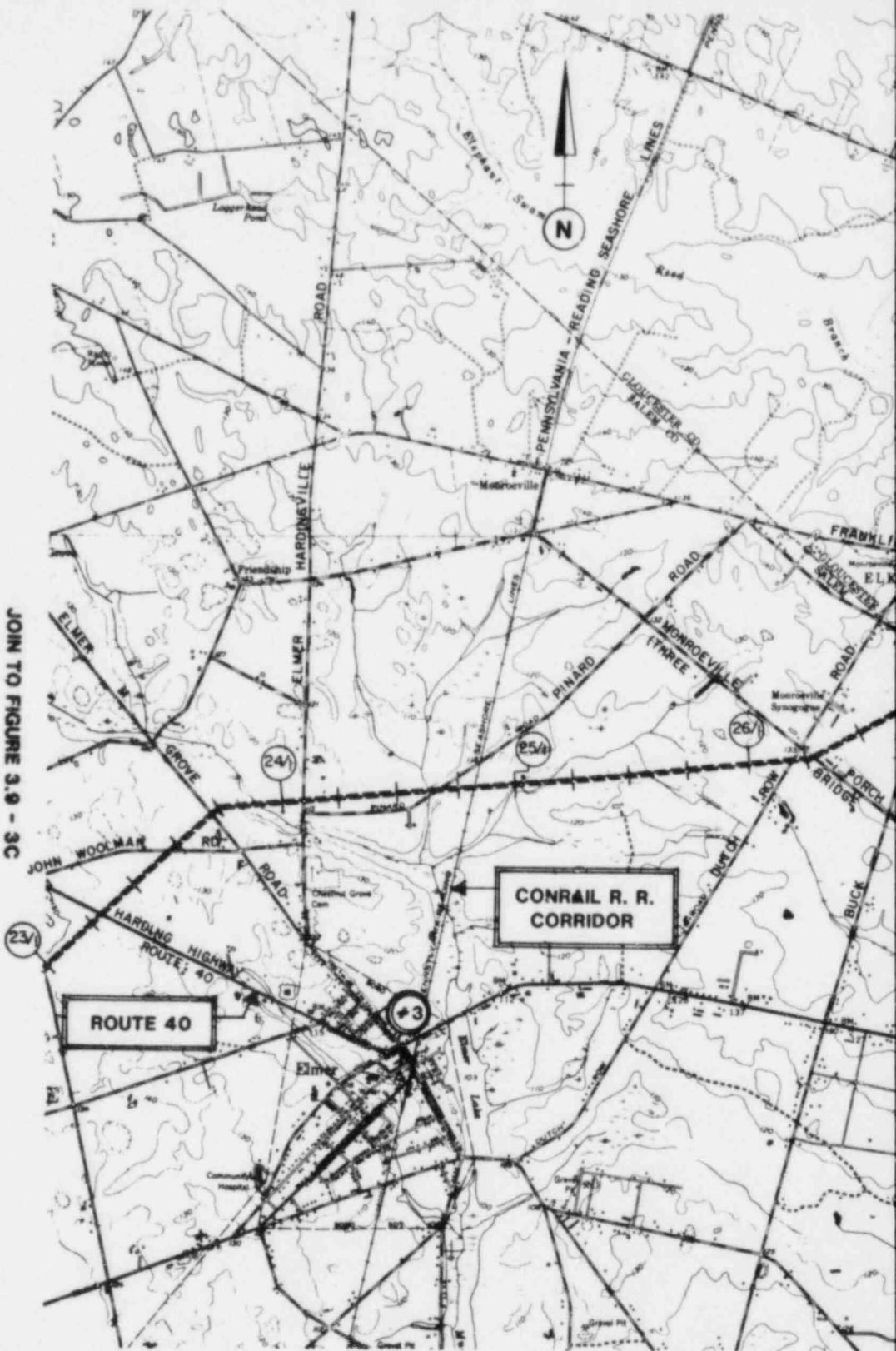
OPERATING LICENSE STAGE

SALEM - DEANS
(HOPE CREEK - NEW FREEDOM
PORTION) ROW

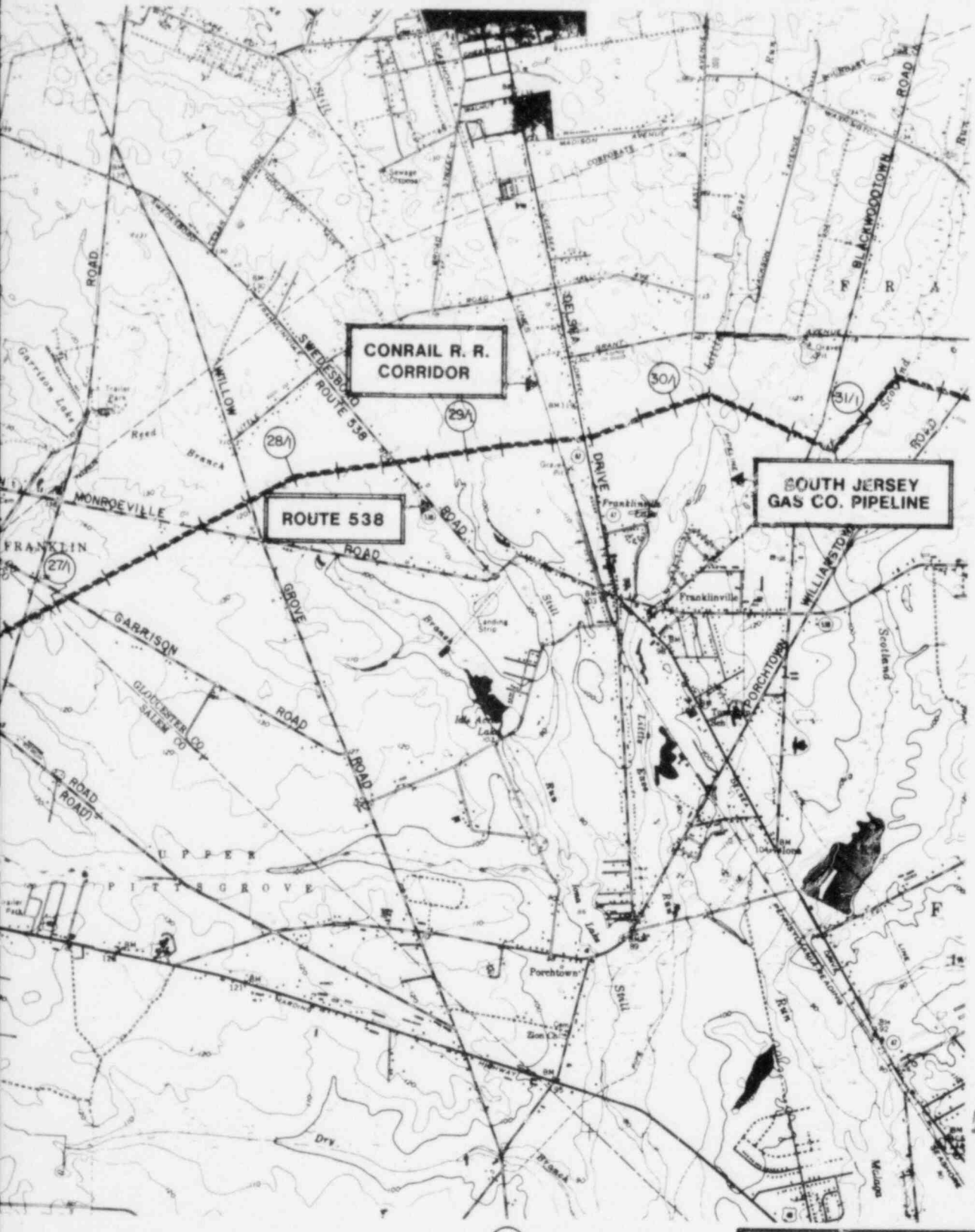
FIGURE 3.9 - 3C

PRC
APERTURE
CARD

Also Available On
Aperture Card



NATIONAL REGISTER OF HISTORIC PLACES SITE



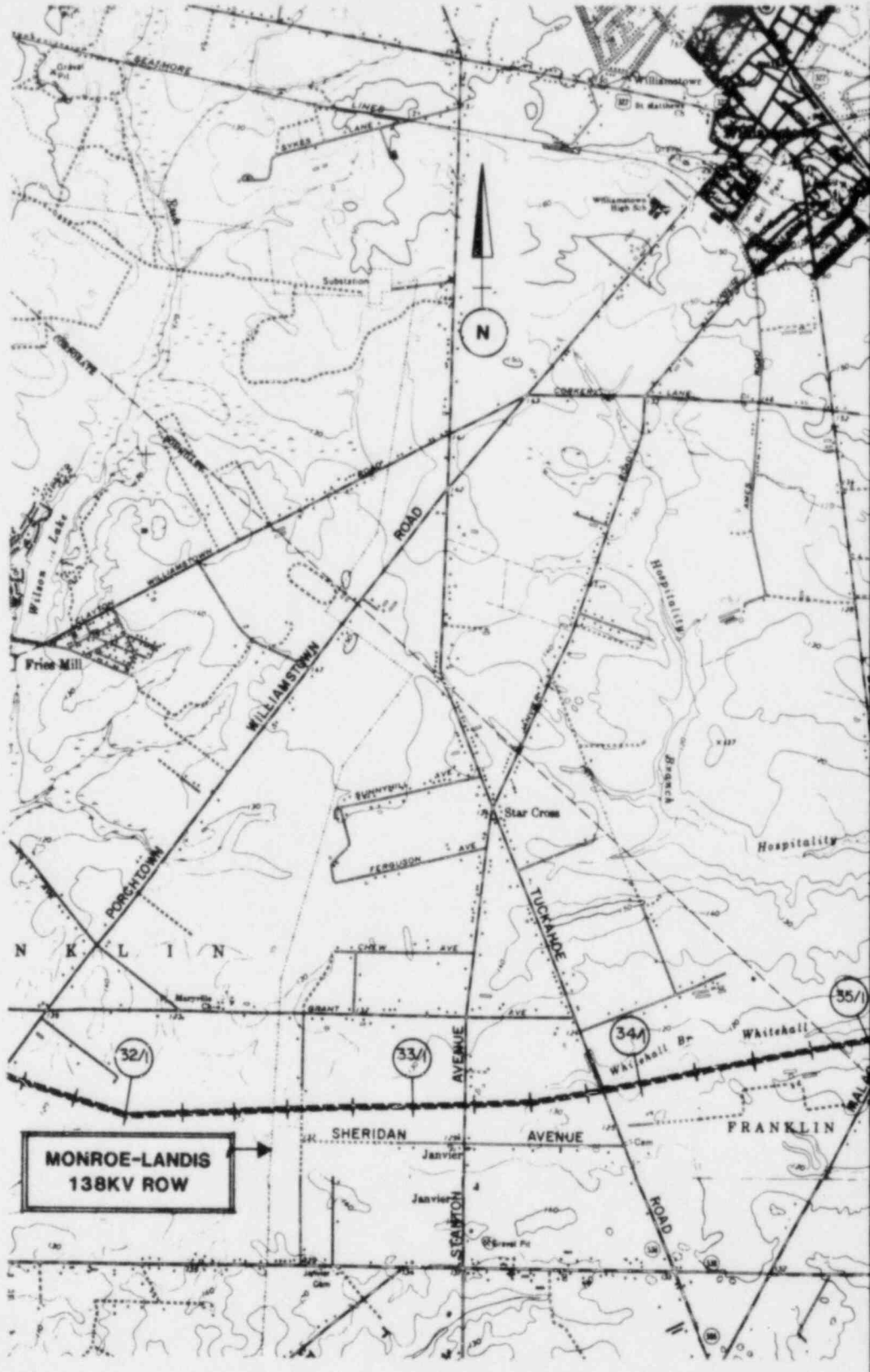
PRC APERTURE CARD
Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

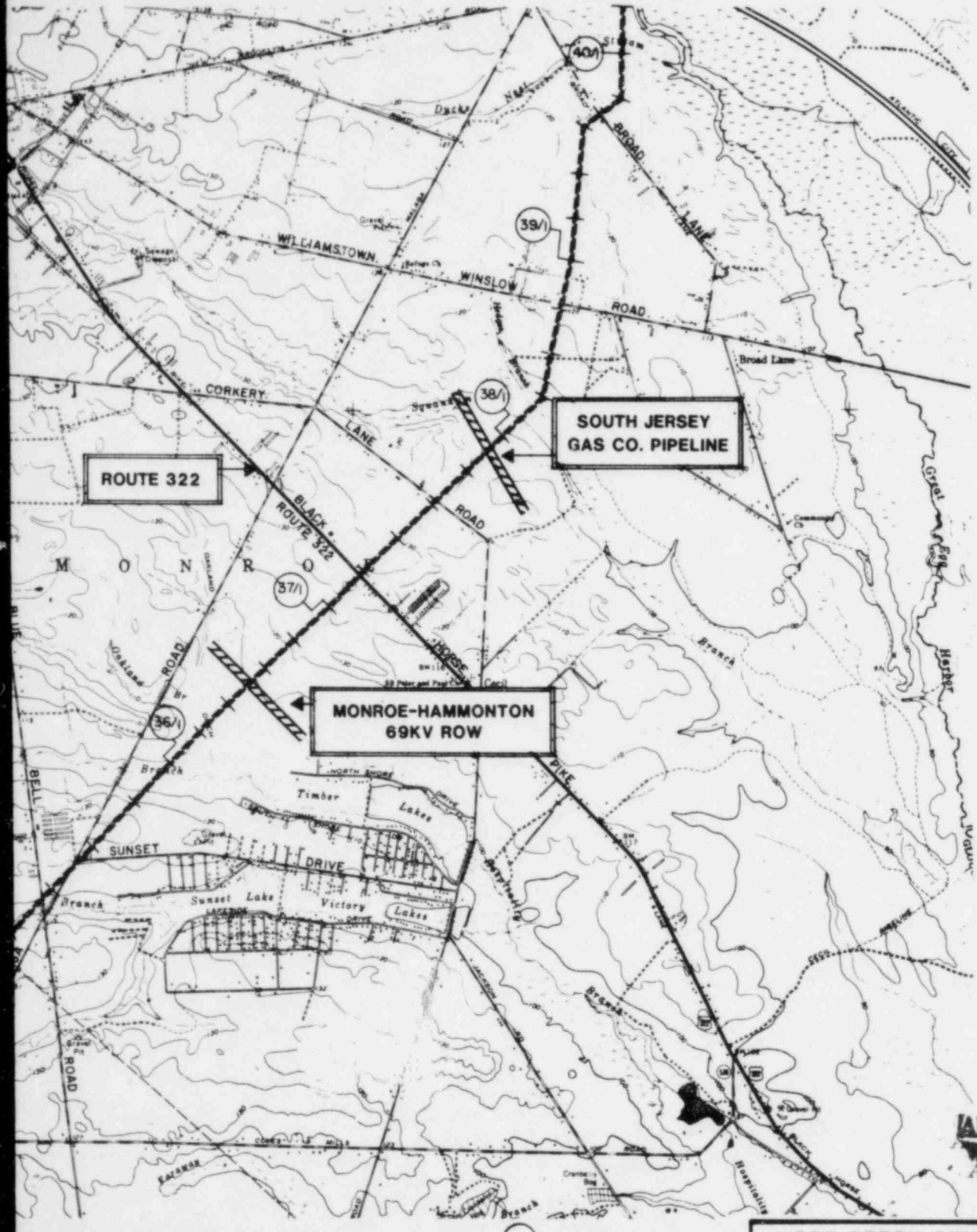
SALEM - DEANS
(HOPE CREEK - NEW FREEDOM PORTION) ROW

FIGURE 3.9 - 3D



JOIN TO FIGURE 3.9 - 3D

NATIONAL REGISTER OF HISTORIC PLACES SITE



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Also Available on Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

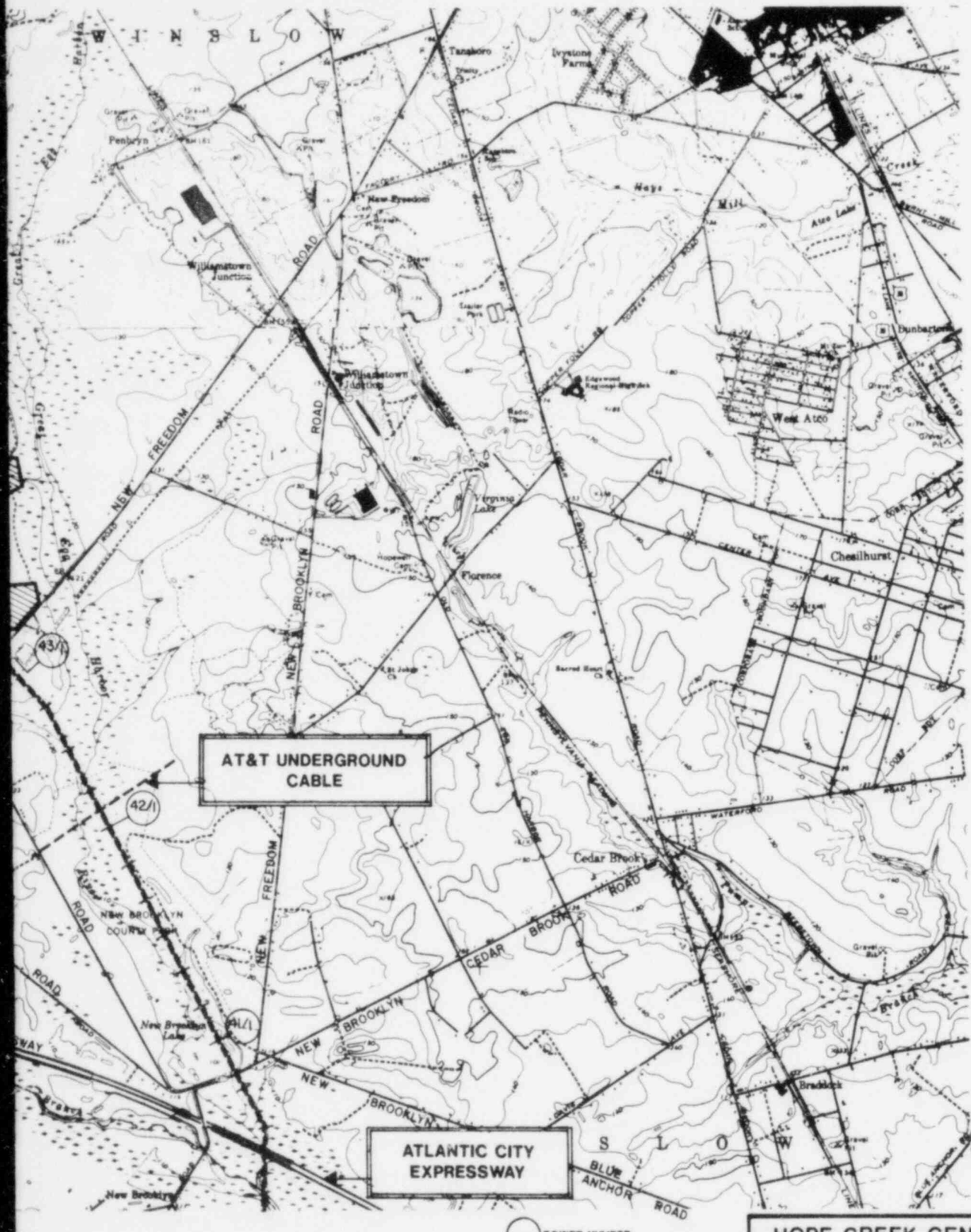
OPERATING LICENSE STAGE

SALEM - DEANS
(HOPE CREEK - NEW FREEDOM PORTION) ROW

FIGURE 3.9 - 3E

JOIN TO FIGURE 3.9 - 3E

NATIONAL REGISTER OF HISTORIC PLACES SITE



PRC APERTURE CARD

Also Available On Aperture Card

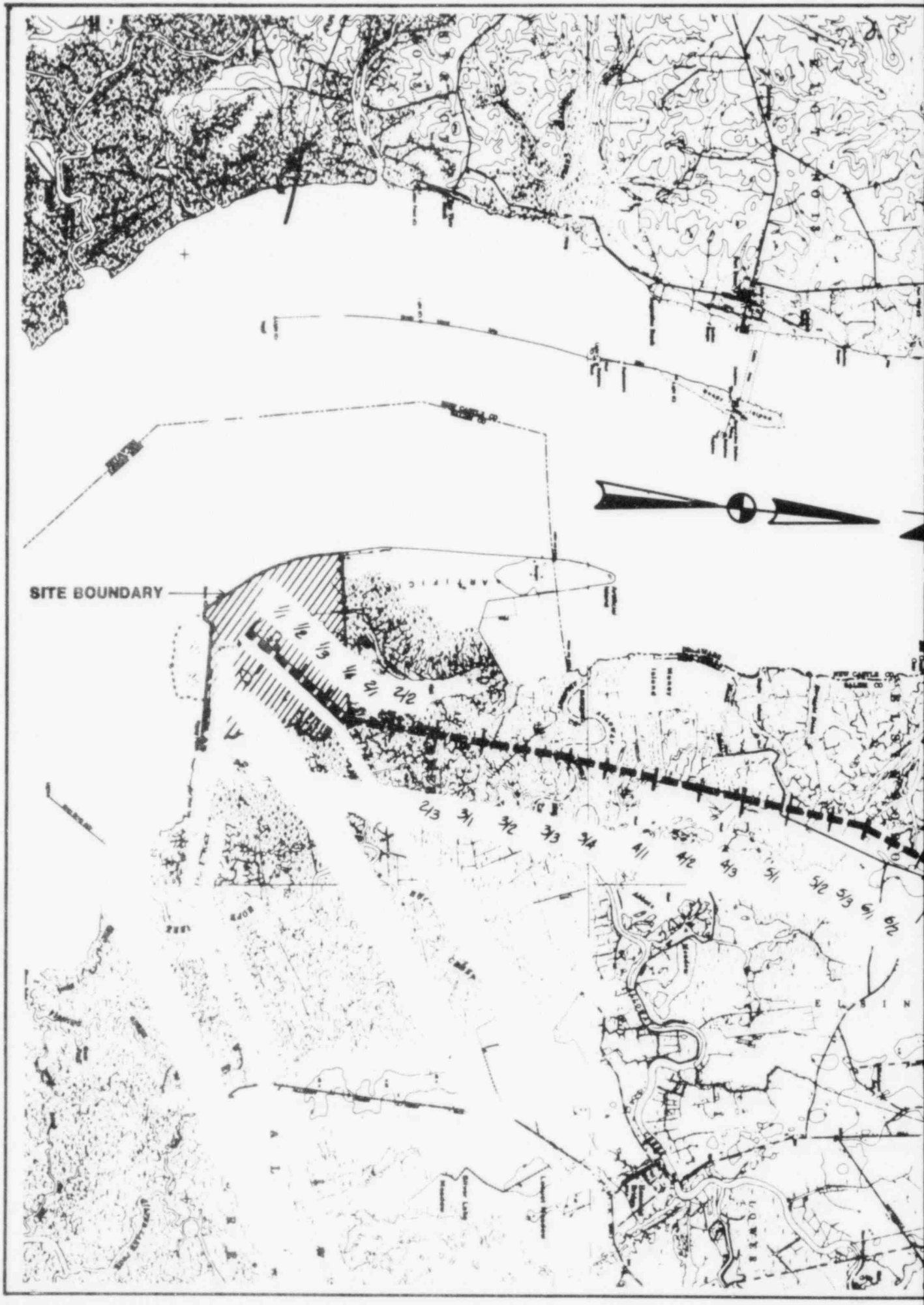
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

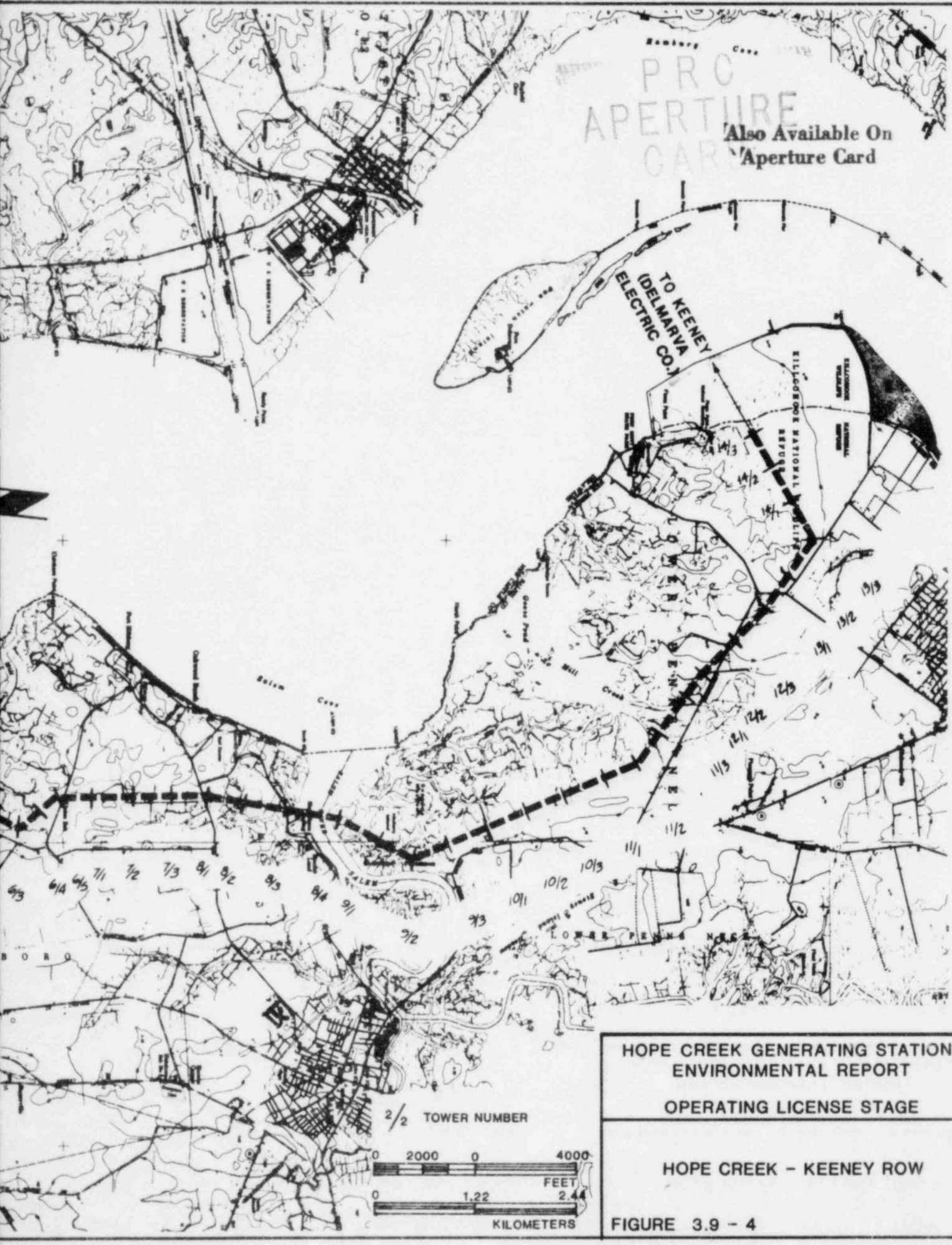
SALEM - DEANS
(HOPE CREEK - NEW FREEDOM
PORTION) ROW

FIGURE 3.9 - 3F

8306290485


SITE BOUNDARY
2/3
3/1
3/2
3/3
3/4
4/1
4/2
4/3
5/1
5/2
5/3
6/1
6/2

PRC APERTURE CARD
Also Available On Aperture Card

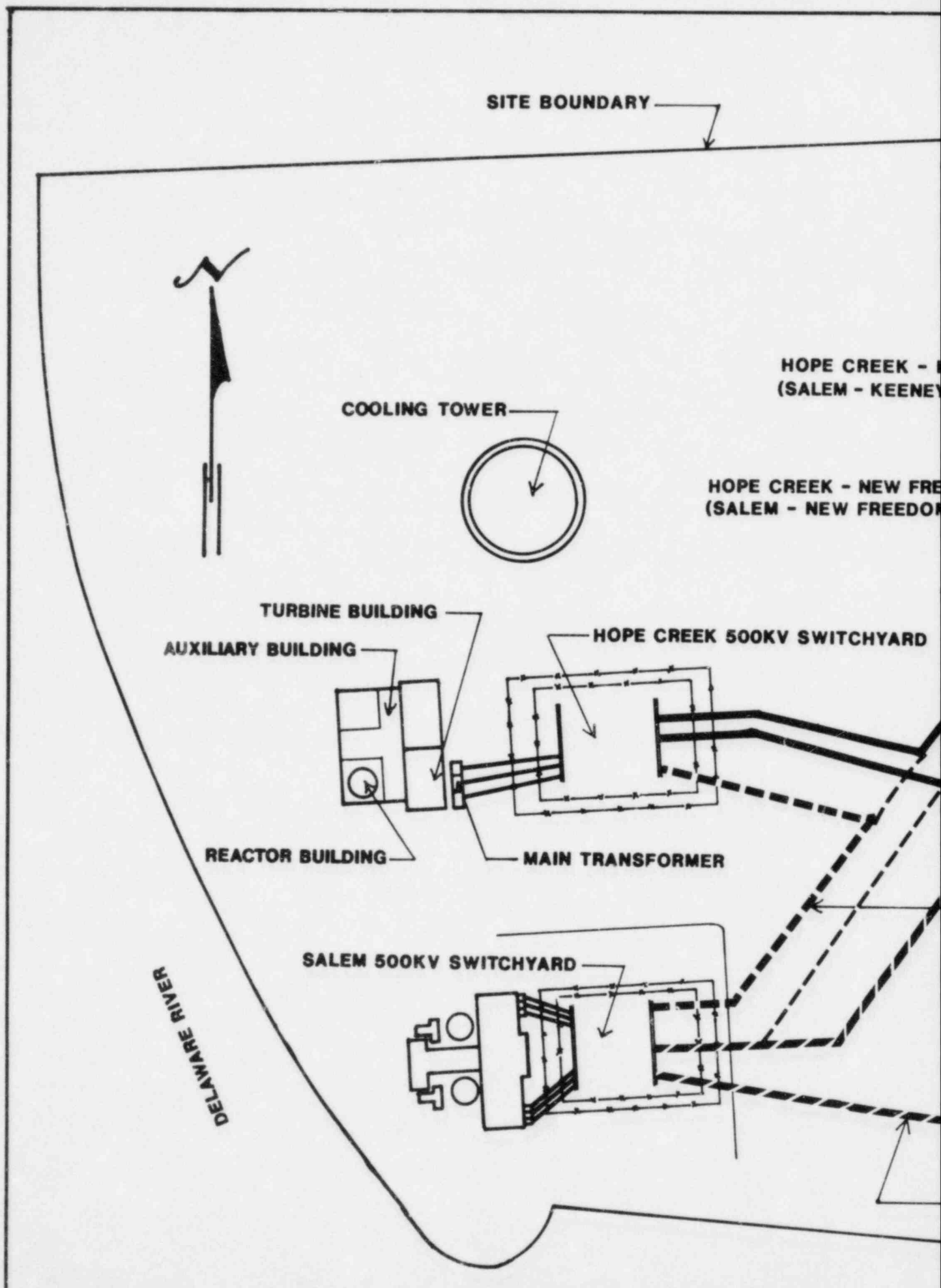


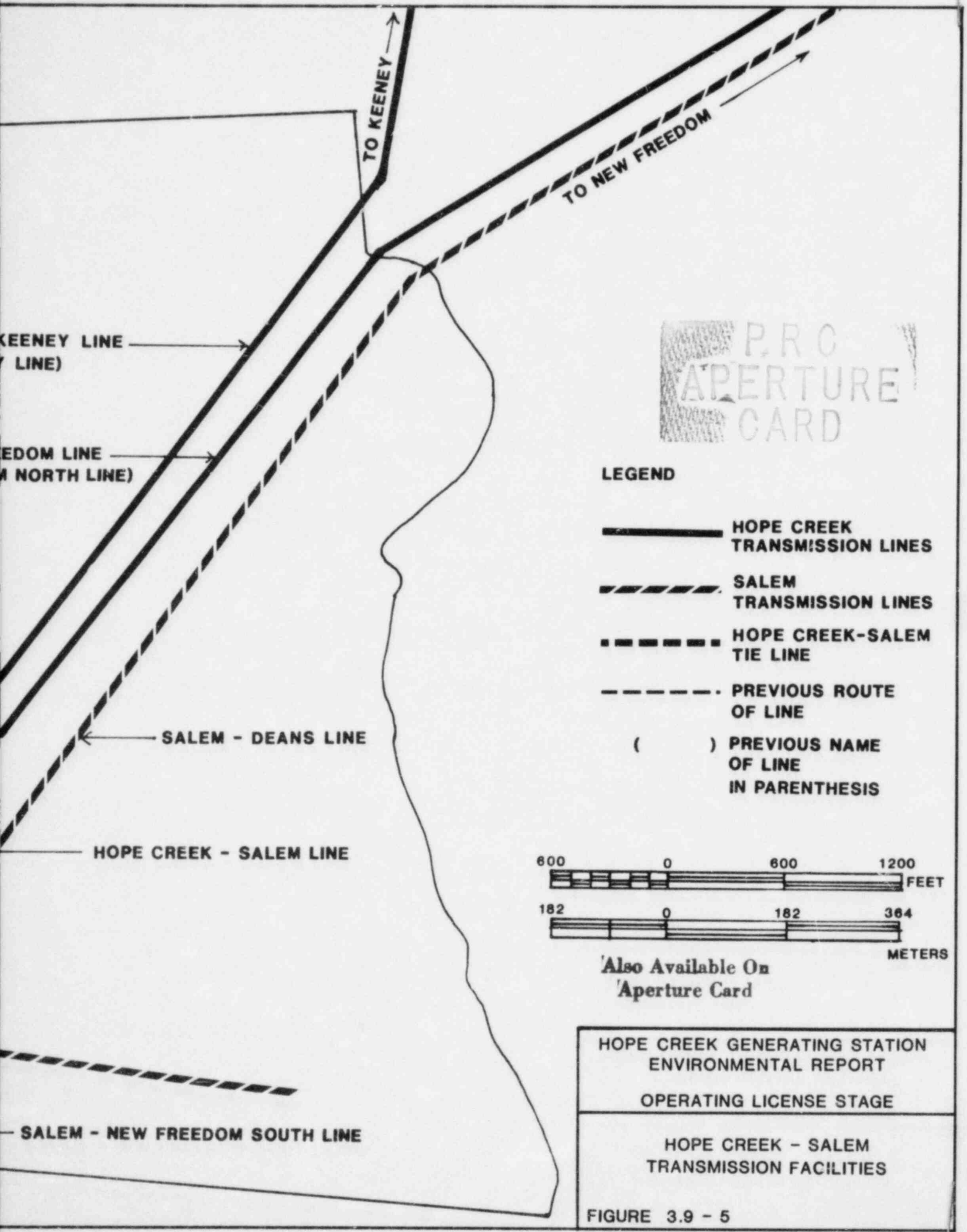
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

HOPE CREEK - KEENEY ROW

FIGURE 3.9 - 4


SITE BOUNDARY
HOPE CREEK -
(SALEM - KEENEY
COOLING TOWER
HOPE CREEK - NEW FRE
(SALEM - NEW FREEDOM
TURBINE BUILDING
AUXILIARY BUILDING
HOPE CREEK 500KV SWITCHYARD
REACTOR BUILDING
MAIN TRANSFORMER
SALEM 500KV SWITCHYARD
DELAWARE RIVER



P.R.C.
APERTURE
CARD

'Also Available On
'Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

HOPE CREEK - SALEM
TRANSMISSION FACILITIES

FIGURE 3.9 - 5

HOPE CREEK GENERATING STATION

APPLICANT'S ENVIRONMENTAL REPORT-OPERATING LICENSE STAGE

VOLUME 2

The Energy People

PSE&G

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT - OPERATING LICENSE STAGE

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CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, STATION CONSTRUCTION, AND TRANSMISSION FACILITIES CONSTRUCTION

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CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, STATION CONSTRUCTION AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND STATION CONSTRUCTION

The environmental effects of construction as presented in the construction permit stage analysis are consistent with actual conditions (Reference 4.1-1). Methods used in the construction of the facility were those detailed in the construction permit proceeding and the New Jersey Coastal Area Facility Review Act (CAFRA) permit process (Reference 4.1-2).

Control and monitoring of construction activities followed various local, state and federal permit requirements and commitments. Site preparation involved dredging, excavation, drainage, removal and deposit of natural materials for the erection of the major structures.

Preparation activities have resulted in the complete removal of vegetation and soils in certain areas. Associated dewatering operations required for laying the plant foundation and filling low elevation areas temporarily changed the water table. Changes to terrain and vegetation on the rest of the site were minimal.

The visual impact of construction activities was minimal due to the isolation of the site.

Dredging, Excavation and Spoil Disposal

Dredging was necessary in order to form and deepen the channels to the circulating and service water intake system. Dredging disturbed approximately seven hectares (17 acres) of the Delaware River bottom. The total amount of the hydraulically dredged material that was removed was about 10,000 cubic meters (13,000 cubic yards). Restrictions imposed by the DRBC limited dredging activities to the months of September and December through February (Reference 4.1-3).

The dredged materials were disposed of as fill in a 26 hectare (65 acre) diked area, so that very little suspended sediments returned to the Delaware River.

Construction of the reactor structure, power generating components, turbine, and the administration, service and auxiliary buildings, resulted in a considerable quantity of surplus excavated materials. There were two disposal areas located on the site; the northern disposal site received the hydraulically dredged spoils and some excavated materials, while the eastern disposal site was used predominantly for disposal of excavated fill. One to two meters (three to six feet) of fill covers approximately 57 hectares (140 acres) of wetlands.

Dredging, excavation and disposal activities were in compliance with standards for Soil Erosion and Sediment Control in New Jersey, adopted June 14, 1972 by the New Jersey State Soil Conservation Committee.

Dewatering

Soil dewatering operations resulted in the discharge of several million liters per day of brackish water from shallow aquifers into the Delaware Estuary. The aquifers, which are partially recharged by tidal intrusion, contain water whose quality characteristics are not significantly different from those of the estuarine water; thus, there was no impact on the aquatic resources from these discharges (Reference 4.1-4). Observation wells were installed east and west of the excavation, for the turbine generator and the auxiliary and reactor buildings, to monitor the groundwater level and to insure that the dewatering operation did not significantly affect the existing groundwater level. Dewatering did not affect wells and vegetation in the vicinity of the island (Reference 4.1-5a).

Service Water Intake Structure

The intake is located at the waterfront; it is substantially submerged. Temporary cofferdams, erected during construction, restricted disturbance to relatively small and immediate, and relatively unproductive, areas in water. Some of the sheet piling was removed following construction; however, the rest of the sheet piling remained as part of the permanent structure. The pilings on the east and the west ends were cut out to allow for unobstructed flow of water.

All disturbed shoreline protection works were reestablished or replaced with suitable materials.

Access Roads, Barge Channel and Traffic

The only access by land to the site is a road constructed by PSE&G; this road connects with a secondary road about five kilometers (three miles) to the east.

Waterborne (barge) traffic reaches the site by way of a navigation channel maintained from the site to the main channel in the river, and by a secondary channel dredged to an unloading site at the southern end of Artificial Island.

During the peak of HCGS construction employment, which ranged between 7000 and 8000 people, HCGS workers used an estimated 4600 to 5300 passenger cars. Traffic between the site and the city of Salem was heavy during the peak of construction, especially at starting and quitting time. On-site parking facilities were sufficient to accommodate all cars. Deliveries of construction materials were scheduled where possible during off-peak hours. Construction of an on-site concrete batch plant reduced construction traffic by a significant amount.

Buildings and Major Components

The main structure on site is identified as the Power Block. The Power Block consists of; reactor building, turbine building, radwaste/service area, control/diesel generator area, and administration facility. Other major structures are the auxiliary boilers, a natural draft cooling tower, shops and warehouses. Construction forces used numerous temporary buildings and trailers for offices, equipment storage and workshops; most of these buildings will be dismantled and removed when they are no longer needed.

A temporary concrete batch plant was constructed on the site, and removed after concrete operations were terminated.

Noise

The major source of noise during construction was pile driving. There was no noticeable noise impact at the nearest New Jersey residence, within five kilometers (three miles).

Dust and Gaseous Control

Some roads were paved in order to help control dust. Water was sprinkled on unpaved roads during construction to cut down and control the dust.

NJDEP permits were obtained where applicable for construction-related stationary emissions sources, and their terms were adhered to.

Gaseous emissions from gasoline and diesel-powered motor vehicles and equipment did not have any significant effect on the air quality of the area.

Water Supply and Sanitary Wastes

Two freshwater wells supply water for construction, potable and sanitary purposes (Reference 4.1-5b).

During the first few years of construction, sanitary waste facilities consisted, at first, of portable self-contained units, which were followed by septic tanks and a temporary septic field. Later during construction, three package sewage treatment plants were installed to handle and treat sanitary wastes (see Section 3.7) (Reference 4.1-5c).

REFERENCES

4.1-1 United States Atomic Energy Commission, Hope Creek Construction Permit (CPPR-120), November, 1974.

4.1-2 New Jersey Department of Environmental Protection, Coastal Area Facility Review Act (CAFRA), (N.J.S.A. 13.19, et seq.), Permit CA-74-014, January, 1976.

4.1-3 Delaware River Basin Commission, Docket Decision D-73-193CP, June, 1975.

4.1-4 United States Environmental Protection Agency - Effluent Discharge, NPDES Permit NJ0025411, July, 1975.

4.1-5 New Jersey Department of Environmental Protection, Division of Water Resources:

a. Dewatering Permit, W.S. No. P-956, July, 1974.
b. Subsurface Water Diversion Permit, W.S. P-998, January, 1975.
c. Water Treatment Construction and Operation Permits No. SO-5-76-5720 A-B, SC-76-0193-4, January, 1975.

4.2 TRANSMISSION CORRIDORS

Clearing operations associated with transmission line footings, rights-of-way and access roads minimized disturbance of the terrestrial ecosystem, in accordance with plans at the construction permit stage (References 4.2-1 and 4.2-2). The transmission line parallels a pre-existing 500 kilovolt transmission line between Salem Generating Station and the New Freedom Switching Station. The existing right-of-way was sufficient to accommodate the new line without any additional right-of-way width. The accomplishment of much of the site preparation at the time of the original installation minimized the need for additional disturbance. Existing roads were used as much as possible in the marshland. The design and grading of new access roads and tower sites minimized erosion problems by including and installing culverts and drainage ditches where necessary.

The design of the transmission lines conforms to the requirements set forth by the National Electrical Safety Code (Reference 4.2-3). Routes are in accordance with all applicable safety rules for the installation and maintenance of electric supply lines (Reference 4.2-4). Also, guidelines established during the construction permit stage for overhead transmission lines have been followed where applicable (see Section 5.5). Height and clearance of the lines over flood areas are in compliance with Army Corps of Engineers restrictions (Reference 4.2-5).

For more details see Section 3.9.

REFERENCES

4.2-1 United States Atomic Energy Commission, Hope Creek Construction Permit (CPPR-120), November, 1974.

4.2-2 New Jersey Department of Environmental Protection, Coastal Area Facility Review Act (CAFRA), N.J.S.A. 13.19, et seq., Permit CA-74-014 (January, 1976), p. 39, 40, 41.

4.2-3 ANSI, National Electric Safety Code (ANSI C2-1981) Section 23 (Clearances), p. 138.

4.2-4 American National Safety Institute, Safety Rules for Installation and Maintenance of Electric Supply and Communication Lines, (ANSI C2-1981).

4.2-5 Army Corps of Engineers, letter from Colonel Carroll D. Strider to Mr. R. L. Reed, PSE&G, February 19, 1971.

4.3 RESOURCES COMMITTED DURING CONSTRUCTION

Construction materials consumed were neither exotic nor scarce, and were consistent with construction permit stage plans. Their commitment was not considered to be of serious concern. Station construction did not result in any significant irreversible or irretrievable commitments of resources. The associated loss of terrestrial habitat was considered acceptable and was within the area allocated at the construction permit stage.

Wells provided water to meet construction requirements. Maximum water withdrawal was limited to 68,000,000 liters (18,000,000 gallons) per month. This use of wells during construction did not result in a significant lowering of groundwater tables, except for intentional dewatering of the near surface water table to aid construction. With the cessation of dewatering, this level has returned to its previous state.

4.4 RADIOACTIVITY

The applicant planned HCGS as two nuclear units and described it as such at the construction permit stage. On December 23, 1981, PSE&G cancelled further construction of Unit 2, but continued work on Unit 1. Since HCGS is no longer a multi-unit station, the information requested by Regulatory Guide 4.2, Section 4.4 is no longer applicable.

4.5 CONSTRUCTION IMPACT CONTROL

PSE&G established a program to assign responsibilities and to provide for periodic review of all construction activities in order to assure conformance with the environmental conditions set forth in the construction permits issued by the Atomic Energy Commission (Construction Permit CPPR-120) (Reference 4.5-1) and by New Jersey under the Coastal Area Facility Review Act (CAFRA Permit CA #74-014) (Reference 4.5-2). The program included written procedures, instructions and work rules. Environmental monitoring procedures were established within a framework which ensured protection of the site and prompt response to any problem. The PSE&G Construction Manager and his staff had the responsibility for the day-to-day adherence to and monitoring of the environmental protection program. PSE&G environmental personnel conducted site inspections on a continuous basis. For details refer to Section 4.1.

REFERENCES

4.5-1 United States Atomic Energy Commission, Hope Creek Construction Permit (CPPR-120), November, 1974.

4.5-2 New Jersey Department of Environmental Protection, Coastal Area Facility Review Act (CAFRA), (N.J.S.A. 13.19, et seq.), Permit CA-74-014, January, 1976.

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CHAPTER 5

ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

5.1.1 EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

All non-radioactive liquid waste streams at HCGS discharge to the Delaware River or are collected for treatment. The various point sources must meet applicable effluent limitations, as defined by state and federal regulatory agencies. These effluent limitations are adequate to assure that water quality standards for the Delaware River, as set forth by these agencies, are not exceeded.

HCGS discharges are controlled to meet effluent limitations established by the DRBC and the EPA. In those instances where different limitations have been established for the same parameter, PSE&G has observed the stricter requirement in establishing treatment processes.

The applicable water quality standards and effluent limitations of the DRBC are provided in Table 5.1-1. These standards are based on a given industry's location in one of the Commission's geographic zones. As Figure 5.1-1 shows, HCGS is situated at River Mile (RM) 51, which falls within DRBC Zone No. 5 (RM 78.8 to RM 58.2).

The EPA, through the National Pollutant Discharge Elimination System (NPDES), regulates waste streams that discharge into navigable waters. In 1975, PSE&G applied for and obtained an NPDES permit (No. NJ0025411). Within the permit (Reference 5.1-1) the EPA established effluent limitations and monitoring requirements for station discharges. These discharge constraints were based on effluent guidelines and standards for the Steam Electric Power Generating Point Source Category as codified in 40 CFR 423, which was in effect at the time.

In 1980, PSE&G submitted a timely renewal application for this permit (Reference 5.1-2). (The NPDES renewal application was submitted on February 1, 1980, when HCGS was still designed for two reactor units; the application does not reflect single-unit operation.) The EPA revised 40 CFR 423 on November 9, 1982 (Table 5.1-2). There is no serious conflict between the old and new regulations. Under the new limitations, cooling tower maintenance chemicals can be discharged (i.e., iron and chromium).

On April 13, 1982, the NJDEP, in accordance with the provisions of the Clean Water Act, became responsible for enforcement of this permitting system (NJPDES). The new administering agency (NJDEP) has not yet renewed the HCGS permit; however, under NJAC 7:14-2.3, the 1975 permit remains valid.

Effluent characteristics for HCGS as a two-unit plant, including certain design changes subsequent to 1975, are provided in the NPDES renewal application (Reference 5.1-2).

Agency regulations require that waste streams from the generating station may not be initiated without the requisite permits and approvals from both the DRBC and the NJDEP. Agency licensing and a 401 certification assures that water quality standards will be met for pollutants of concern to both groups.

Thus, acquisition of and adherence to the required permits assures that facility discharges will not have an adverse impact on Delaware River water quality or on the water quality of other states.

5.1.2 PHYSICAL EFFECTS

HCGS now consists of a single unit, which results in a discharge flow from the heat dissipation system that is considerably reduced from that evaluated at the CP stage (Sections 3.3 and 3.4). This section reexamines the effects of the heat dissipation system on the Delaware River, taking into account up-to-date cooling tower performance data, discharge exist velocity and location, and the elimination of the cold water bypass.

Mathematical modeling determined seasonal behavior characteristics of the HCGS heat dissipation system's thermal plume in the Delaware River. The MIT near-field and Transient Plume Models (TPM) simulated near-field and far-field dilution and dispersion behavior of the discharge (see Appendix A). The near-field model included modifications to incorporate shallow water effects (predominantly from bottom interactions), and the TPM model was applied directly for far-field shallow water analysis using boundary conditions supplied by the near-field analysis.

To establish a conservative set of model input conditions, predicted cooling tower discharge characteristics, including temperature and dissolved solids, were examined. A comparison was made among these conditions, ambient river conditions (temperature and salinity) and Delaware River Zone 5 water quality standards.

Within each three-month season, the month that contained the worst case condition represented that season in the simulation.

Station discharge temperatures expected to be exceeded less than five percent of the time were used, along with a cooling tower dissolved solids concentration factor of 1.8, which is above anticipated monthly concentrations. Each simulation assumed a constant discharge of 87,000 liters per minute (23,000 gallons per minute).

Maximum river current velocity values of 0.54 meter per second (1.76 feet per second) at maximum flood, and 0.56 meter per second (1.84 feet per second) at maximum ebb, were selected to approximate the frictional drag effect of the shoreline. Delaware River mainstem average maximum velocity in the vicinity is 0.8 meter per second (2.6 feet per second) at maximum flood and 1.0 meter per second (3.2 feet per second) at maximum ebb (Reference 5.1-3).

Section 3.4 presents blowdown discharge characteristics for temperature, dissolved solids and flow. Section 3.4 also provides maximum expected temperatures (to be exceeded less than five percent of the time), ambient temperature and cycles of concentration in the cooling tower blowdown.

Each seasonal simulation was performed for a complete tidal cycle; the resulting thermal plume was plotted for the four tidal stages (low slack, maximum flood, high slack and maximum ebb). Model results indicate that the HCGS discharge is predominantly negatively buoyant. In those cases where the near-field analysis results indicated that the discharge plume would stratify, surface and bottom cross sections were generated. The summer simulation proved the plume to be below mid-depth; therefore, an additional mid-depth cross section was generated.

During winter (February), at high slack tide, a distance of 680 meters (2230 feet) is required for mixing in order to meet the 2.2°C (4°F) maximum temperature limitation. This distance is well within the DRBC's 1070 meters (3500 feet) mixing zone requirement. Temperature increases above 2.2°C (4°F) at the surface during these same conditions are confined within 180 meters (600 feet) of the HCGS discharge. Under all other conditions, the thermal plume meets temperature standards at a mixing zone distance of less than 610 meters (2000 feet) (see Appendix A).

Figures 5.1-2 through 5.1-5 depict the model results that indicate that the HCGS thermal plume meets the DRBC temperature increase standard of 2.2°C (4°F) from September to May and 0.8°C (1.5°F) from June to August, or a maximum of 30°C (86°F) outside a 1070 meter (3500 foot) mixing zone, under all conditions simulated.

Maximum temperature in the summer (August) at the end of a 1070 meter (3500 foot) mixing zone is 26.9°C (80.4°F), which is within the 30°C (86°F) DRBC standard.

5.1.3 EFFECTS ON AQUATIC ECOLOGY

Baseline aquatic studies have identified over 100 genera of phytoplankton, 200 invertebrate taxa and 110 species of fish as existing at least part of the year in the Delaware River in the vicinity of HCGS. A small portion of each of these populations is affected by the operation of the station's heat dissipation system, due either to the operation of the intake (impingement/entrainment effects) or the discharge (thermal effects). The cooling system is designed to reduce biotic losses by following the EPA's recommendations for minimizing cooling water system impacts, which involve the control of the design, location and capacity of the heat dissipation system (References 5.1-4 and 5.1-5). Section 3.4 provides a complete description of the heat dissipation system.

5.1.3.1 Impingement

Small fish are impinged on cooling water intakes, because of their presence within that volume of water being withdrawn, or by their attraction to or random movement into the vicinity of the intake. Once in the area of influence, these fish may swim free, by employing swim speeds in excess of the intake velocity, or remain in the area to forage. By remaining in this area to feed, the fishes' energy reserves may decrease, to the point where they may become entrapped because their swim speed can no longer overcome the intake velocity. Once a fish's swim speed is reduced below the intake velocity, the fish becomes impinged by the hydraulic forces against the traveling water screens within the intake structure. Mortality may occur due to asphyxiation (by holding the individual against the screen, thereby inhibiting proper gill movement, or holding the individual out of the water for a prolonged period of time), descaling (by screen wash water sprays or the flow of water through the screen), exhaustion (from swimming against the intake velocity) or starvation.

The key elements in the design of the HCGS intake which minimize impingement losses are:

a. Closed cycle cooling employing low water makeup requirements: approximately 2.16 cubic meters per second (76 cubic feet per second) during normal operating conditions, and 3.66 cubic meters per second (129 cubic feet per second) following normal shutdown (see Section 3.3). This reduces the number of fish susceptible to impingement.

b. Low intake velocities through the trash racks and through the traveling screens; velocities are approximately 0.03 meter per second (0.1 foot per second) and 0.12 meter per second (0.39 foot per second), respectively (see Section 3.4). This reduces the swim speed necessary to escape the intake's attractive forces.

c. Location of intake structure parallel to and nearly flush with the shoreline. This location increases tidal flushing of the forebay, and eliminates long intake canals and blind pockets, thus reducing the entrapment potential.

d. Continuous operation of traveling screens; traveling screens are outfitted with a fish return system that includes screen panel buckets, a low pressure fish removal system, a high pressure trash removal system, and troughs to return debris and fish to the river (Figures 5.1-6 and 5.1-7). Such operation reduces descaling, asphyxiation and exhaustion.

The Delaware River has an average freshwater discharge of 340 cubic meters per second (12,000 cubic feet per second) into the head of the estuary at Trenton, and 468 cubic meters per second (16,500 cubic feet per second) at the site. The average tidal flow as measured at Wilmington, Delaware, about 32 kilometers (20 miles) north of the site, has been estimated at 11,000 cubic meters per second (400,000 cubic feet per second). Tidal flows dominate flow velocities at the site. Water usage at the station during normal operation accounts for less than 0.6 percent of the freshwater flow at Trenton (less than 0.45 percent of the freshwater flow at the site), and less than 0.02 percent of the tidal flow of the river.

The service water intakes at the adjacent Salem Generating Station and HCGS are similar with respect to location, capacity and design. During 1977 and 1978, PSE&G made estimates of service water intake impingement at Salem Generating Station (Reference 5.1-6). Estimates ranged from near zero to approximately 25,000 fish per month (Figures 5.1-8 and 5.1-9). Of the 110 species of fish taken during the overall ecological study (1970 to 1978), bay anchovy, weakfish, white perch and spot were consistently among the most abundant species in the Delaware River. They were also the most abundant in the impingement samples. Impingement abundances of these species were extremely variable by season (Figures 5.1-10 through 5.1-17), compared to the abundances of these species in the river.

Impingement losses, from such an intake, however, represent a very small fraction of riverine abundance. This supports the conclusions presented at the construction permit stage concerning the low aquatic impact of impingement.

5.1.3.2 Entrainment

Entrainment is the process by which smaller organims are drawn through the heat dissipation system by the mass motion of the water. Approximately 2.16 cubic meters per second (76 cubic feet per second) of water is withdrawn from the Delaware River through the service water intake structure. This water is primarily used to make up for evaporative cooling tower losses and blow down. It is prepared for this use by straining out (through 0.013 centimeter (0.005-inch) mesh) both biota and particulate material, and chlorinating. This water is introduced into the cooling tower basin after passing through the safety auxiliaries cooling system (SACS) and reactor auxiliaries cooling system (RACS) heat exhangers of the service water system (SWS).

As this cooling water is withdrawn from the river, plankton and other small organisms entrained in this water enter the SWS. Generally, entrained organisms do not survive passage through such a system. Plankton exhibit great fluctuations in their temporal and spatial abundances and distributions (see Section 2.2.2); they are very resilient due to their short regeneration times and the diversity of sources from which individuals may be recruited. Potential phytoplankton mortality due to station operation should have an insignificant effect on the various trophic levels in the vicinity of HCGS (Reference 5.1-7).

The closed-cycle cooling systems used at HCGS reduce the potential exposure of the plankton to entrainment. Densities of planktonic species are generally low during fall, winter and early spring, so the periods of high exposure are limited to the late spring and summer. Station water usage accounts for less than 0.02 percent of the tidal river flow at Wilmington, Delaware, and 0.6 percent of the fresh water flow at Trenton, New Jersey (less than 0.45 percent of the fresh water flow at the site). Water usage by the station is nominal compared to the volume of water available in the Delaware River.

PSE&G anticipates that the HCGS service water intake will not selectively entrain microzooplankton or macroinvertebrates. This conclusion is based on two series of river and entrainment abundance samples collected in 1978 during one-unit operation at the adjacent Salem Generating Station's circulating water system (CWS) (Reference 5.1-6). Both series had similar species compositions, abundances and temporal distributions. Based on these data, it appeared that Salem did not selectively entrain invertebrates.

According to the same study, the Salem Generating Station CWS also entrained ichthyoplankton with relatively little selectivity. Differences between the series were predominantly due to size-specific gear selectivity or to small sample size.

The incidence of ichthyoplankton in entrainment samples in the Salem Generating Station's CWS is consistent with patterns of temporal occurrence, species composition and relative abundance noted during both the concurrent and the preoperational riverine ichthyoplankton samplings. HCGS should function in the same manner as the Salem Generating Station.

5.1.3.3 Effect of Thermal Discharge

At full power operation, the maximum winter monthly average discharge temperature is 16.1°C (29.5°F) above ambient river temperature. The highest summer monthly average discharge temperature is 4.2°C (7.5°F) above ambient river temperature. The flow rate of this heated water is approximately 1.32 cubic meters per second (21,360 gallons per minute).

With an average tidal flow of approximately 11,000 cubic meters per second (400,000 cubic feet per second) past the site, there should be no discernible far-field temperature rise in the river as a result of this discharge. Section 5.1.2 presents a characterization of the thermal plume as it exists in the immediate vicinity of the discharge.

An organism in the river entering the plume at the discharge point should experience a very rapid increase in temperature, possibly to the maximum discharge temperature. Temperature changes are expected to occur for a pe od of less than two minutes. Even at the highest ambient summer temperature, a rapid change in water temperature is unlikely to be lethal to any significant portion of the organisms present. Temperature shock within the thermal plume during the winter is unlikely to have a measurable effect on local populations due to the low volume of the plume and the small cross-sectional area that the plume will occupy.

The potential for cold shock to aquatic organisms resulting from winter shutdowns of the plant is negligible. As Figure 5.1-4 shows, the small size of the thermal plume and the small area of the bottom affected by the effluent (a less than 8 meter (25 foot) radius from the end of the discharge pipe) suggest an insignificant effect on aquatic life due to any winter shutdown.

5.1.4 EFFECTS OF HEAT DISSIPATION FACILITIES

This section discusses the effects of the cooling tower on the meteorology of the area surrounding HCGS. Fogging, icing, precipitation modification, humidity changes, cooling tower blowdown and drift, noise and air quality impact are also addressed in this section. Sections 3.1 and 3.4 provide descriptions of the location and dimensions of the cooling tower.

5.1.4.1 Ground Fogging and Icing

Several studies have shown that natural-draft cooling tower plumes never intersect the ground; thus, they do not cause significant ground fogging or icing (References 5.1-8 and 5.1-9). The height of release and the buoyancy of natural-draft cooling tower plumes ensure this. Ground icing due to cooling tower drift is also negligible, since the total surface accumulation of water drift from natural-draft towers is insignificant. Measurements done in England for a 2000 megawatt fossil plant, downwind from a natural-draft cooling tower complex of eight towers with efficient drift eliminators, indicate a maximum drift deposition rate of 0.02 millimeters per hour (7.9E-04 inch per hour) of liquid water (Reference 5.1-10). This rate is too low to cause any ground icing or wetting.

5.1.4.2 Precipitation Modification

Observations of precipitation falling from natural draft plumes are very limited. Kramer, et al., have documented one observation of light rain falling from a natural draft plume, and several observations of light snowfall (Reference 5.1-11). Though it may be possible for a cooling tower to modify the precipitation pattern immediately downwind of the tower, it would not significantly alter the total precipitation in the region, as the water vapor emissions from the towers are small compared to natural fluxes (Reference 5.1-9).

During the winter of 1975-1976, Kramer, et al., observed light snow from several different cooling towers on 10 separate days (Reference 5.1-12). This effect was found only during stable atmospheric conditions, with temperatures below -12°C (10°F) at the height of the plume centerline. There are several other variables, such as atmospheric stability, blowdown water chemistry, drift eliminator condition and condensation nuclei availability, which play a role in snowfall formation. The height to which the plume rises is such that in most cases the snow crystals would sublimate before reaching the ground. No precipitation modification is expected because of the low probability of these variables combining on any given day to create precipitation conditions.

5.1.4.3 Humidity Changes

Observational studies have shown that changes in ground-level relative humidity as a result of natural-draft cooling tower operation should not be expected. Spurr found no ground-level

relative humidity increases either upwind or downwind of the plant studied (Reference 5.1-10).

5.1.4.4 Cooling Tower Blowdown and Drift

Reference 5.1-13 shows, using 1977 on-site meteorological and hydrological data, that the average salt emission rate is 6.6 kilograms per hour (14.5 pounds per hour). This is not statistically different from the results obtained using the circulating water quality data presented in Section 3.4. Table 5.1-3 shows the comparison of maximum calculated annual and 24-hour average ground level air salt concentrations with the National Ambient Air Quality Standards (NAAQS). The maximum and second maximum 24-hour and the annual average ground level particulate concentrations are well below the NAAQS and State of New Jersey standards. Table 5.1-4 shows deposition rates, which were found acceptable by the NJDEP (Reference 5.1-13). All deposition rates are small; these rates rapidly decrease with distance from the tower.

5.1.4.5 Noise

See Section 5.6.2.

5.1.4.6 Visible Plume

The cooling tower plume only becomes visible if the water vapor contained within the plume condenses. The plume will remain visible until the droplets evaporate into the drier ambient air. Whether or not the plume is visible at any particular time depends primarily on the temperature and moisture content of the ambient air. Studies have shown that ambient saturation deficit is the best indicator of visible plume persistence (References 5.1-8 and 5.1-14). Saturation deficit is defined as a condition in which additional water vapor is required to produce moisture saturation at a given ambient temperature and pressure. Saturation of the air by the cooling tower plume results in a visible plume of condensed water droplets. Observational evidence has shown that the vast majority of visible plumes from natural-draft cooling towers do not persist downwind for more than 1.0 kilometer (0.6 mile) (Reference 5.1-9).

Table 5.1-5 presents visible plume lengths. The data on plume length are based on merging plumes from two single-point sources. With the cancellation of Unit 2, these numbers do not change significantly.

5.1.4.7 Cloud Enhancement and Shadowing

The extent to which natural-draft cooling tower plumes contribute to cloud formation can be qualitatively assessed based on observational studies conducted at the sites of three

operating cooling towers (Reference 5.1-8). At each of these sites, cooling tower plumes were observed to occasionally cause broken cloud decks to become overcast, and to enhance thin clouds. Separate cloud formations were occasionally observed to result from visible plume formation from the cooling towers, usually at altitudes of several thousand feet above ground. Based on the above observations, the potential for increased cloud development due to cooling tower operation appears to be minimal compared to the potential for development due to natural causes.

A cooling tower does have the potential, due to visible plume shadowing, to cause slight decreases in the amount of solar radiation received at a point on the ground. A study conducted on the natural-draft cooling tower of a 1500 megawatt fossil plant in Europe found that on a cloudy day the maximum shadowing effect is a 20 percent reduction in total radiation for short time periods (Reference 5.1-15). The effects of visible plume shadowing are obviously affected by the variability in wind direction, which causes the plume to move horizontally; thus, the plume does not remain over any one point for long periods of time. Long persisting visible plumes are relatively rare, so the effects of plume shadowing are minimal.

5.1.4.8 Meteorological Distributions

Section 2.3 contains wind direction - speed, air temperature and relative humidity distributions.

5.1.4.9 Aesthetic Effects

PSE&G discussed aesthetic effects caused by the structure itself at the Construction Permit stage. The effect of the visible plume should be negligible since plume lengths are generally less than 1.0 kilometer (0.6 mile), and the nearest residences are located 5.4 kilometers (3.4 miles) from HCGS.

5.1.4.10 Air Quality Impacts

EPA-Region II determined that HCGS does not require a Prevention of Significant Deterioration (PSD) permit (Reference 5.4-16).

24-hour TSP Concentration

Plant emissions inventory prior to the cancellation of Unit 2 included those from two cooling towers, three auxiliary boilers and eight diesel generators; however, two auxiliary boilers and only one diesel generator were assumed

to be operating at any one time. With the cancellation of Unit 2 and its associated cooling tower, the actual emissions inventory is reduced to those from one cooling tower, four diesel generators and three auxiliary boilers, with no more than two boilers operating at any given time.

Second 24-hour maximum average ground level TSP concentration increases resulting from the original set of plant operations are summarized in Table 5.1-6 for downwind distances of up to 3.2 kilometers (two miles). At greater distances, peak concentrations are well below 1.0 microgram per cubic meter; therefore, it can be assumed that there are no significant TSP contributions to existing baseline concentrations from HCGS. Concentrations in Delaware, Maryland and Pennsylvania are always less than 0.5 microgram per cubic meter. For direction sectors in which the second peak value exceeds 1.0 microgram per cubic meter at any distance, the second maximum 24-hour concentration reported in Table 5.1-6 is used. This second maximum concentration always occurrs on the same day for a given direction, at the distances reported. The dates of occurrence, based on the 1977 data used, are given. On these dates, cooling tower operations are responsible for the major portion of the total plant contributions, except ENE, SSW and SW of the plant, where emissions from all three sources are important. At all distances WSW, W and WNW of the plant, peak concentrations are always less than 1.0 microgram per cubic meter. For all directions, peak values always decrease with distance beyond 3.2 kilometers (two miles) downwind.

Plant contributions for the distances reported in Table 5.1-6 were added to peak 24-hour baseline TSP levels reported in Table 5.1-7 in order to determine compliance with national and state ambient air quality criteria for TSP. It is seen that operation of HCGS does not contravene any national or state 24-hour ambient air quality standard for TSP. With the reduction in the emission inventory, the impact on these standards is even less.

Annual TSP Concentrations

The same techniques were used for the annual TSP concentrations as for 24-hour TSP concentrations, with the following results. For all directions, estimated concentrations are below 0.5 microgram per cubic meter. Estimated concentrations exceed 0.1 microgram per cubic meter at distances less than 2.4 kilometers (1.5 miles) in directions NE, ESE, SE, NW and NNW of the plant, only. Beyond 3.2 kilometers (two miles), concentrations always decrease with distance for all directions. It is

seen that particulate emissions resulting from the assumed two-units operation do not contravene any national or state annual ambient air quality standard for TSP. The impact is even less due to the reduction in the emission inventory brought about by Unit 2 cancellation.

5.1.4.11 Effects on Visibility

The knowledge of visibility pollutant relationships uses prediction methods that are largely empirical. It is known that particle mass concentration and size distribution can be related to changes in an extinction coefficient, B, which in turn provides an estimate of visibility reduction.

It is well established that the major contribution to visibility reduction is due to submicron secondary particulate pollutants formed in the atmosphere from sulfate and other gaseous emissions at large distances from the source. The larger primary particulate emissions resulting from the operation of HCGS add very little to extra extinction (changes in B), and therefore play a minor role in visibility reduction.

5.1.4.12 Other Effects

Due to the minimal amount of cooling tower fogging and the high effluent release height, natural draft cooling tower operation is expected to cause no disruption of transportation.

There are no significant sources of pollutants within 1.9 kilometers (1.2 miles) of HCGS; therefore, no chemical interactions between the cooling tower and other industrial plumes should occur.

Turbulent Wake Effects from Plant Structures

As part of the technical support for the tall stack regulations in the 1977 Clean Air Act Amendments, the U.S. EPA has published a comprehensive review and literature search on the aerodynamic effects caused by building structures (Reference 5.1-17). According to this review, a structure produces a cavity of increased turbulence on its leeward side, 1.5 building heights deep, that persists for approximately five building heights downwind. Based upon these criteria, it is estimated that the HCGS turbine-reactor enclosure complex produces a turbulent wake on its leeward side, extending approximately 90 meters (295 feet) vertically, and persisting 305 meters (1000 feet) downwind.

Halitsky has shown through wind tunnel testing that the turbulent effects produced by rounded structures are not as large or severe as those produced by sharp-edged buildings (Reference 5.1-18). This is consistent with the results of a combined wind tunnel-field measurement study conducted by Smith and Mirabella on the cooling tower induced wake at the Rancho Seco Plant (Reference 5.1-19). Their results indicate that cooling towers produce a turbulent wake only when wind speeds exceed two meters per second (seven feet per second). They estimate that the wake would be 1.5 structure heights deep, and would persist for two to three tower diameters downwind. According to these criteria, the maximum wake produced by the HCGS cooling tower would be a turbulent region extending 235 meters (771 feet) vertically, and persisting 395 meters (1296 feet) downwind.

Effect of Turbulent Wakes on the Gaseous Reactor Effluent

The primary effect of structurally-induced wakes on the reactor effluent is to enhance dispersion; this is discussed in Section 2.3.5.

Effect of Turbulent Wakes on the Meteorological Tower
Tower Measurements

The turbulent wakes produced by the turbine-reactor enclosure and the cooling tower do not extend far enough to affect the meteorological tower. The tower is located approximately 1.6 kilometers (one mile) from the turbine-reactor buildings and the cooling tower, well beyond the distorted flow region in the lee of the plant.

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5.1-1 U.S. Environmental Protection Agency, National Pollutant Discharge Elimination System Discharge Permit for Public Service Electric and Gas Company, Hope Creek Generating Station, effective July 31, 1975.

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5.1-3 National Oceanographic and Atmospheric Administration National Ocean Survey, Atlantic Coast of North America - 1982 Tidal Current Tables, U.S. Department of Commerce, 1981.

5.1-4 USEPA, Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact, Effluent Guidelines Div., Office of Water and Hazardous Materials, USEPA, Washington, D.C., April, 1976.

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5.1-14 J. H. Coleman and T. L. Crawford, Characterization of Cooling Tower Plumes from Paradise Steam Plant, Proceeding of the Symposium on Environmental Effects of Cooling Tower Emissions, 1978.

5.1-15 J. Seeman, et al., Effects Produits sur l'Agriculture par les Tours de Refroidissement dans l'Environment descentrales Nucleaires, Department Etudes Generales - Programmes, Sites - Environment, Paris, France, 1976.

5.1-16 Richard J. Dewling, Ph.D., Acting Regional Administration, U.S. EPA Region II, correspondence containing PSD policy decision for Hope Creek Generating Station, October 19, 1981.

5.1-17 U.S. EPA, Guideline for Determination of Good Engineering Practice Stack Height, Office of Air Quality Planning and Standards, 1980.

5.1-18 J. Halitsky, "Gas Diffusion Near Buildings," Meteorology and Atomic Energy (1968), ed., D. H. Slade, Chapter 5-5.

5.1-19 J. B. Smith and V. A. Mirabella, Meteorological Effects of Cooling Towers at the SMUD Site, Appendix 3C, Rancho Seco Nuclear Generating Station Unit No. 1 Environmental Report, Sacramento Municipal Utility District, 1971.

TABLE 5.1-1

APPLICABLE
DELAWARE RIVER BASIN COMMISSION
WATER QUALITY REQUIREMENTS

PARAMETER	STREAM QUALITY[1] OBJECTIVES	EFFLUENT LIMITATIONS
Alkalinity	20≤ x ≤ 120 mg/l	-
Ammonia	-	< 35 mg/l (as nitrogen) as 30-day average
BOD^5	-	85% reduction for all secondary treatment systems
Color	-	< 100 units of true color
Debris, scum, floating material	-	None
Dissolved Oxygen	24 hr avg. ≥ 6.0 mg/l; April to June 15 and Sept. 16 to Dec. 31. Seasonal avg. ≥ 6.5 mg/l throughout the zone	-
Fecal Coliform	Max. geometric average; 200 per 100 ml	Max. geometric avg.; 200 per 100 ml or 1,000 per 100 ml in more than 10% of the samples over 30 consecutive days
MBAS	30 day avg.; ≤ 1.0 mg/l	-
Metal[2] (values not to exceed):		
Arsenic	0.05	0.1 mg/l
Barium	1.0	2.0
Cadmium	0.01	0.02
Chromium (VI)	0.05	0.10
Copper	-	0.20
Lead	0.05	0.10
Mercury	0.005	0.01
Selenium	0.01	0.02
Zinc	0.05	0.60
Oil	-	< 10 mg/l
pH	6.5 < x < 8.5	6 <x < 9
Phenols	< 0.01 mg/l	-
Suspended solids (for waste water treatment facilities)	-	< 30 mg/l as a 30 day average < 45 mg/l as a 7 day average

(1) NJDEP water quality standards for this zone of the Delaware River are equivalent to DRBC limitations.

The DEP further restricts toxic or deleterious substances, including but not limited to mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, phenols, pesticides. The allowable levels of these parameters are:

"None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota, produce undesirable aquatic life, or which would render the water unsuitable for the designated uses."

(2) The trace metals will not exceed these limits or one-twentieth of the 96 hour LC_{50}, whichever is lower.

TABLE 5.1-1 (Continued) (Page 2 of 2)

Temperature[3]	Net increase $\leq$ 2.2°C (40°F) during September through May. Net increase $\leq$ 0.8°C (1.5°F) during June through August. Max allowable = 30.1°C (86°F)	The induced increase shall not exceed 2.2°C (4°F) from September through May and 0.9°C (1.5°F) from June through August, or a maximum of 30.0°C (86°F), whichever is less, which temperatures shall be measured outside of designated heat disspation areas as described for parameter No. 13(b).
Heat Dissipation Areas	-	No longer than 1,100 m (3,500 ft) from point where waste enters stream
TON	$\leq$ 24 at 60°C (140°F)	$\leq$ 250
Toxicity	-	1:1 dilution, < 96 hr LC_{50}
Turbidity	Max 150 ntu 30 day avg.; $\leq$ 40 ntu	-

[3]As of February 27, 1984.

TABLE 5.1-2 (Page 1 of 4)

USEPA
EFFLUENT LIMITATIONS FOR THE SALEM ELECTRIC
POWER GENERATING POINT SOURCE CATEGORY APPLICABLE TO HCGS(1)

The following standards of performance establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a new source subject to the provisions of this subpart:

a. The pH of all discharges, except once-through cooling water, shall be within the range of 6.0-9.0.

b. There shall be no discharge of polychlorinated biphenyl compounds such as those commonly used for transformer fluid.

c. The quantity of pollutants discharged from low volume waste sources shall not exceed the quantity determined by multiplying the flow of low volume waste sources times the concentration listed in the following table:

Effluent Characteristic	Maximum for Any One Day	Average of Daily Values for 30 Consecutive Days Shall Not Exceed
TSS.....	100 mg/l	30 mg/l
Oil and Grease....	20 mg/l	15 mg/l

d. The quantity of pollutants discharged from chemical metal cleaning wastes shall not exceed the quantity determined by multiplying the flow of metal cleaning wastes times the concentration listed in the following table:

(1) Based on standards of performance for new sources (from 40 CFR 423, November 19, 1982).

TABLE 5.1-2 (Continued) (Page 2 of 4)

Effluent Characteristic	Maximum for Any One Day	Average of Daily Values for 30 Consecutive Days Shall Not Exceed
TSS.....	100 mg/l	30 mg/l
Oil and Grease....	20 mg/l	15 mg/l
Copper, Total.....	1.0 mg/l	1.0 mg/l
Iron, Total.....	1.0 mg/l	1.0 mg/l

e. The quantity of pollutants discharged in boiler blowdown shall not exceed the quantity determined by multiplying the flow of boiler blowdown times the concentration listed in the following table:

Effluent Characteristic	Maximum for Any One Day	Average of Daily Values for 30 Consecutive Days Shall Not Exceed
TSS.....	100 mg/l	30 mg/l
Oil and Grease....	20 mg/l	15 mg/l
Copper, Total.....	1.0 mg/l	1.0 mg/l
Iron, Total.....	1.0 mg/l	1.0 mg/l

f. The quantity of pollutants discharged in cooling tower blowdown shall not exceed the quantity determined by multiplying the flow of cooling tower blowdown sources times the concentration listed in the following table:

TABLE 5.1-2 (Continued) (Page 3 of 4)

Effluent Characteristic	Maximum Concentration	Average Concentration
Free available chlorine.....	0.5 mg/l	0.2 mg/l
	Maximum for Any One Day	Average of Daily Values for 30 Consecutive Days Shall Not Exceed
Toxic chemicals for cooling tower maintenance(1)	No detectable amount, except: Chromium 0.2 mg/l Iron 1.0 mg/l	No detectable amount, except: Chromium 0.2 mg/l Iron 1.0 mg/l

g. Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than two hours in any one day and not more than one unit in any plant may discharge free available or total residual chlorine at any one time unless the utility can demonstrate to the regional adminstrator or state, if the state has NPDES permit issuing authority, that the units in a particular location cannot operate at or below this level of chlorination.

h. In the event that waste streams from various sources are combined for treatment or discharge, the quantity of each pollutant or pollutant property controlled in paragraphs (a) through (f) of this section attributable to each controlled waste source shall not exceed the specified limitation for that waste source.

i. There shall be no discharge of heat from the main condensers except:

(1) As found in the EPA's list of 129 priority pollutants.

TABLE 5.1-2 (Continued) (Page 4 of 4)

1. Heat may be discharged in blowdown from recirculated cooling water systems provided the temperature at which the blowdown is discharged does not exceed at any time the lowest temperature of recirculated cooling water prior to the addition of the make-up water.

2. Heat may be discharged in blowdown from cooling ponds provided the temperature at which the blowdown is discharged does not exceed at any time the lowest temperature of recirculated cooling water prior to the addition of the make-up water.

[39 FR 36198, Oct. 8, 1974, as amended at 40 FR 7096, Feb. 19, 1975; 40 FR 23987, June 4, 1975; 47 FR 52290, Nov. 19, 1982]

TABLE 5.1-3

COMPARISON OF GROUND LEVEL AIR SALT CONCENTRATIONS
STANDARDS WITH HCGS

Averaging Time	LOCATION OF PEAK Direction (downwind)	LOCATION OF PEAK Distance (km/mi)	Concentration (ug/m^3)	Background Concentration (ug/m^3)	NAAQS Standard[2] (ug/m^3)	Percent of Standard[2]
24 hr	SE	0.8/0.5	5.5[1]	93.0	260 (150)	38 (66)
Annual	SE	0.42/0.26	0.06	42.8	75 (60)	57 (72)

(1) First and second maximum are the same.

(2) Primary - no parenthesis; secondary - in parenthesis.

TABLE 5.1-4

COMPARISON OF PEAK ANNUAL AND SEASONAL DEPOSITION RATES FOR HCGS

Averaging Time	Direction (downwind)	Distance (km/mi)	Deposition Rate (kg/km^2/month)
Annual	SE	0.42/0.26	60
Summer	WNW	0.34/0.21	40
Fall	NE & SE	0.61/0.38	10
Winter	SE	0.42/0.26	100
Spring	SE	0.47/0.29	300

TABLE 5.1-5

MAXIMUM VISIBLE PLUME LENGTHS(1)(2)

Month	NIGHT		DAY	
	meters	feet	meters	feet
January	1340	4380	710	2340
February	1340	4380	710	2340
March	1120	3670	500	1630
April	880	2900	370	1220
May	790	2600	270	870
June	680	2240	200	660
July	650	2140	0	0
August	710	2340	190	610
September	820	2700	220	710
October	1130	3720	330	1070
November	1160	3820	470	1530
December	1430	4690	680	2240

(1) Based on neutral stability conditions (frequency of occurrence: 70%) and wind speed of 24 km/hr (15 mph). Assumptions are that the two plumes (see Section 5.1.4.6) will combine as one, due to tower orientation, and that the source will be at a point above the tower equal to the final plume height.

(2) With cancellation of Unit 2 cooling tower these numbers are a conservative estimate.

TABLE 5.1-6

SECOND 24-HOUR MAXIMUM GROUND LEVEL TSP CONCENTRATIONS (ug/m^3) RESULTING FROM OPERATION OF HCGS[1]

Direction from Plant	DOWNWIND DISTANCE (miles) 0.50	0.75	1.0	1.5	2.0	Date
N	2.2	1.6	1.6	0.6	0.4	8/21/77
NNE	1.9	1.3	1.2	0.5	0.3	5/7/77
NE	4.7	2.9	2.7	1.1	0.6	5/5/77
ENE	1.6	1.1	1.0	0.6	0.4	1/31/77
E	5.1	3.4	3.5	0.8	0.4	2/25/77
ESE	6.3	4.1	4.3	0.6	0.3	5/9/77
SE	11.5[2]	6.9	7.4	1.0	0.5	5/13/77
SSE	3.4	2.1	2.1	0.6	0.3	5/13/77
S	2.7	1.8	1.7	0.7	0.4	8/24/77
SSW	1.2	0.8	0.7	0.5	0.4	4/14/77
SW	1.2	0.9	1.2	0.5	0.4	9/7/77
WSW	0.6	0.7	0.6	0.4	0.3	-
W	0.6	0.3	0.3	0.3	0.4	-
WNW	0.8	0.6	0.6	0.3	0.3	-
NW	10.9	7.3	7.4	1.3	0.9	4/1/77
NNW	7.6	5.1	5.0	0.9	0.4	3/3/77

(1) Concentrations reported in this table represent plant contributions only. Background TSP levels have not been added.

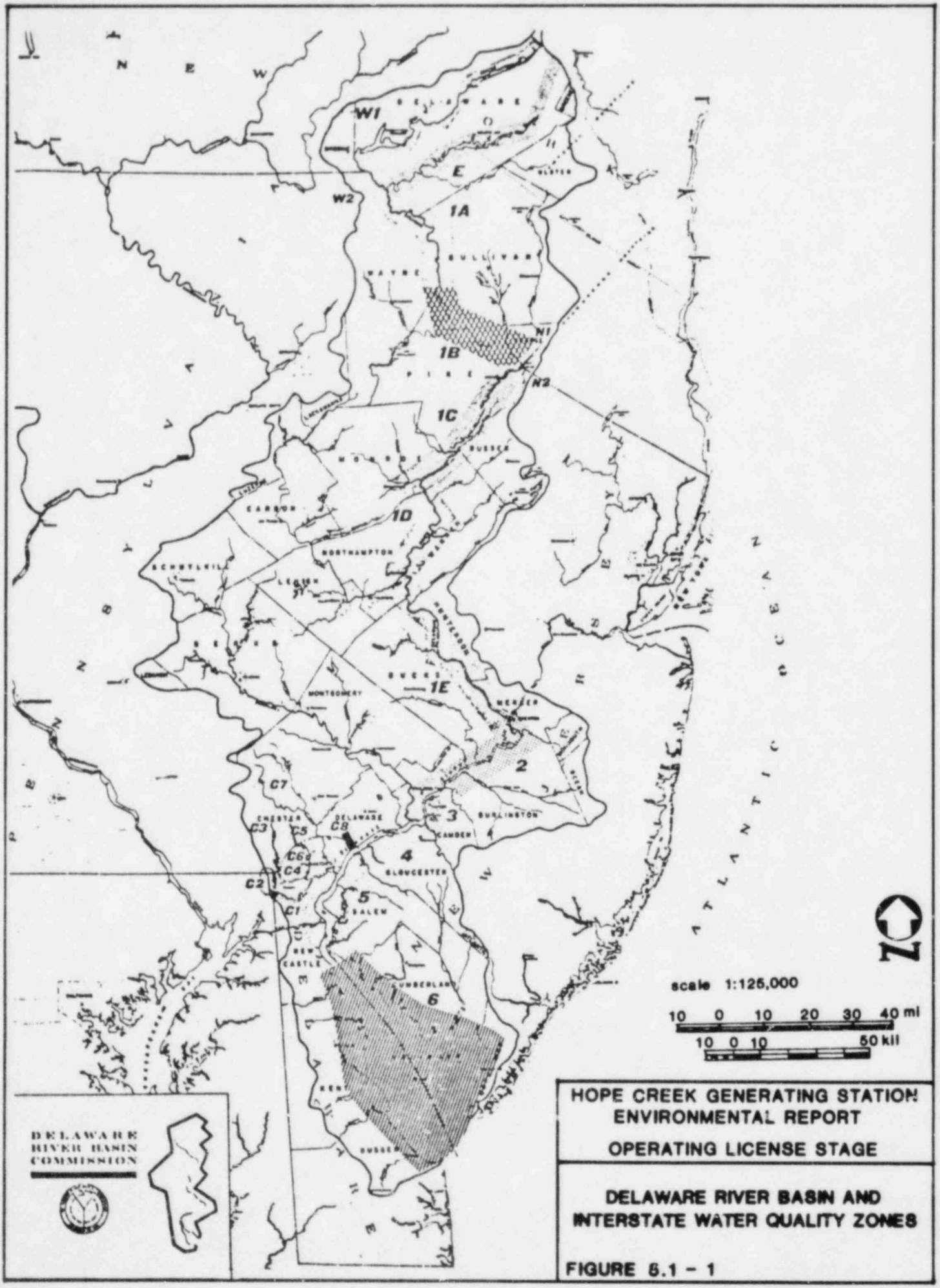
(2) Major source contributions to this peak concentration are the two cooling towers (see Section 5.1.4.10) assumed in the analysis. Based on 1977 data, this day was characterized by high persistent wind speeds from the NW resulting in plume downwash conditions.

TABLE 5.1-7

SECOND MAXIMUM 24-HOUR TSP BASELINE CONCENTRATION
(ug/m^3), 1977

Distance (Misc.)	SECTOR BEARING															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NN
0.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
1.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
1.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
2.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
2.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
3.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
3.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
4.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
4.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
5.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
5.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
6.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
6.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
7.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
7.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
8.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
8.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
9.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
9.5	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
10.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
11.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
12.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
13.0	93	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
14.0	106	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
15.0	106	79	70	70	85	79	67	77	87	97	107	118	119	110	101	9
20.0	275[1]	79	70	70	85	79	67	99	130	126	122	118	119	109	131	15
25.0	138	72	70	70	85	79	67	99	130	126	122	118	119	109	131	9
30.0	138	91	108	86	69	84	67	99	130	126	122	118	119	109	131	9
35.0	135	91	108	86	69	84	67	99	130	126	122	118	119	109	131	9
40.0	135	91	112	86	69	84	67	99	130	126	122	118	119	109	131	18
45.0	138	91	143	86	69	84	67	99	130	126	122	118	119	109	131	18
50.0	138	91	143	76	90	84	67	99	130	126	122	118	119	109	131	18
55.0	128	91	123	76	90	84	67	99	130	126	122	195	145	109	131	18
60.0	128	91	115	76	90	84	67	99	130	126	122	162	417	109	131	18

[1] Number 1 monitor in Wilmington, DE (New Castle County) used an estimated second 24-hour maximum. 24-hour maximum observed 493 ug/m^3. Number 2 monitor located in Wilmington, DE (New Castle County) estimated second 24-hour maximum to be 137 ug/m^3. This was also the observed 24-hour maximum.


W1
W2
E
1A
1B
1C
1D
1E
N1
N2
2
3
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C3
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C5
C6
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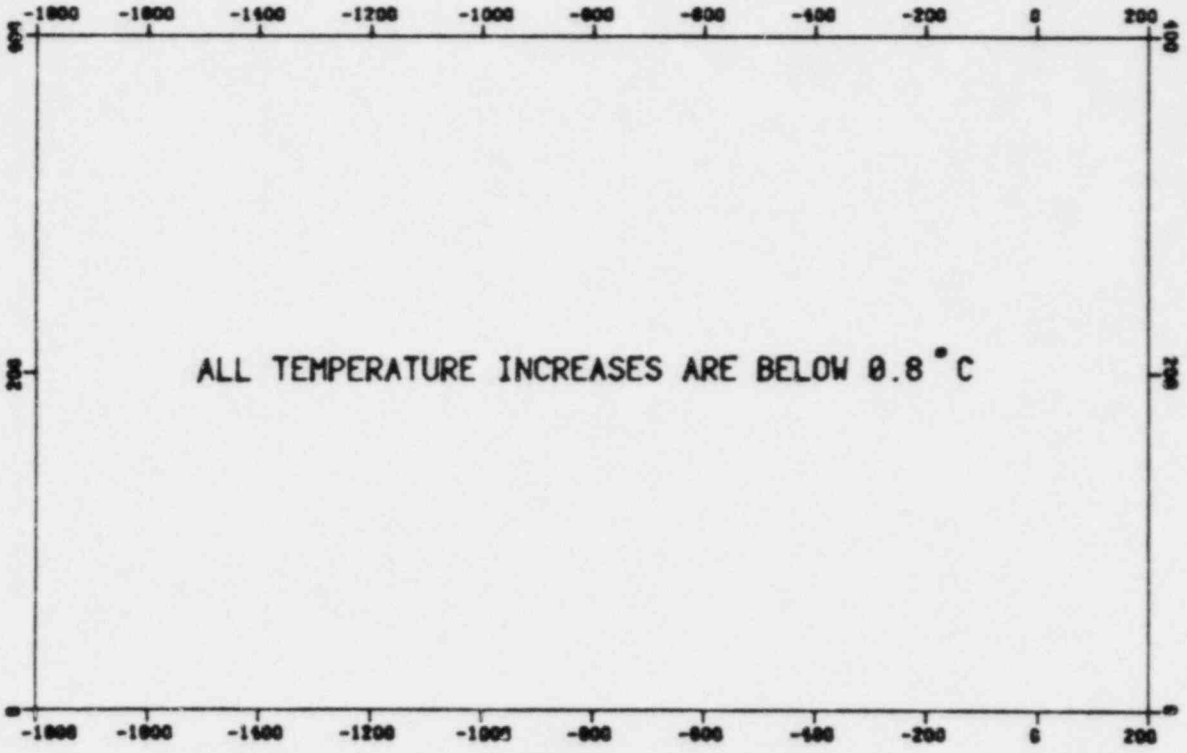
C8
ATLANTIC OCEAN
scale 1:125,000
10 0 10 20 30 40 mi
10 0 10 50 kil
DELAWARE RIVER BASIN COMMISSION
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE
DELAWARE RIVER BASIN AND INTERSTATE WATER QUALITY ZONES
FIGURE 5.1 - 1

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



EBB TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

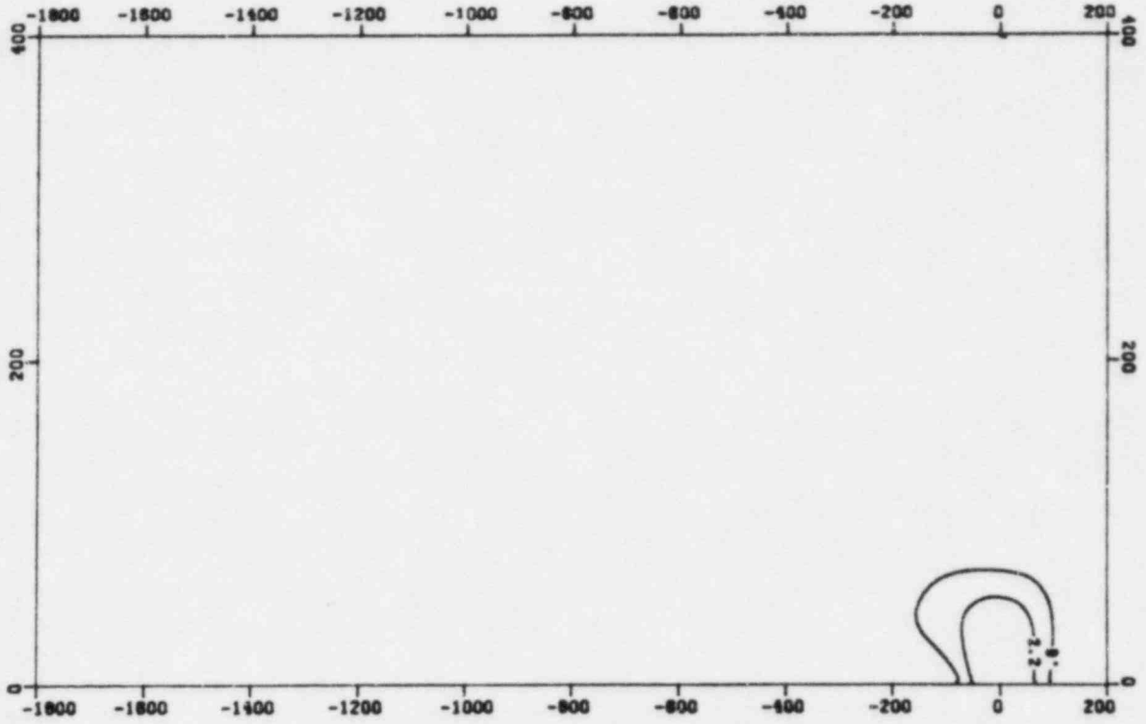
OPERATING LICENSE STAGE

AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2A

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



EBB TIDE
MID DEPTH

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

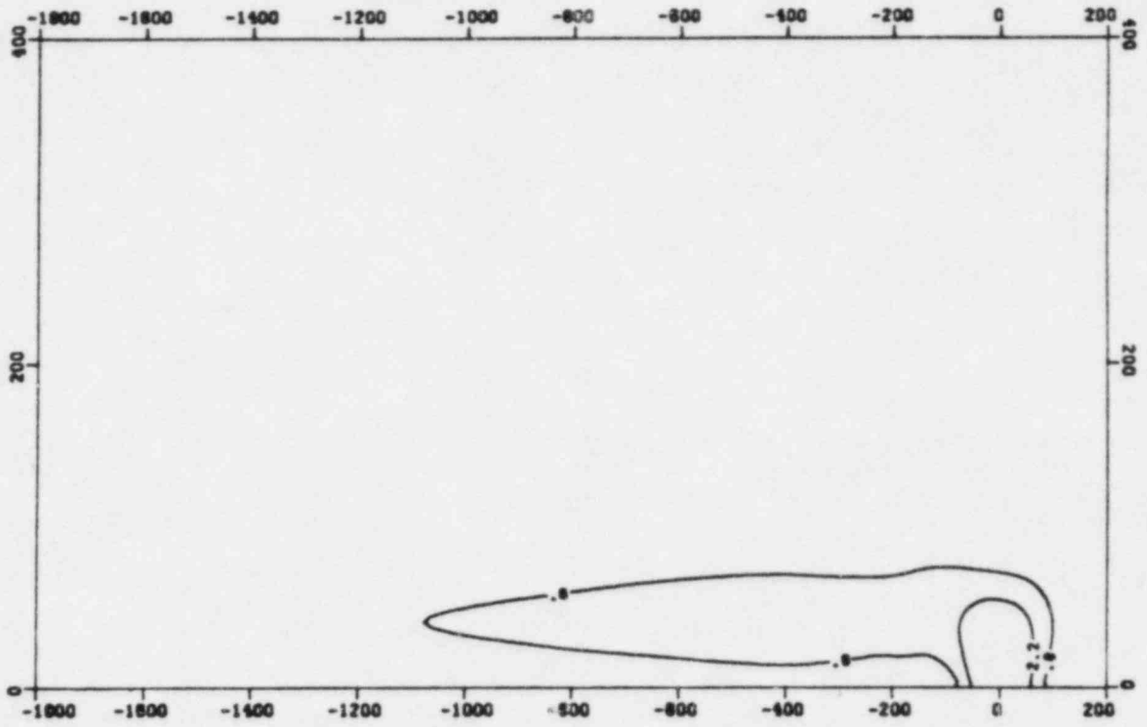
OPERATING LICENSE STAGE

AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2B

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



EBB TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

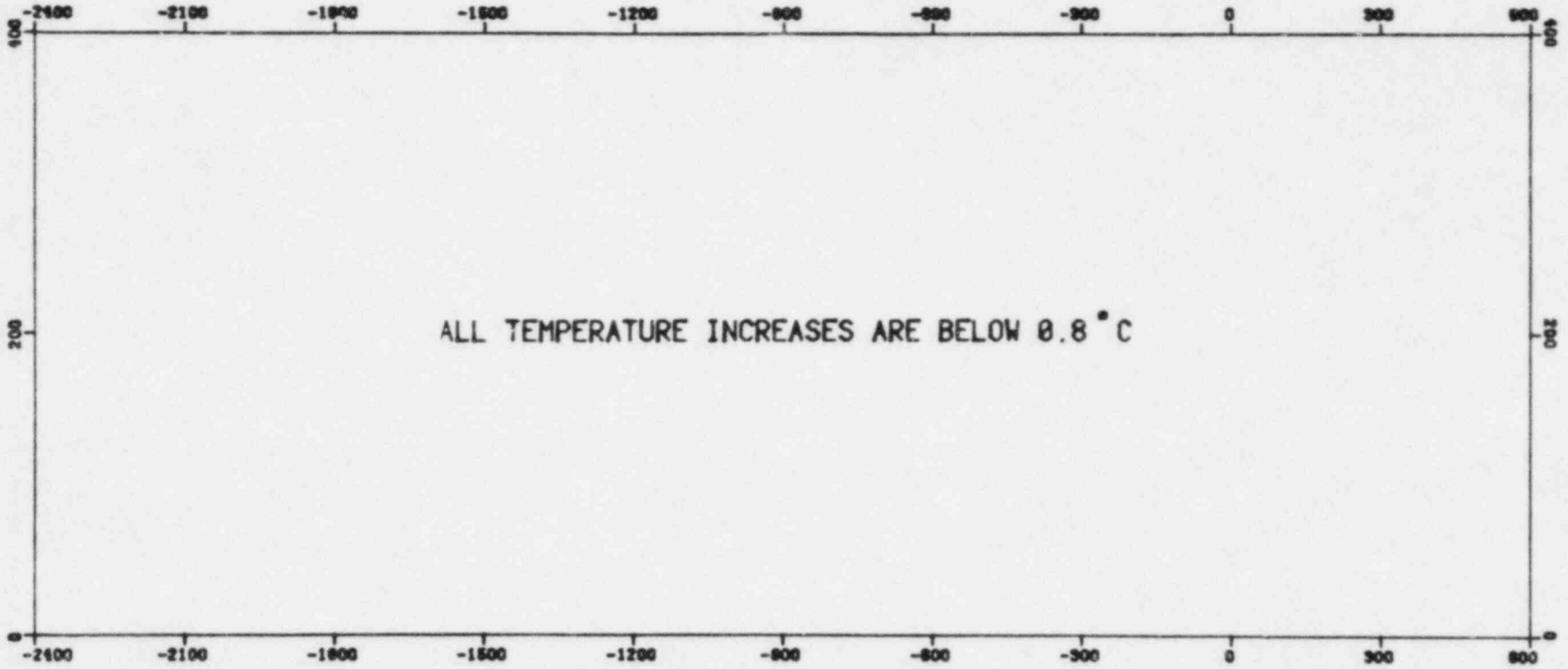
OPERATING LICENSE STAGE

AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2C

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



LOW SLACK TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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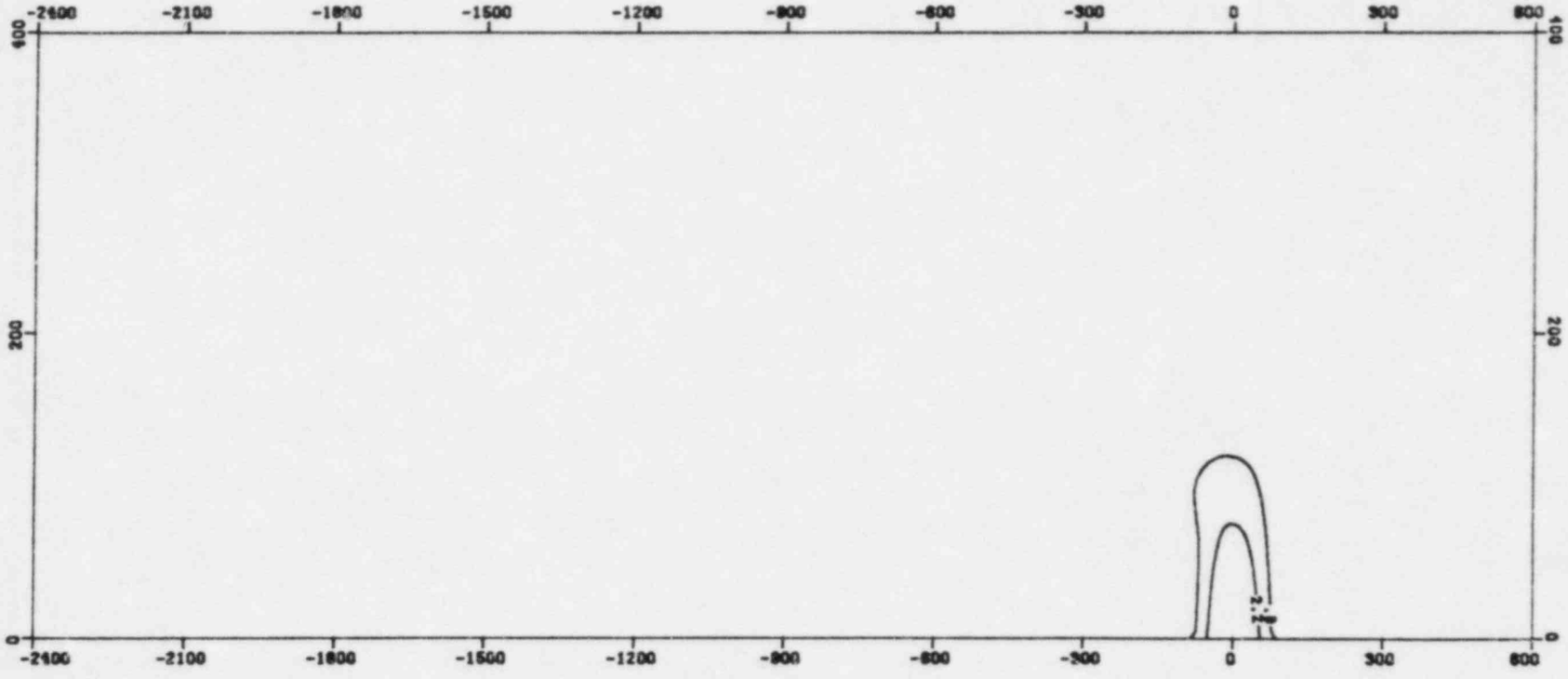
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE *
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2D

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



LOW SLACK TIDE
MID DEPTH

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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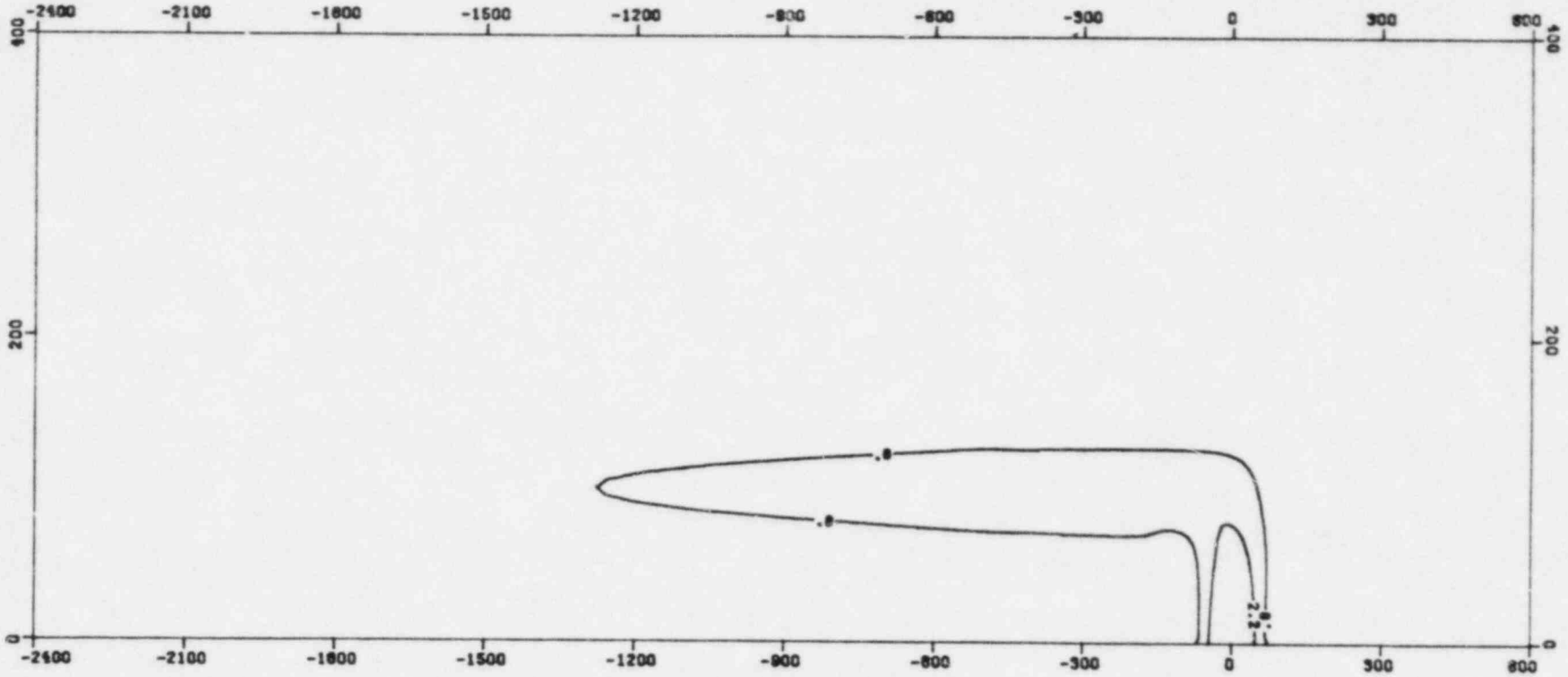
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2E

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



LOW SLACK TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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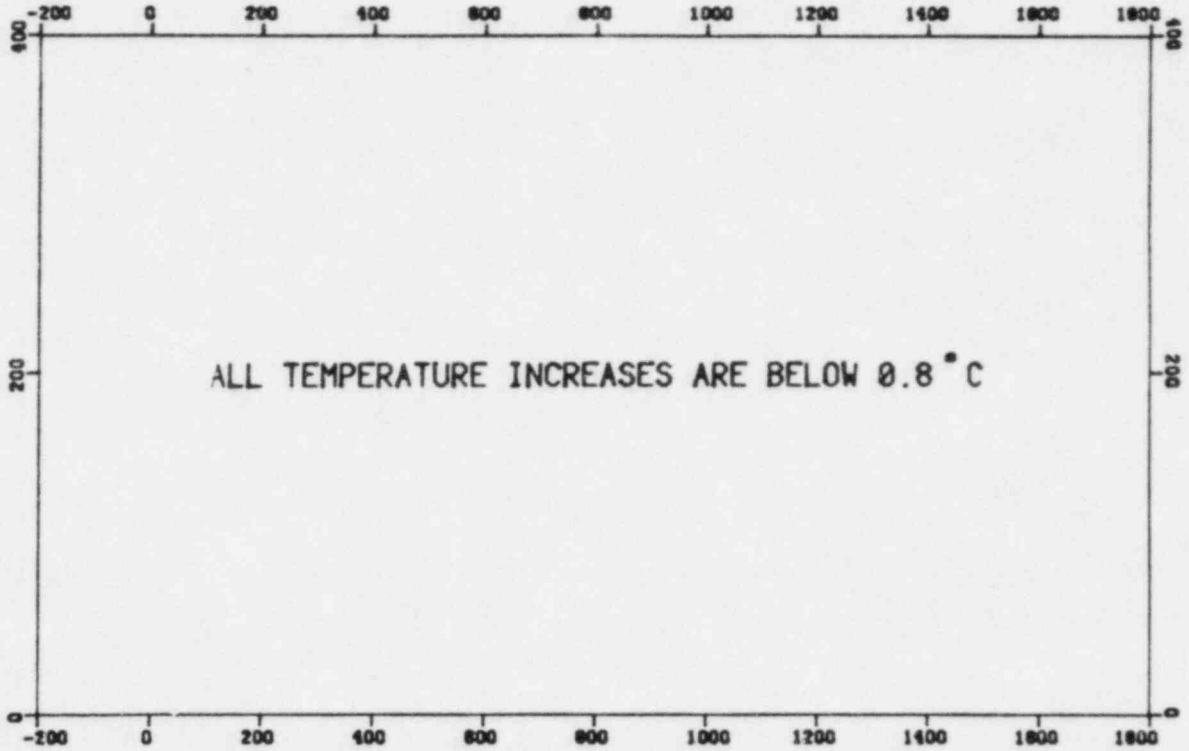
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE *
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2F

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



FLOOD TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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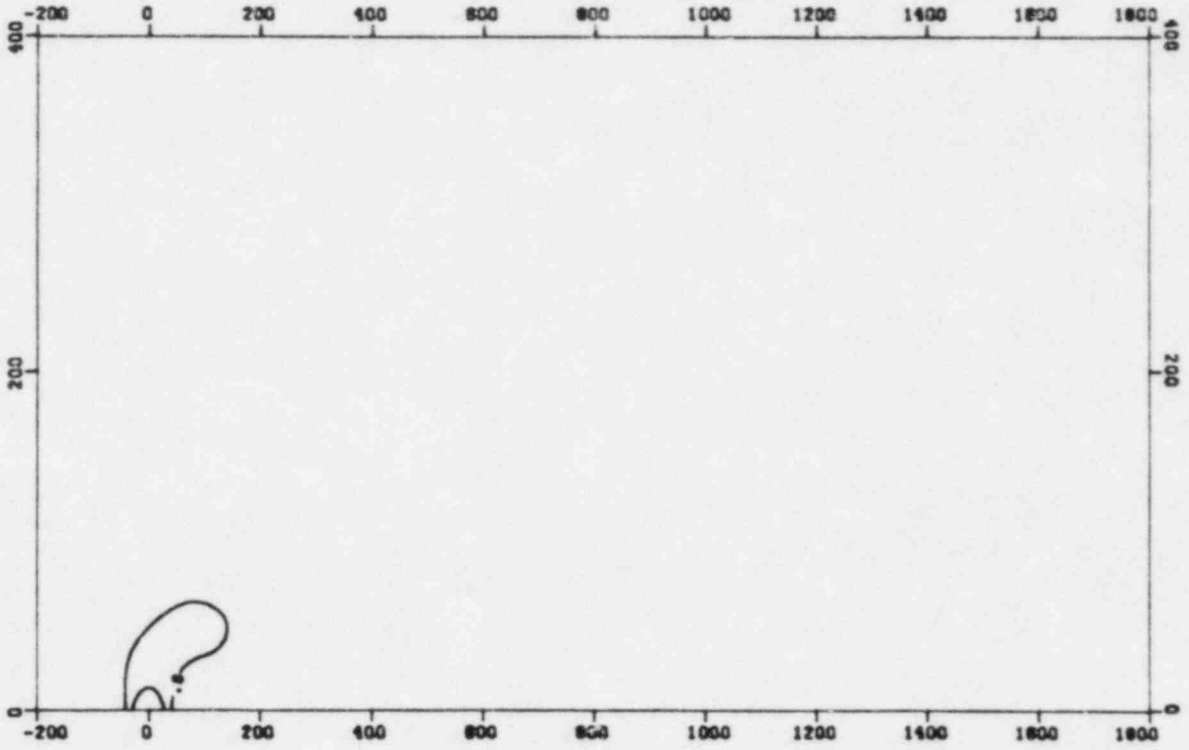
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2G

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



FLOOD TIDE
MID DEPTH

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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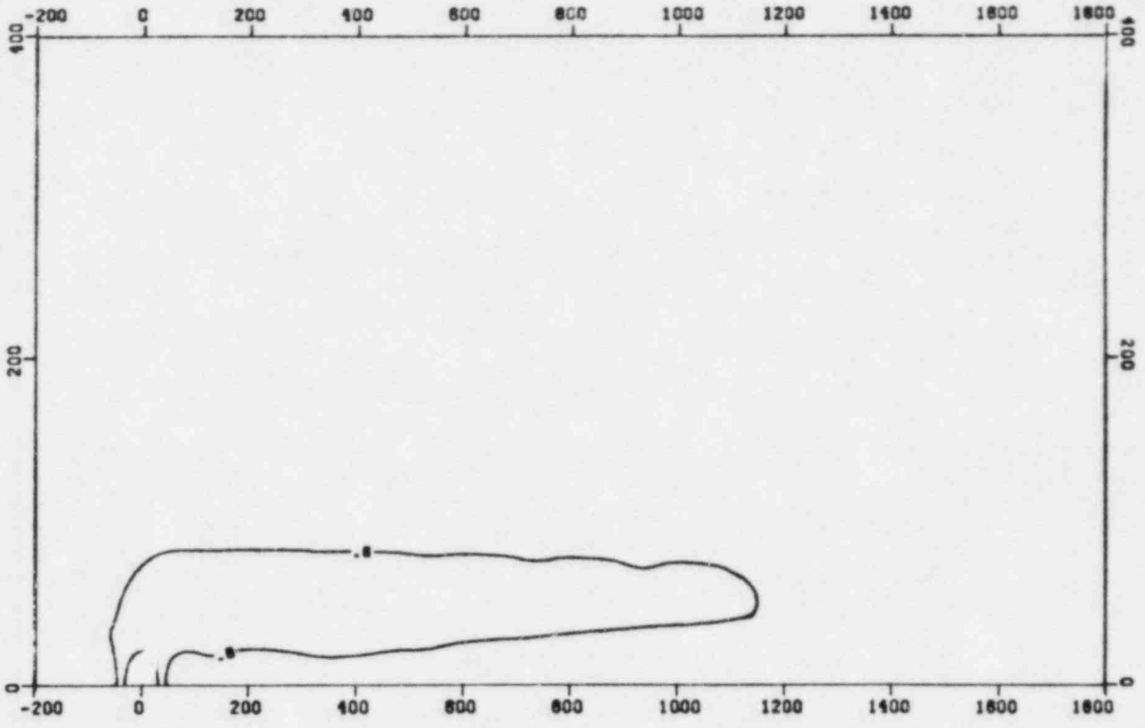
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE *
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2H

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



FLOOD TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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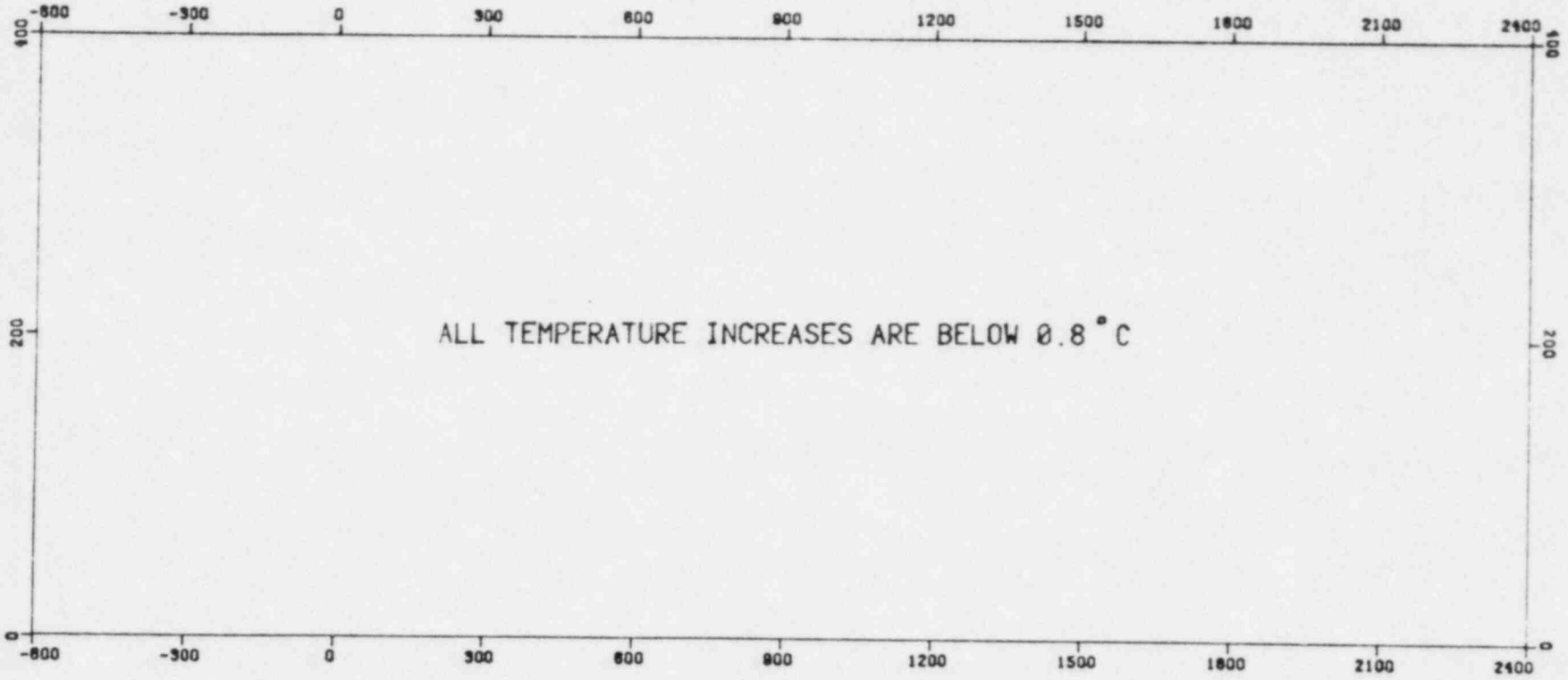
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2J

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



HIGH SLACK TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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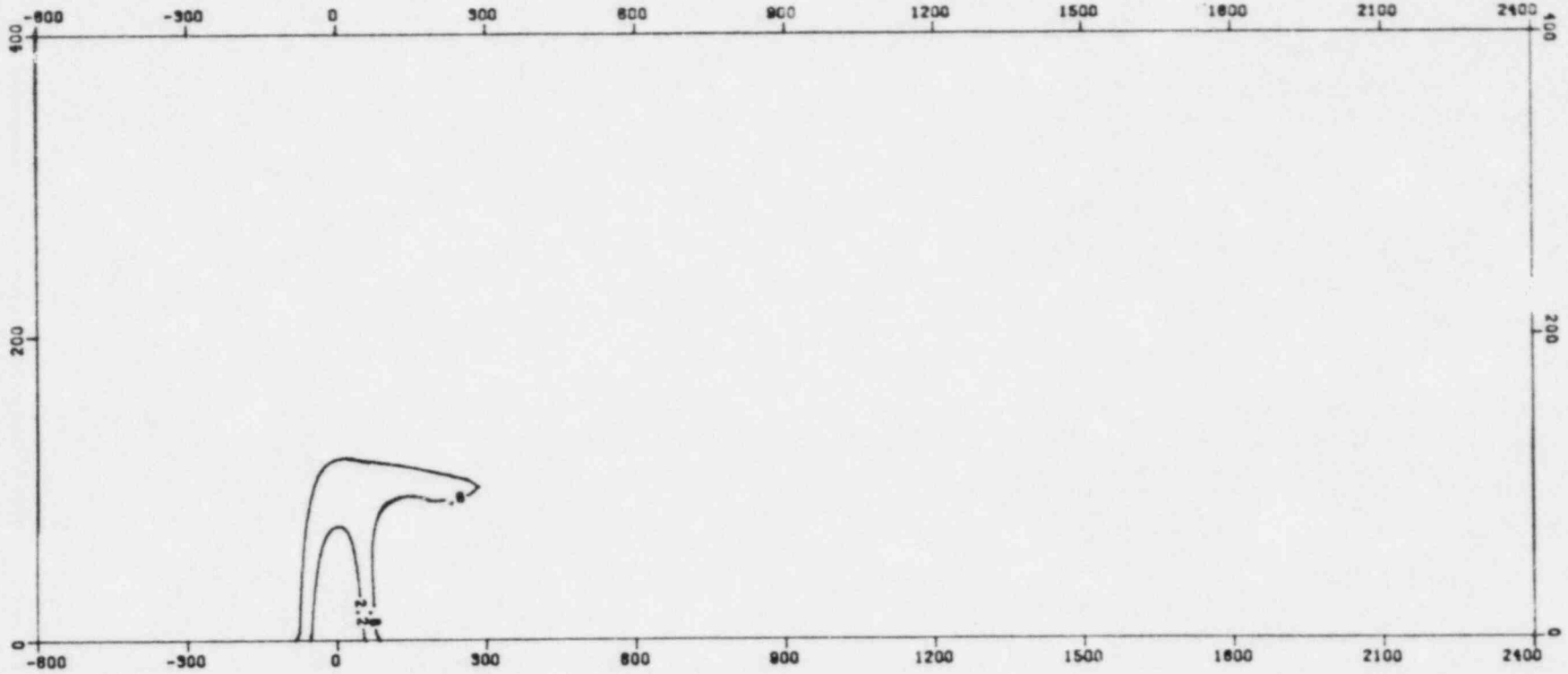
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE *
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2K

Blowdown Temperature = 31.C°C

River Temperature = 26.7°C



HIGH SLACK TIDE
MID DEPTH

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SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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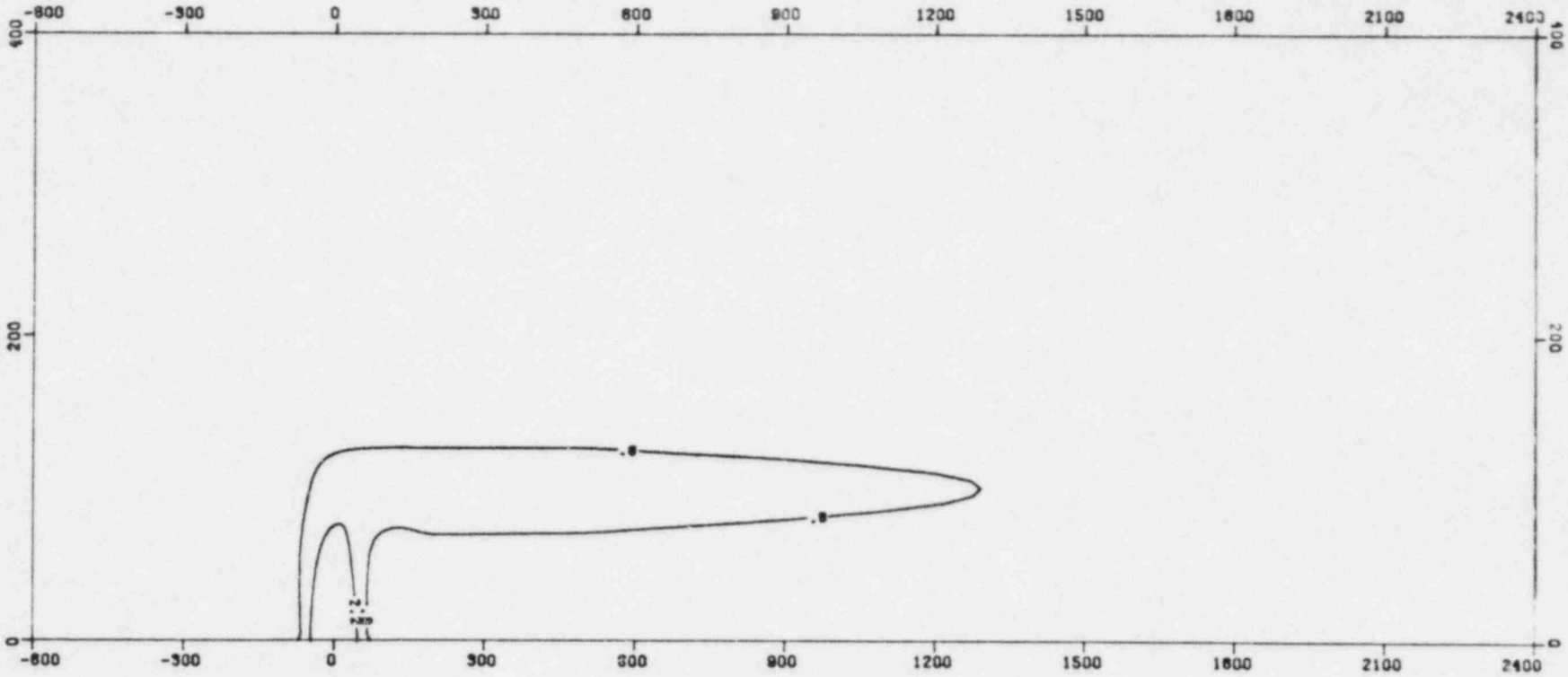
AUGUST - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2L

Blowdown Temperature = 31.0°C

River Temperature = 26.7°C



HIGH SLACK TIDE
BOTTOM

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SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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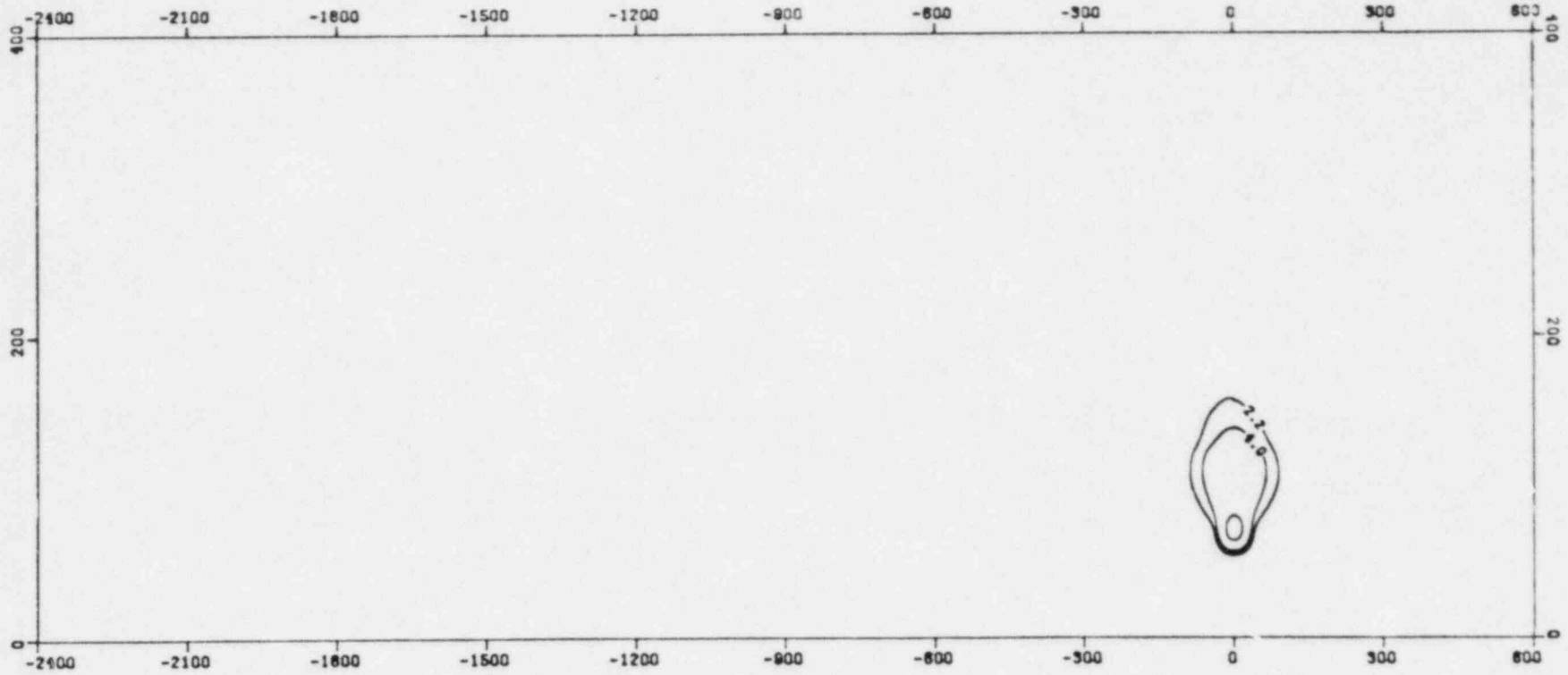
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 2M

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



LOW SLACK TIDE
SURFACE

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SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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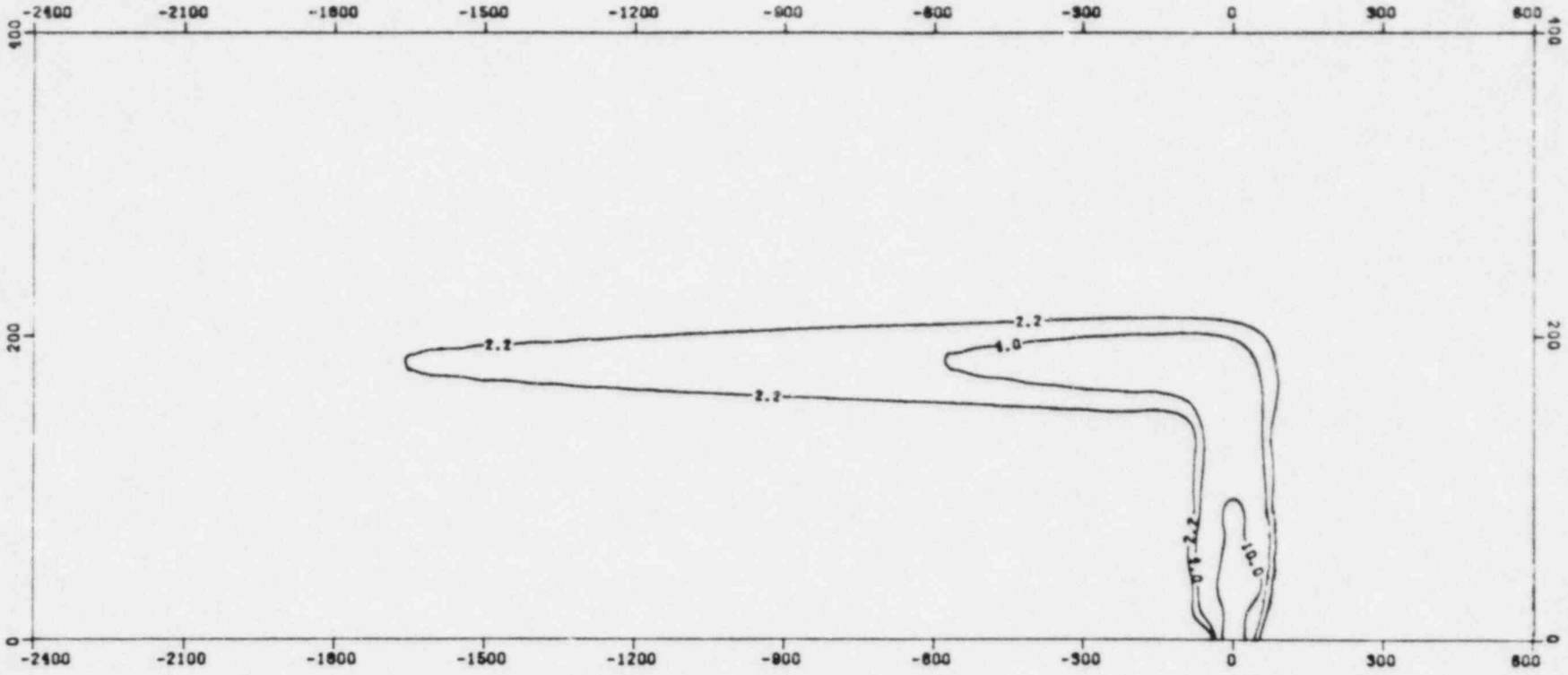
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3A

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



LOW SLACK TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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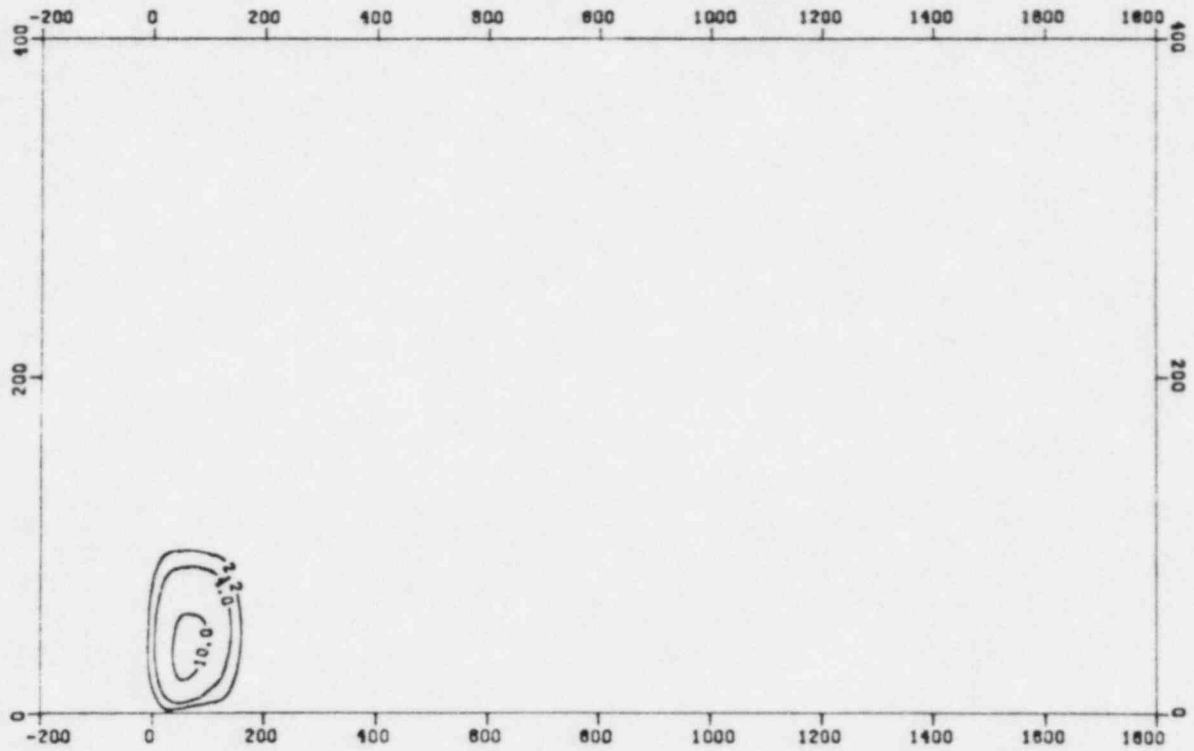
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3B

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



FLOOD TIDE
SURFACE

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SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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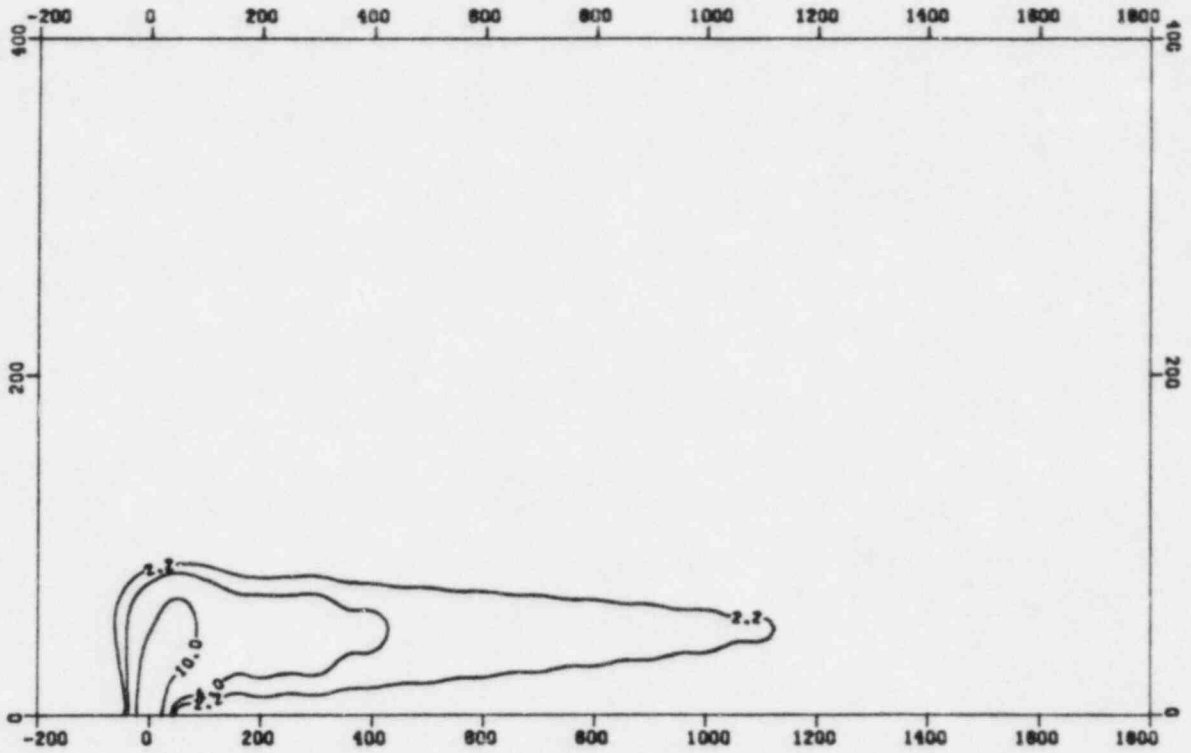
NOVEMBER - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3C

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



FLOOD TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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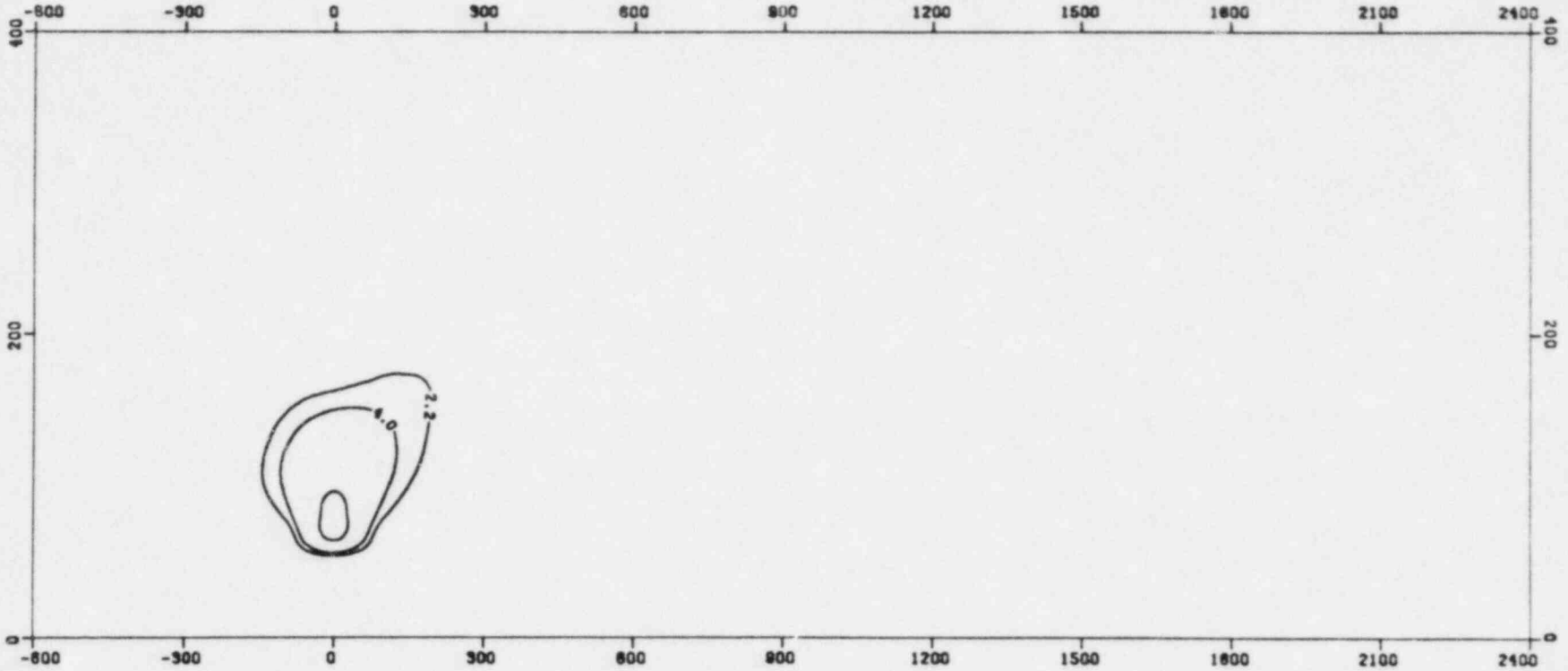
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3D

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



HIGH SLACK TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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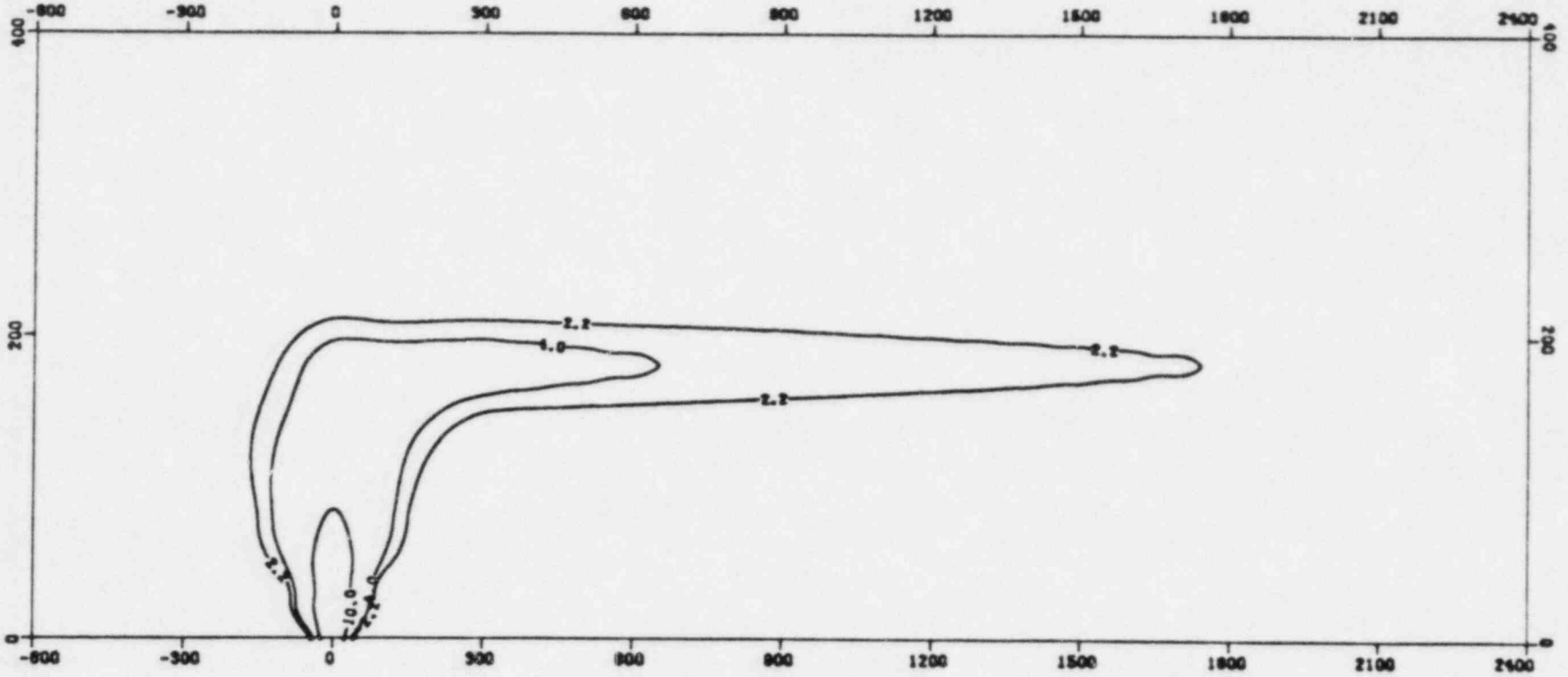
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3E

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



HIGH SLACK TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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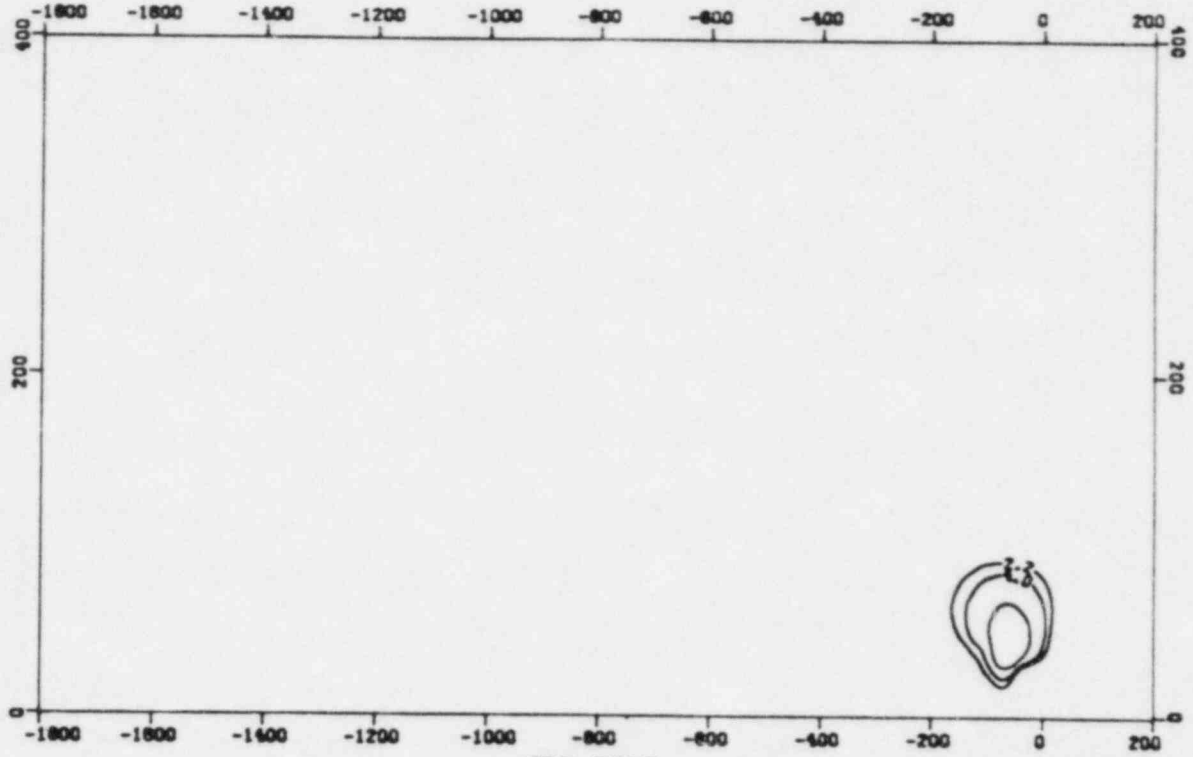
NOVEMBER - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3F

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



EBB TIDE

SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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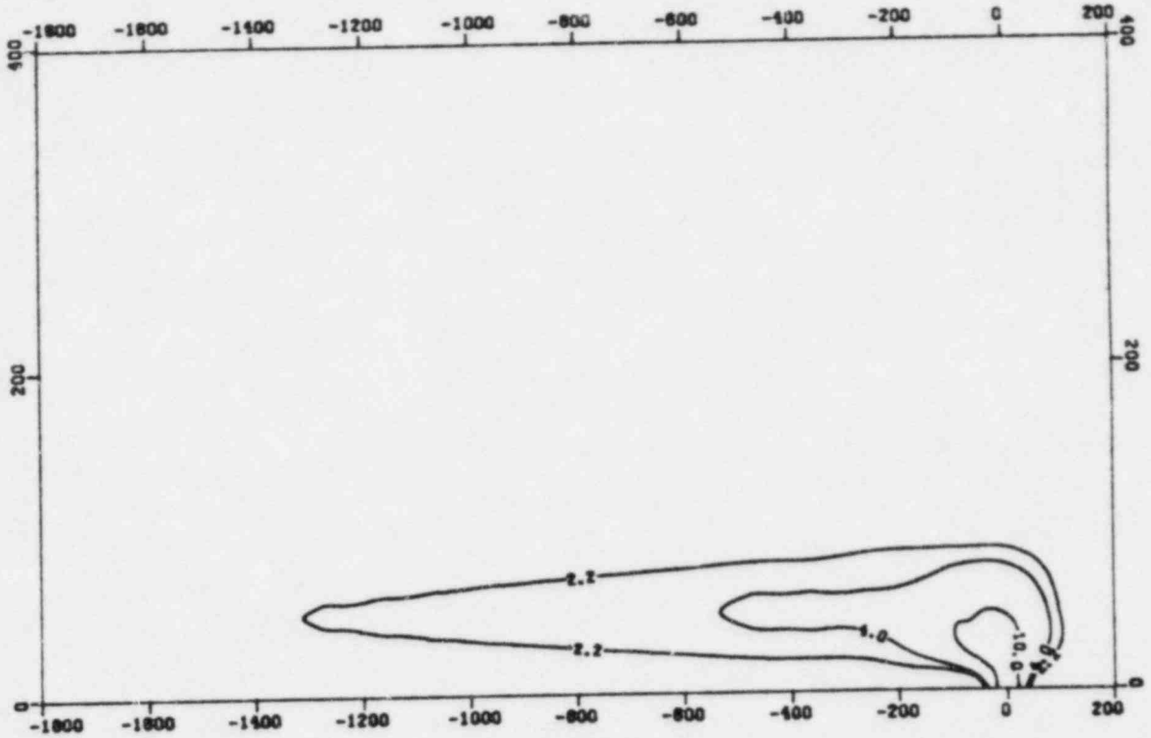
NOVEMBER - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3G

Blowdown Temperature = 25.5°C

River Temperature = 9.5°C



EBB TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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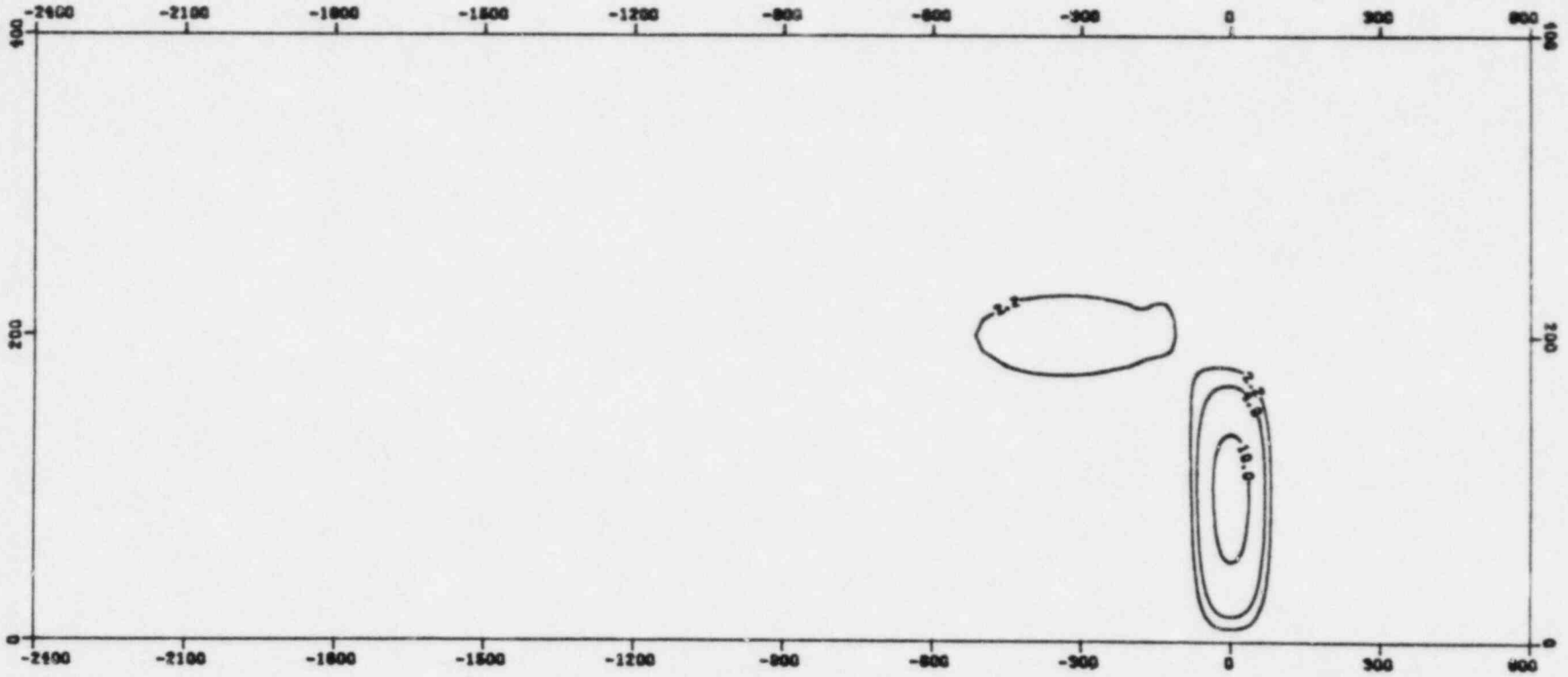
NOVEMBER - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 3H

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



LOW SLACK TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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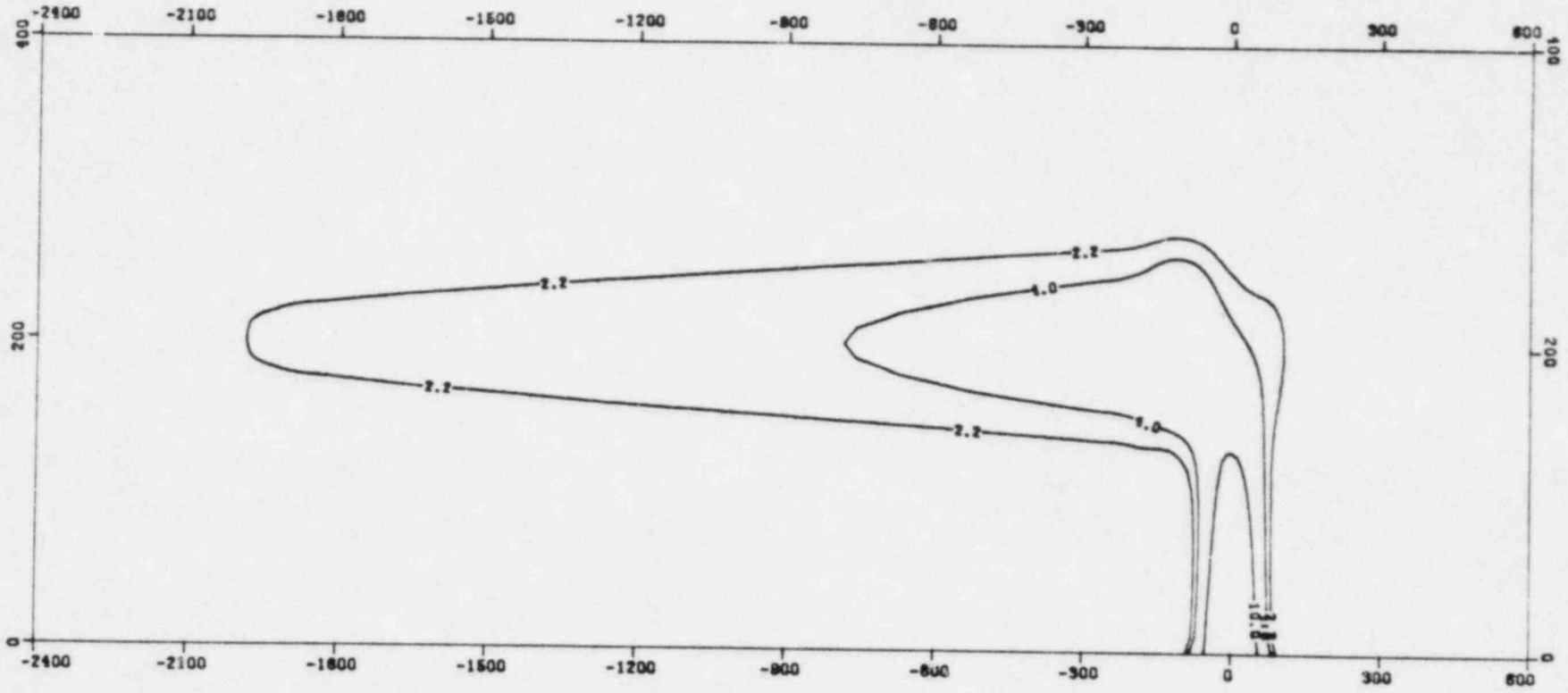
FEBRUARY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4A

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



LOW SLACK TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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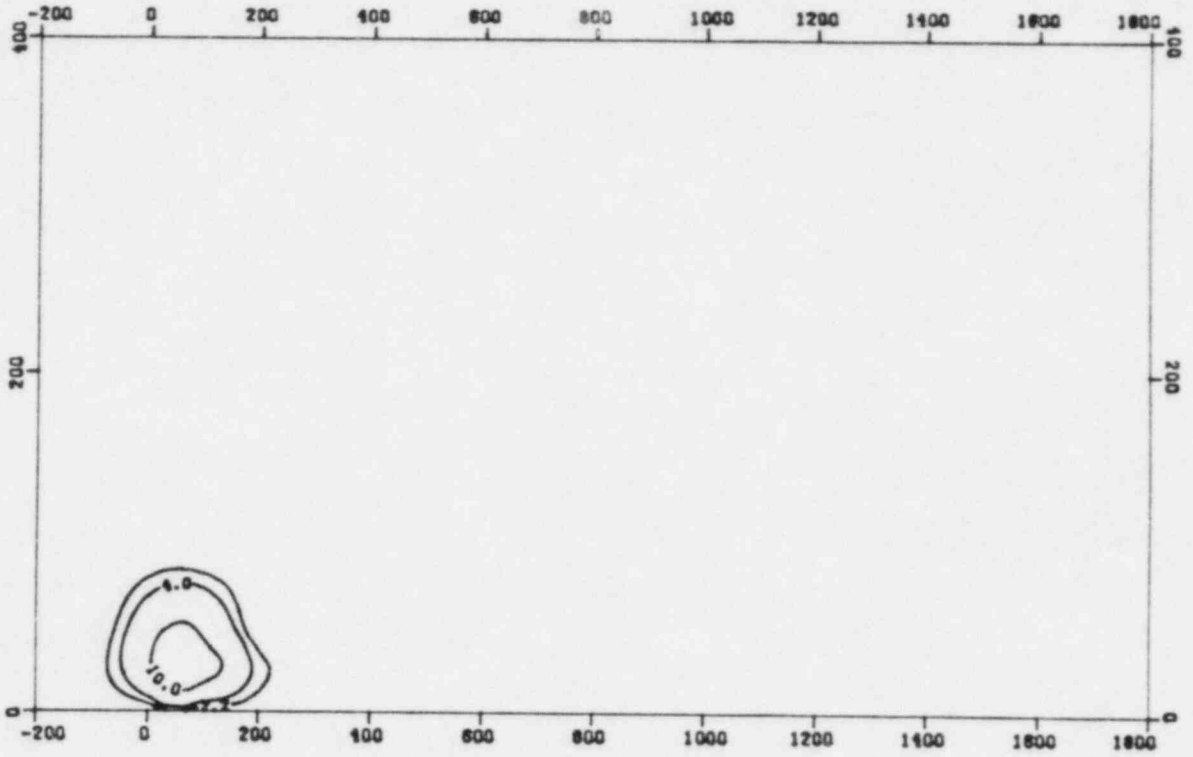
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4B

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



FLOOD TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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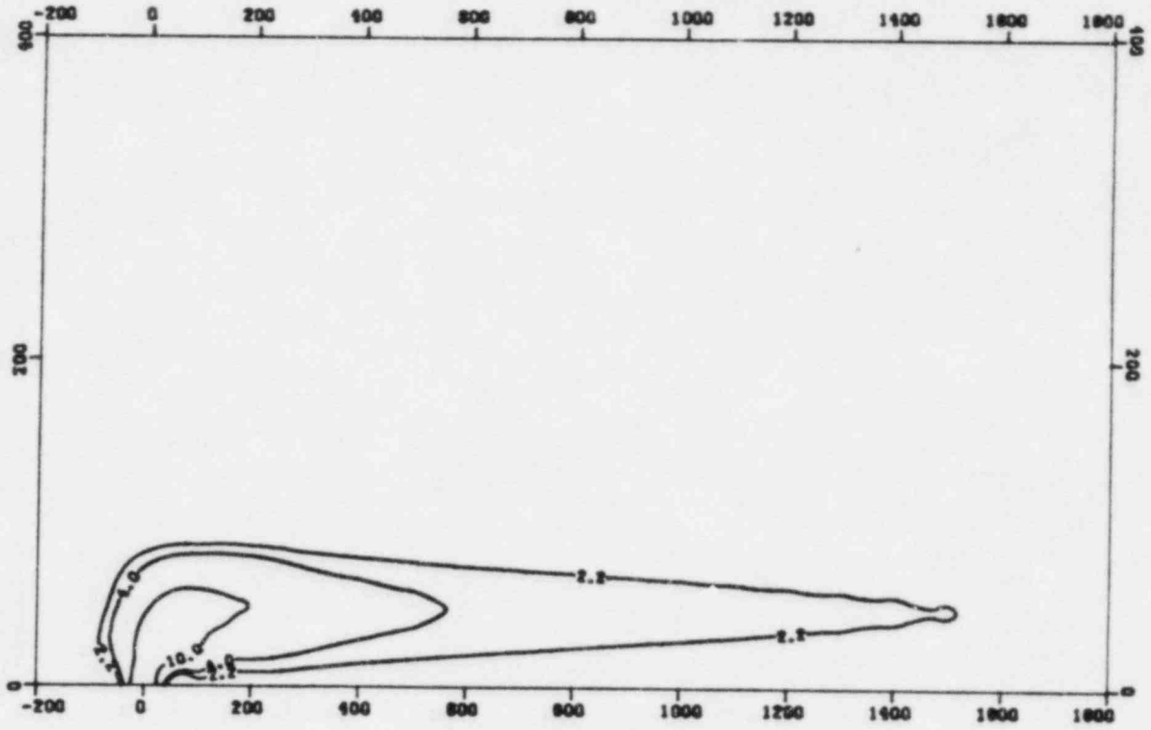
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4C

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



FLOOD TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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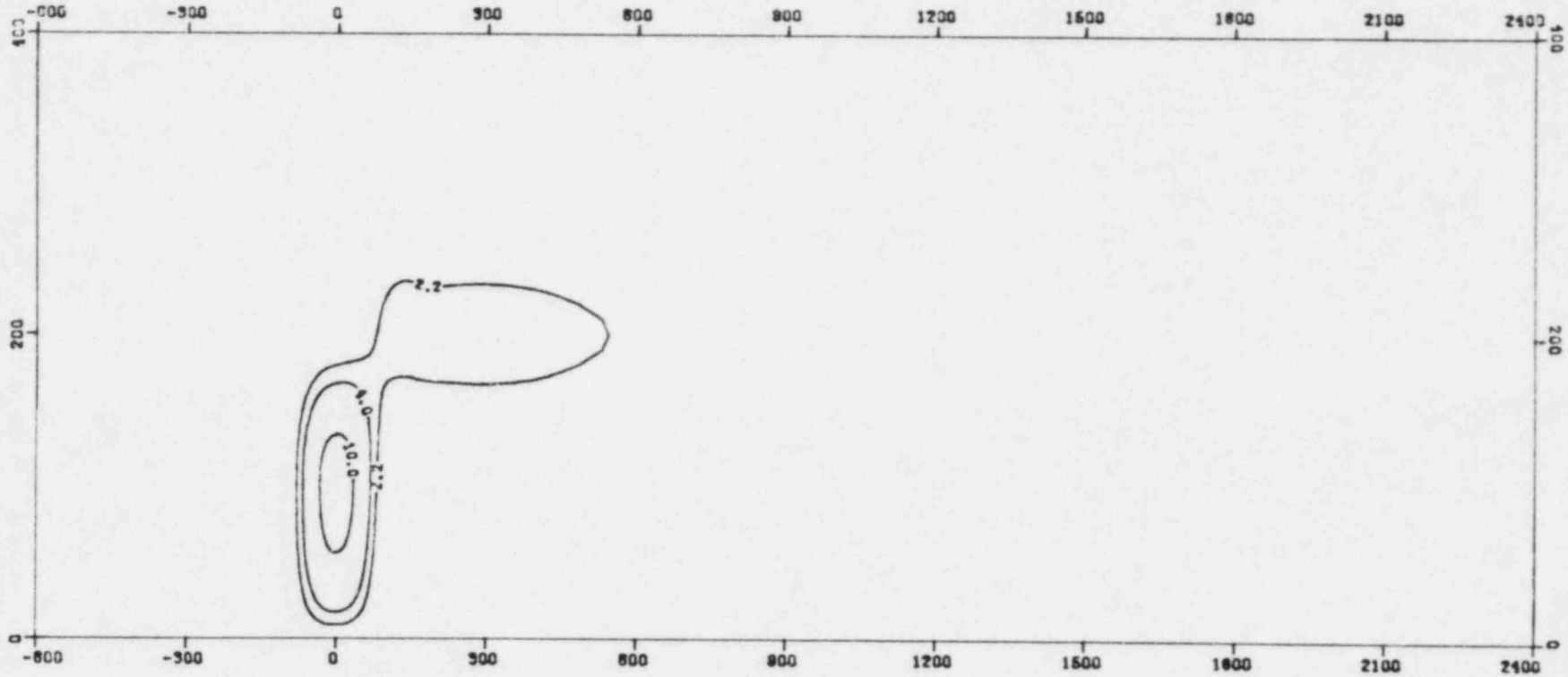
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4D

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



HIGH SLACK TIDE
SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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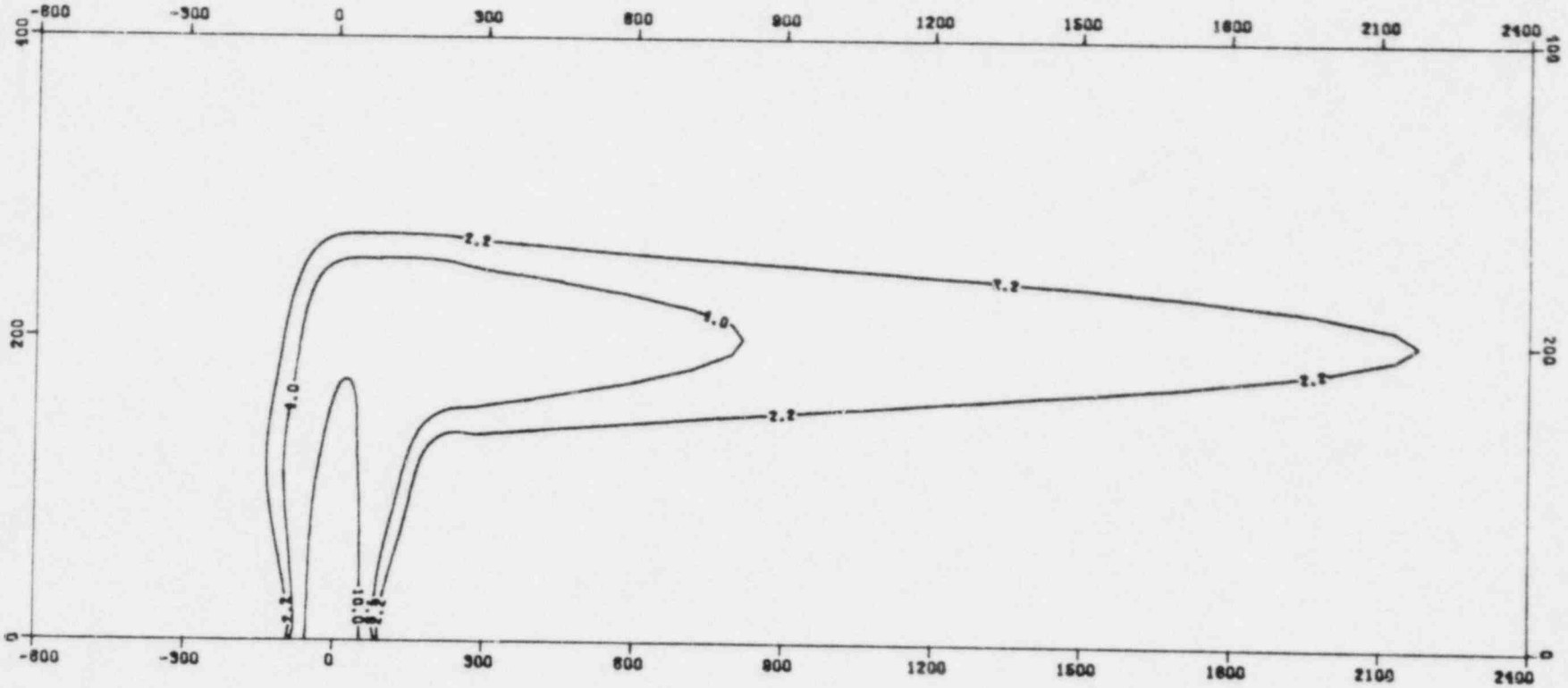
FEBRUARY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4E

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



HIGH SLACK TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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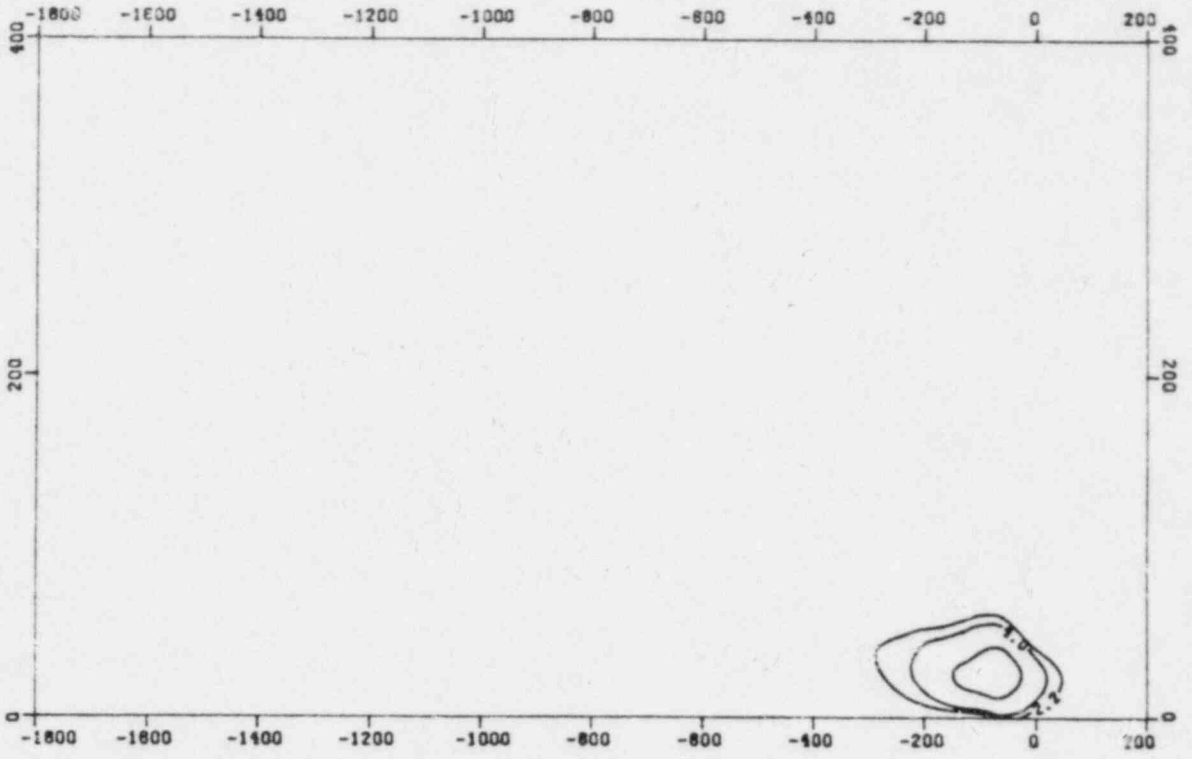
FEBRUARY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4F

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



EBB TIDE

SURFACE

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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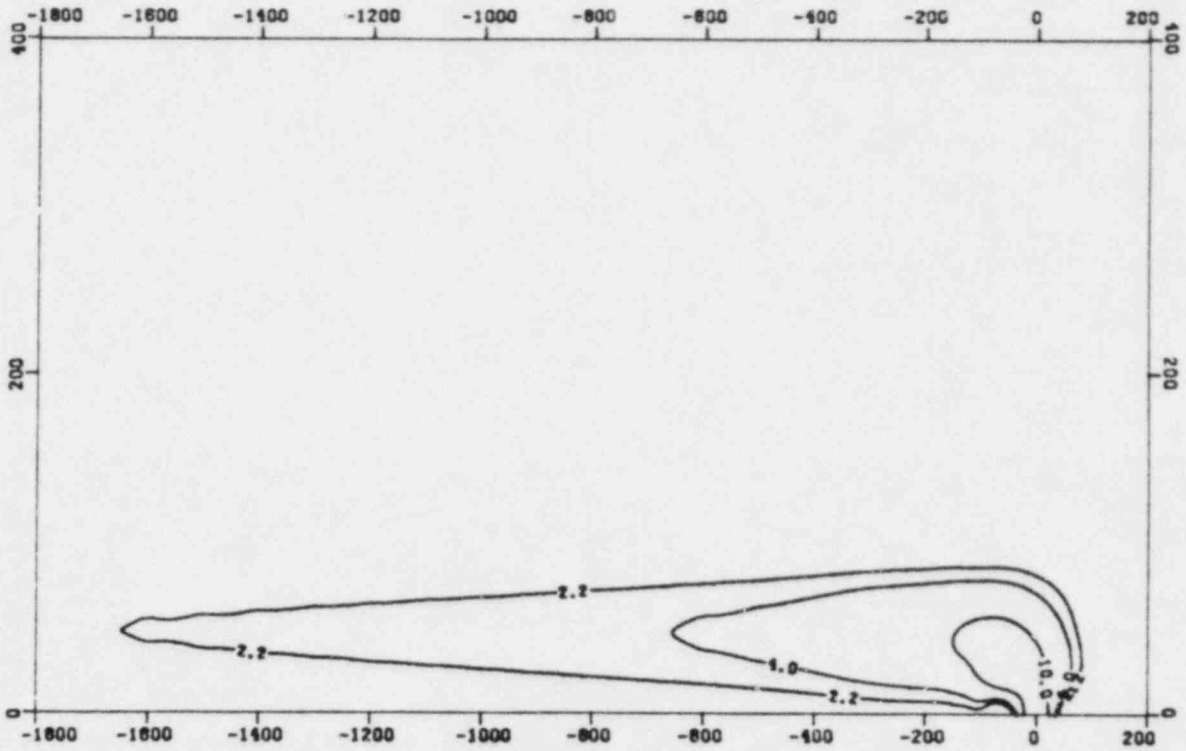
FEBRUARY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4G

Blowdown Temperature = 21.0°C

River Temperature = 1.4°C



EBB TIDE
BOTTOM

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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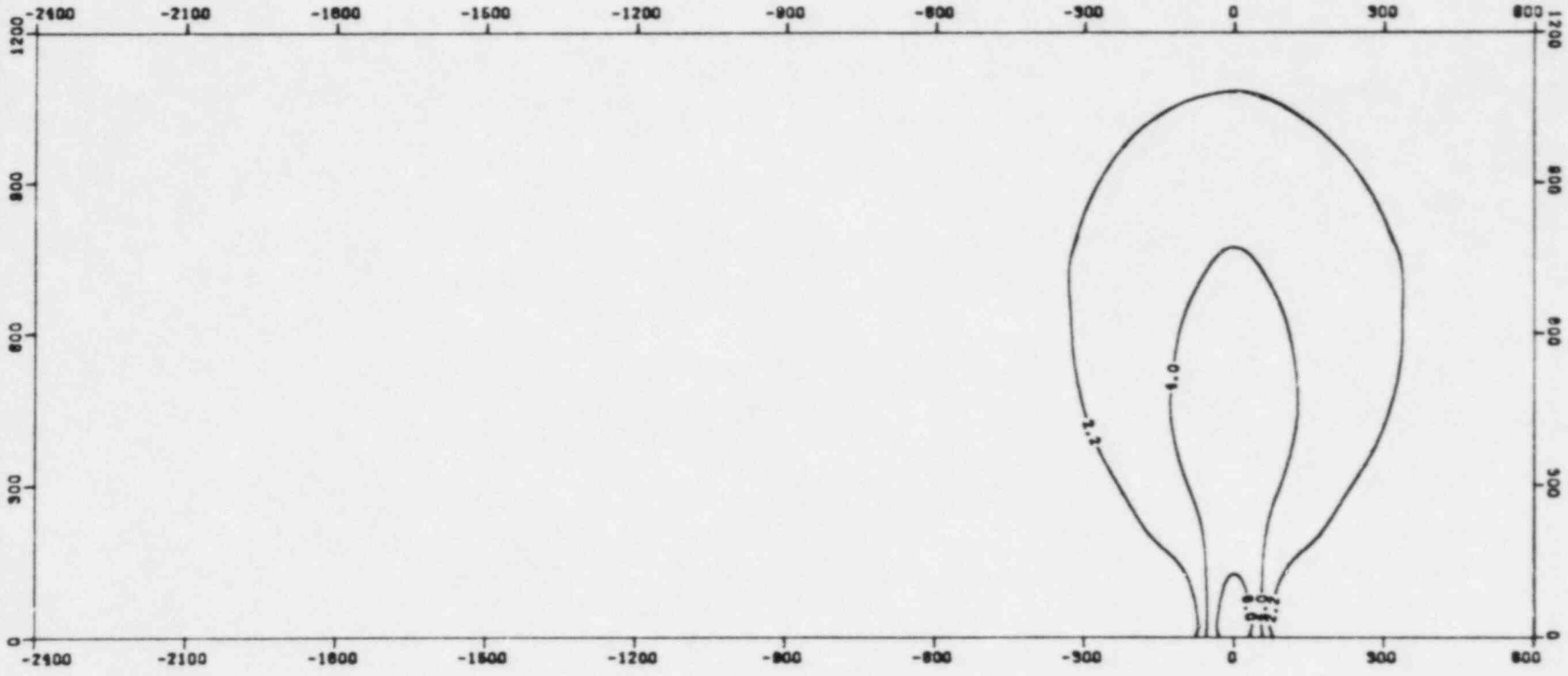
FEBRUARY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 4H

Blowdown Temperature = 27.0°C

River Temperature = 18.9°C



LOW SLACK TIDE
ALL DEPTHS

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

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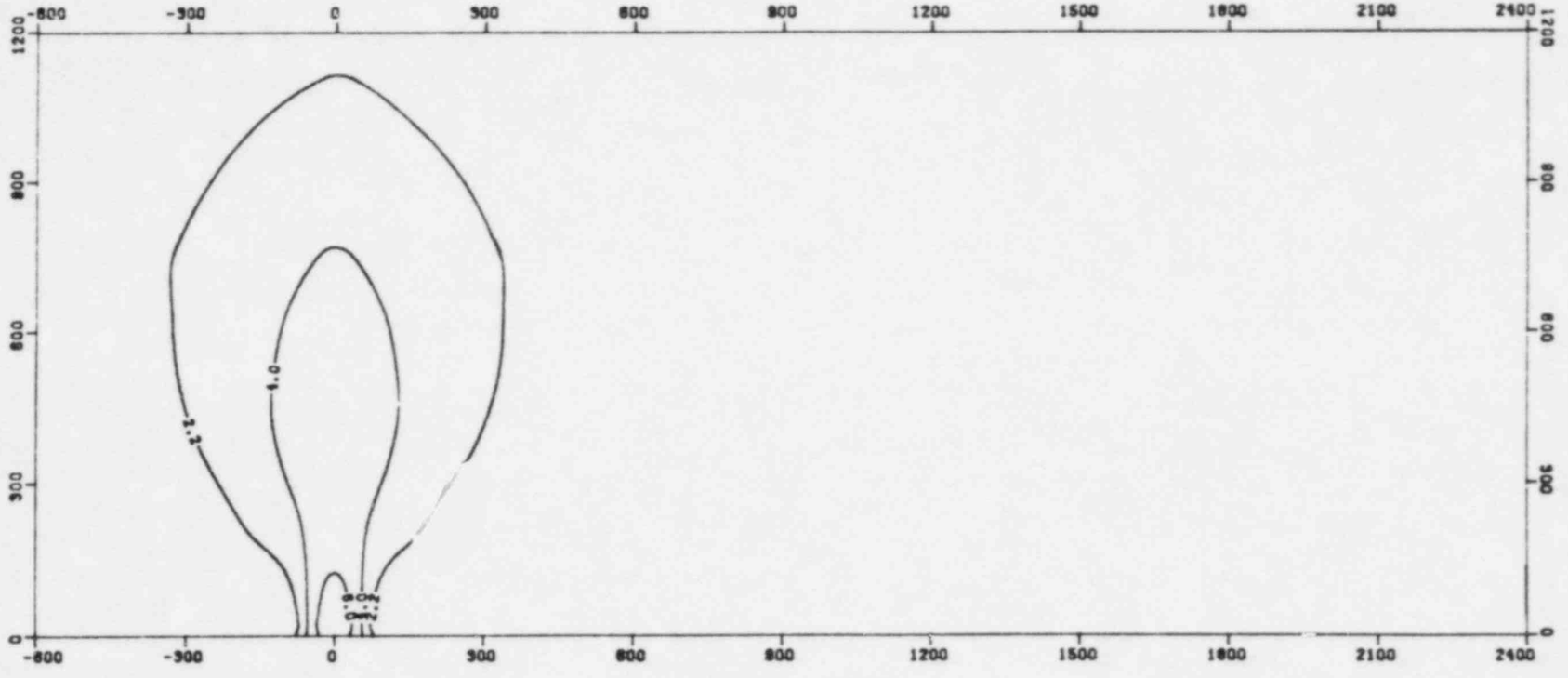
MAY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 5A

Blowdown Temperature = 27.0°C

River Temperature = 18.9°C



HIGH SLACK TIDE
ALL DEPTHS

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
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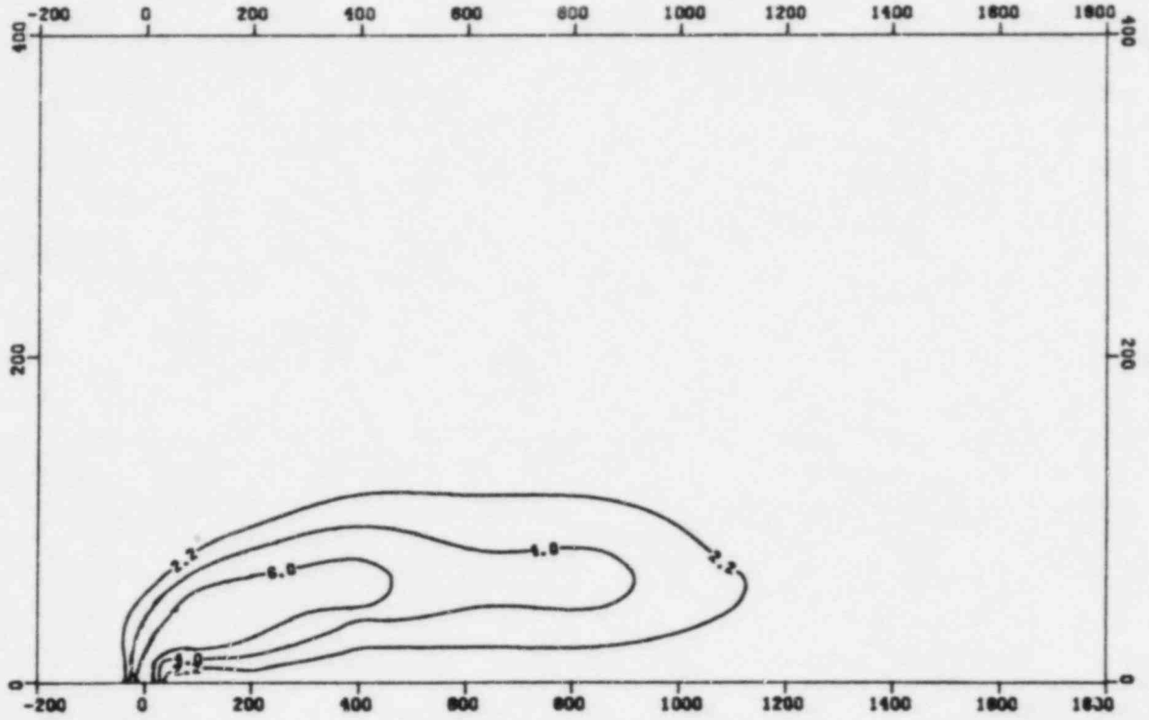
OPERATING LICENSE STAGE

MAY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 5B

Blowdown Temperature = 27.0°C

River Temperature = 18.9°C



FLOOD TIDE
ALL DEPTHS

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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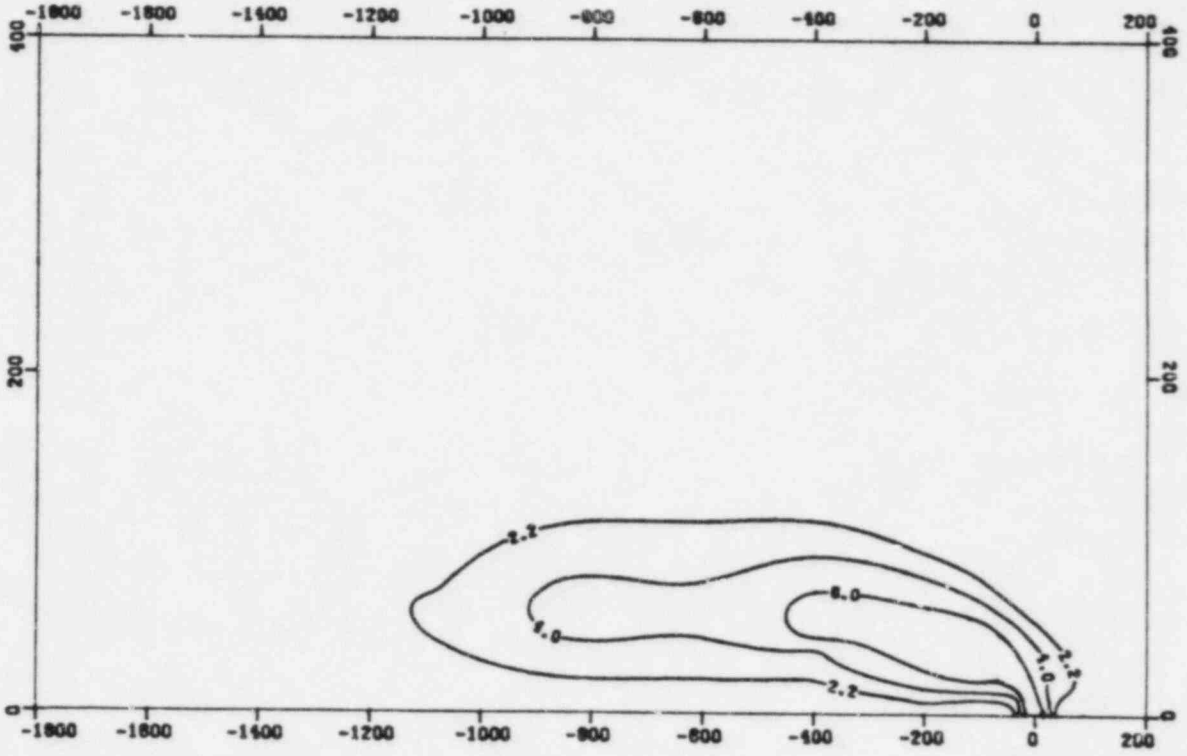
MAY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 5C

Blowdown Temperature = 27.0°C

River Temperature = 18.9°C



EBB TIDE
ALL DEPTHS

* EXPECTED TO BE EXCEEDED LESS THAN 5% OF THE TIME DURING NORMAL PLANT OPERATION

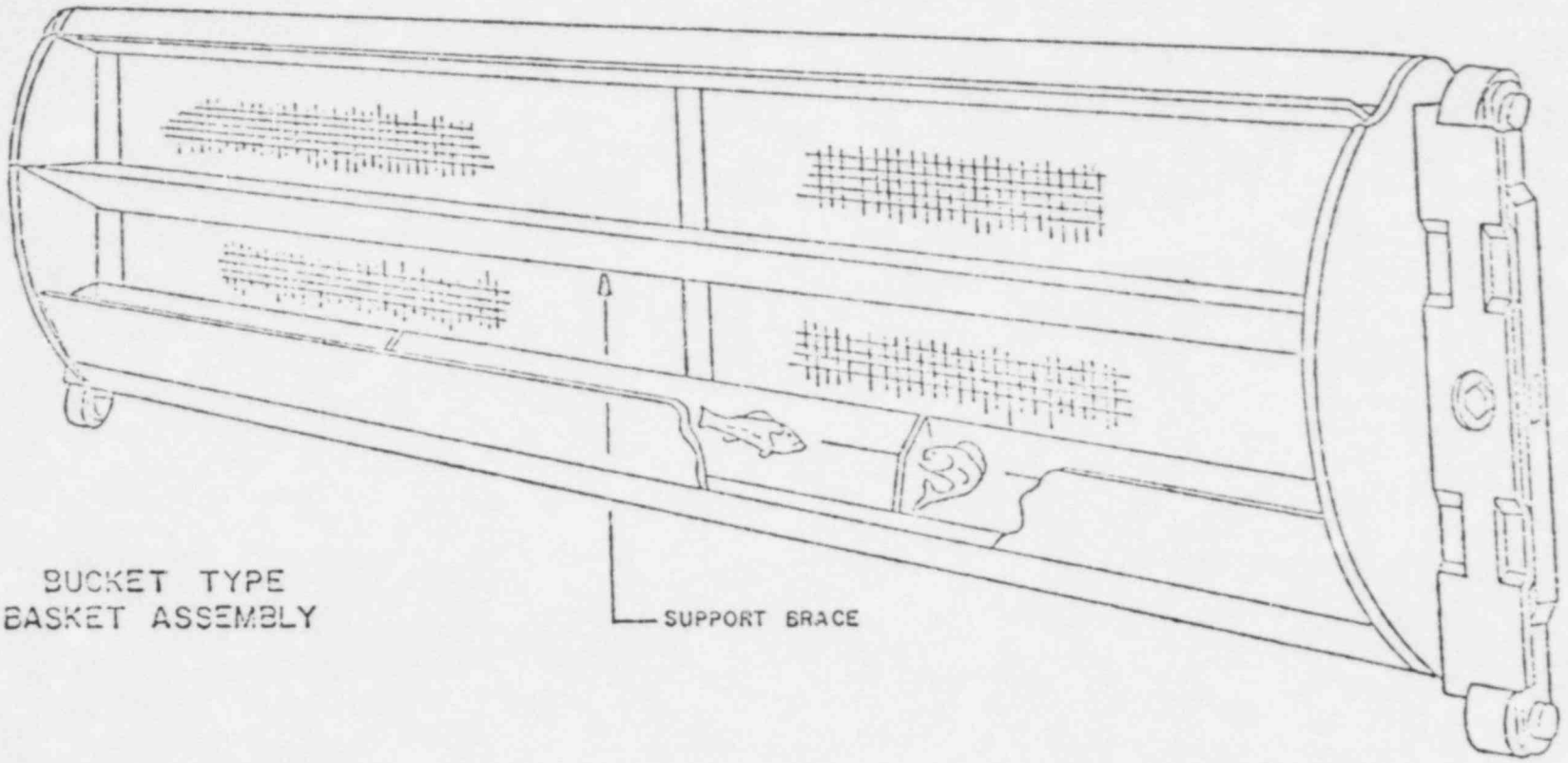
SCALE IN FEET
(1 FOOT = 0.3048)
METERS

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MAY - MAXIMUM
DISCHARGE TEMPERATURE*
TEMPERATURE (ΔT) ISOTHERMS (C°)

FIGURE 5.1 - 5D

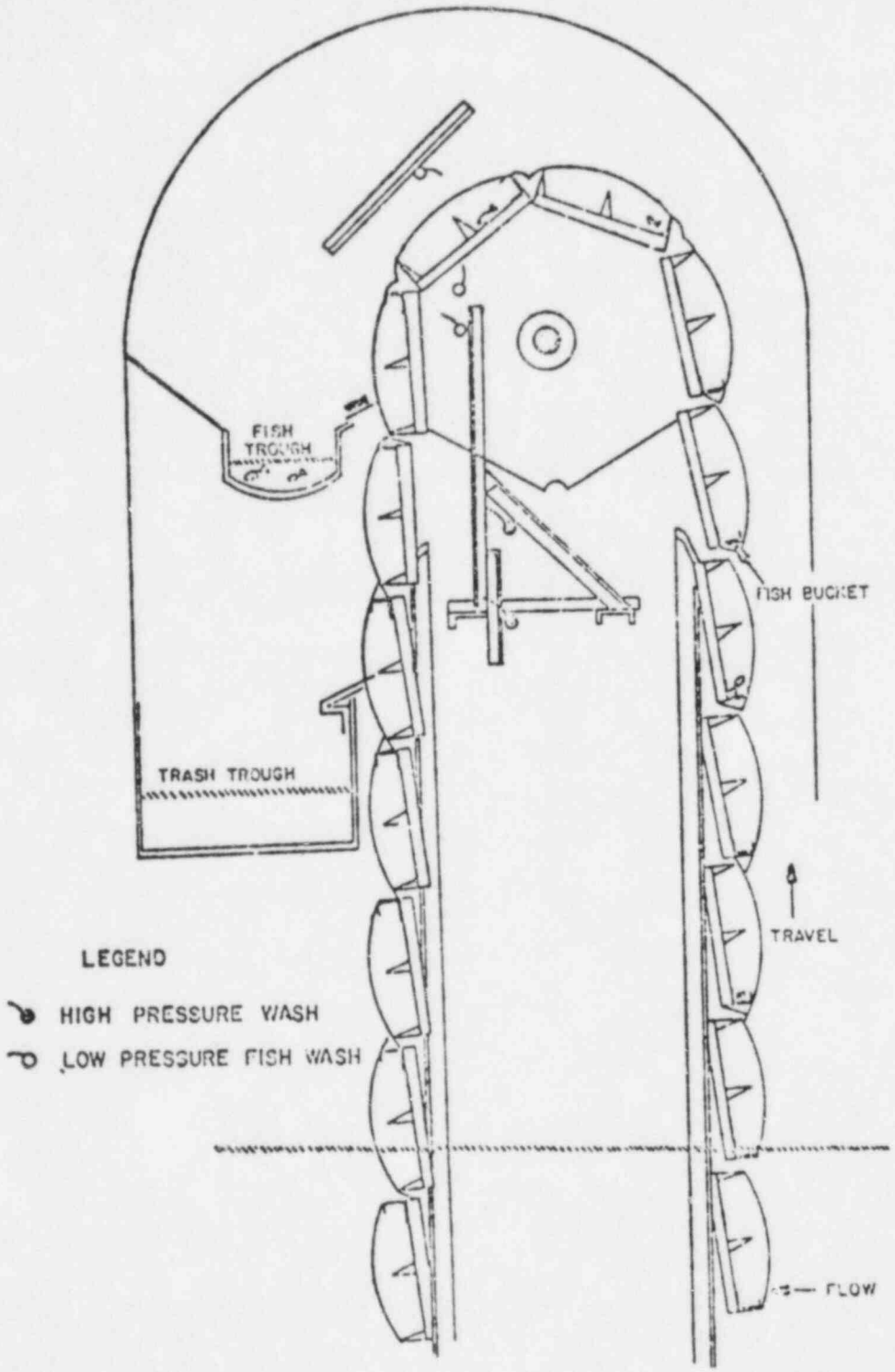


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

FISH BUCKET TYPE
SCREEN BASKET ASSEMBLY

FIGURE 5.1 - 6



HOPE CREEK GENERATING STATION
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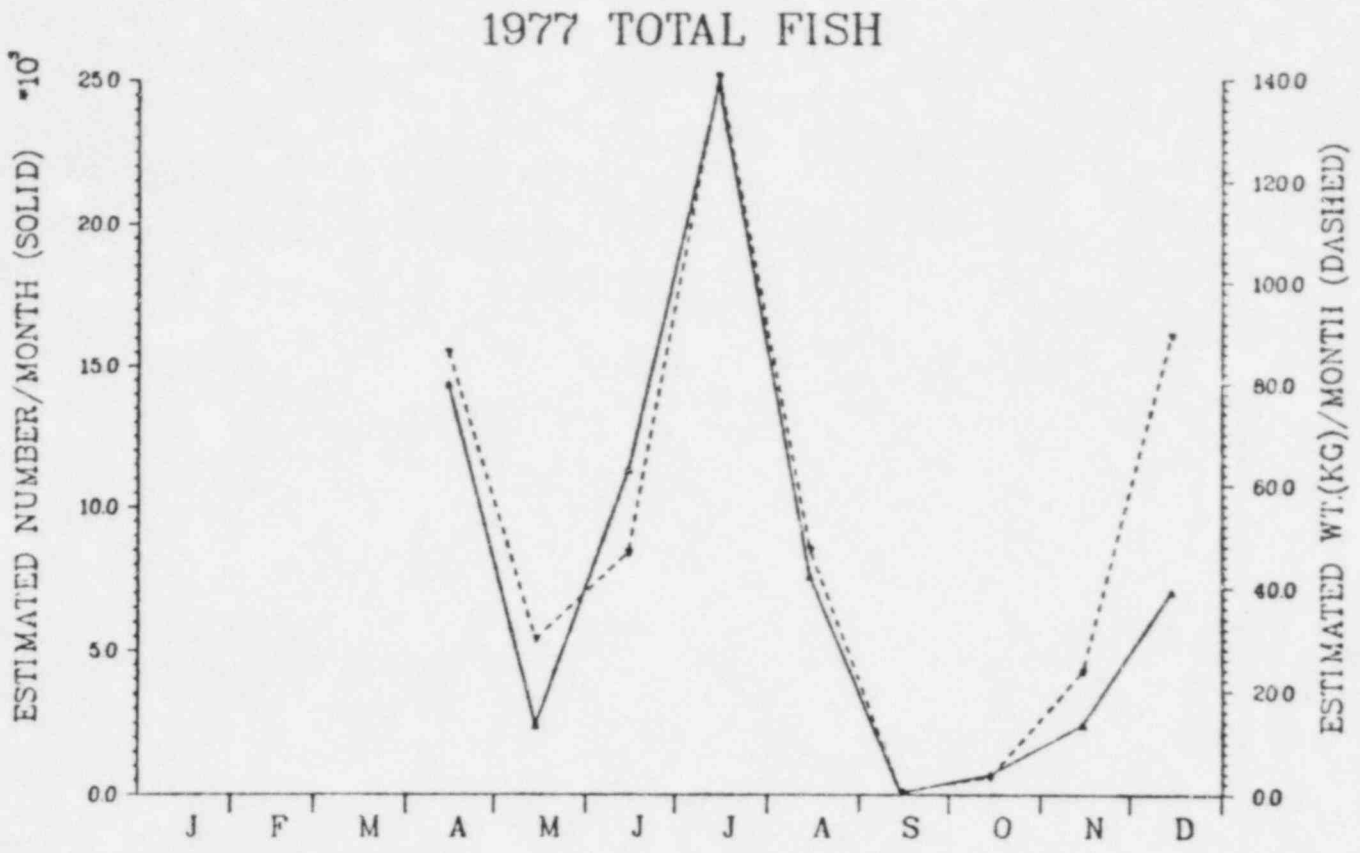
MODIFIED VERTICAL
TRAVELING WATER SCREEN

FIGURE 5.1 - 7

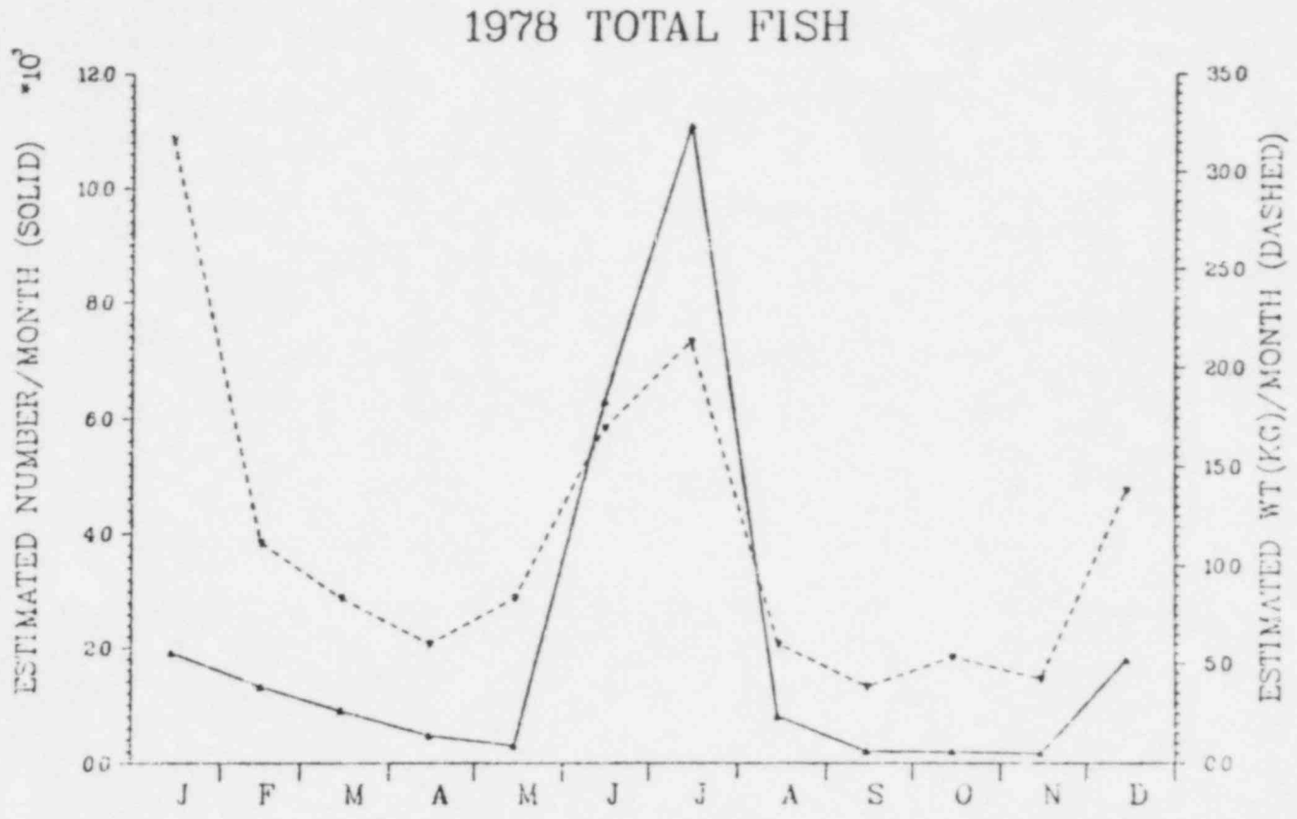


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED TOTAL FISH
SALEM SWS - 1977

FIGURE 5.1 - 8



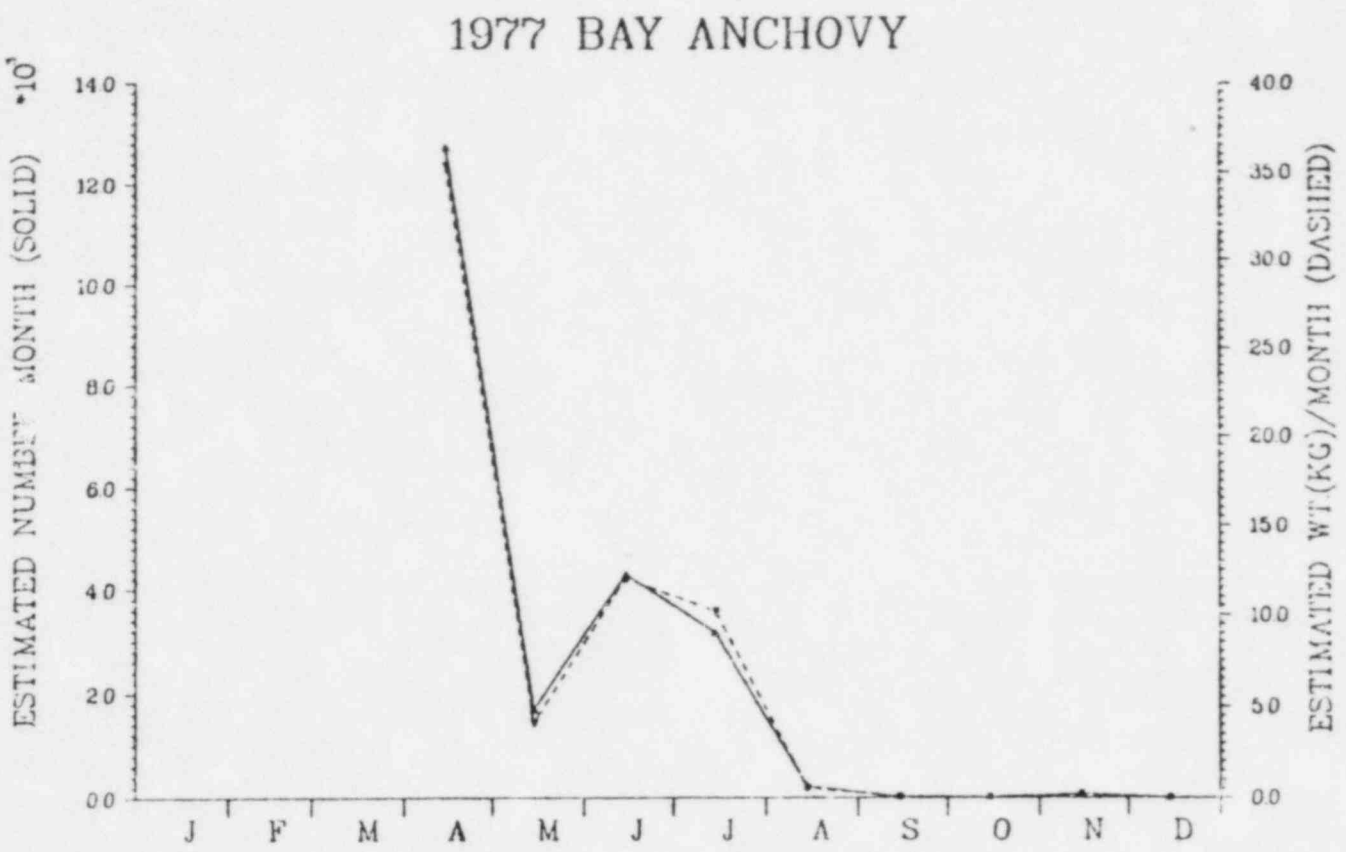
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED TOTAL FISH

SALEM SWS - 1978

FIGURE 5.1 - 9



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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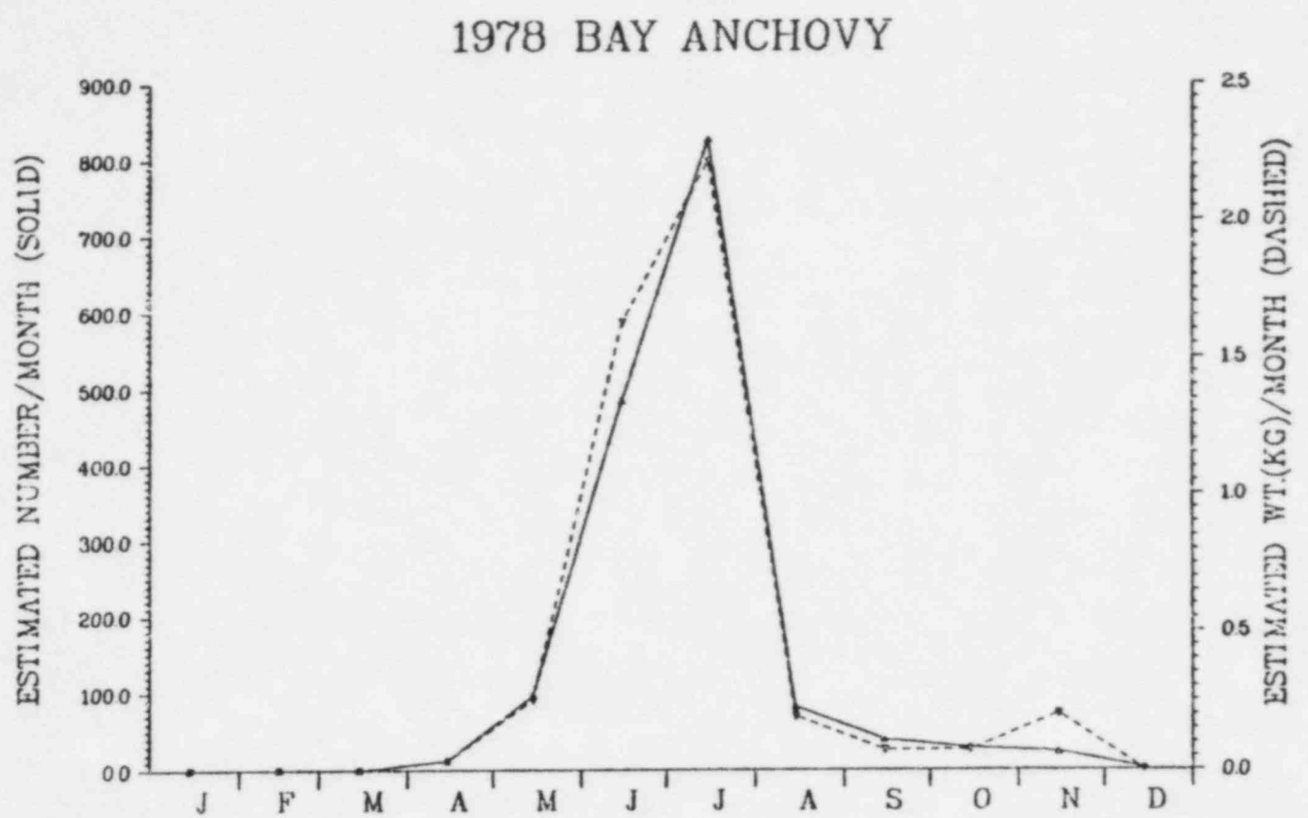
MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED BAY ANCHOVY

SALEM SWS - 1977

FIGURE 5.1 - 10



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

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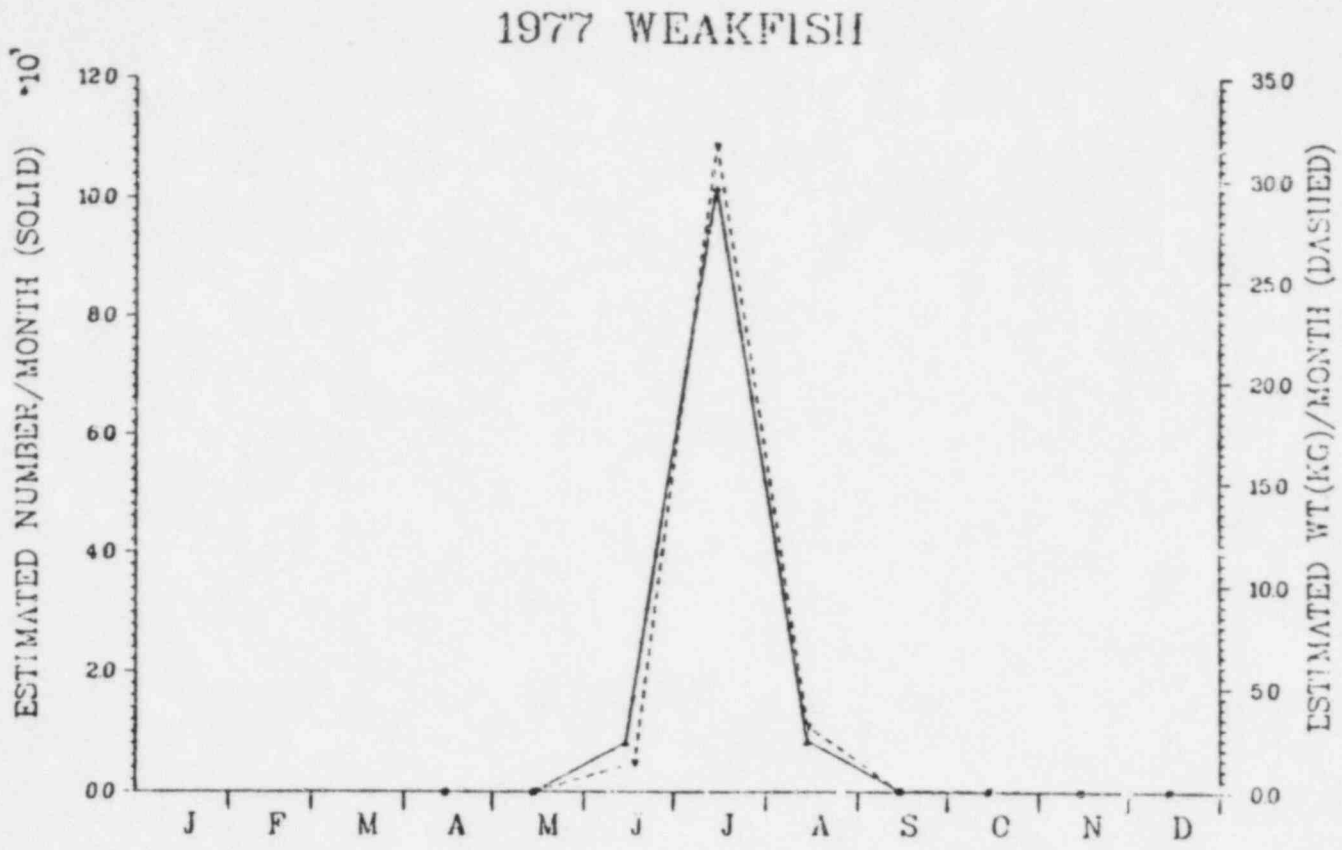
MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED BAY ANCHOVY

SALEM SWS - 1978

FIGURE 5.1 - 11



HOPE CREEK GENERATING STATION
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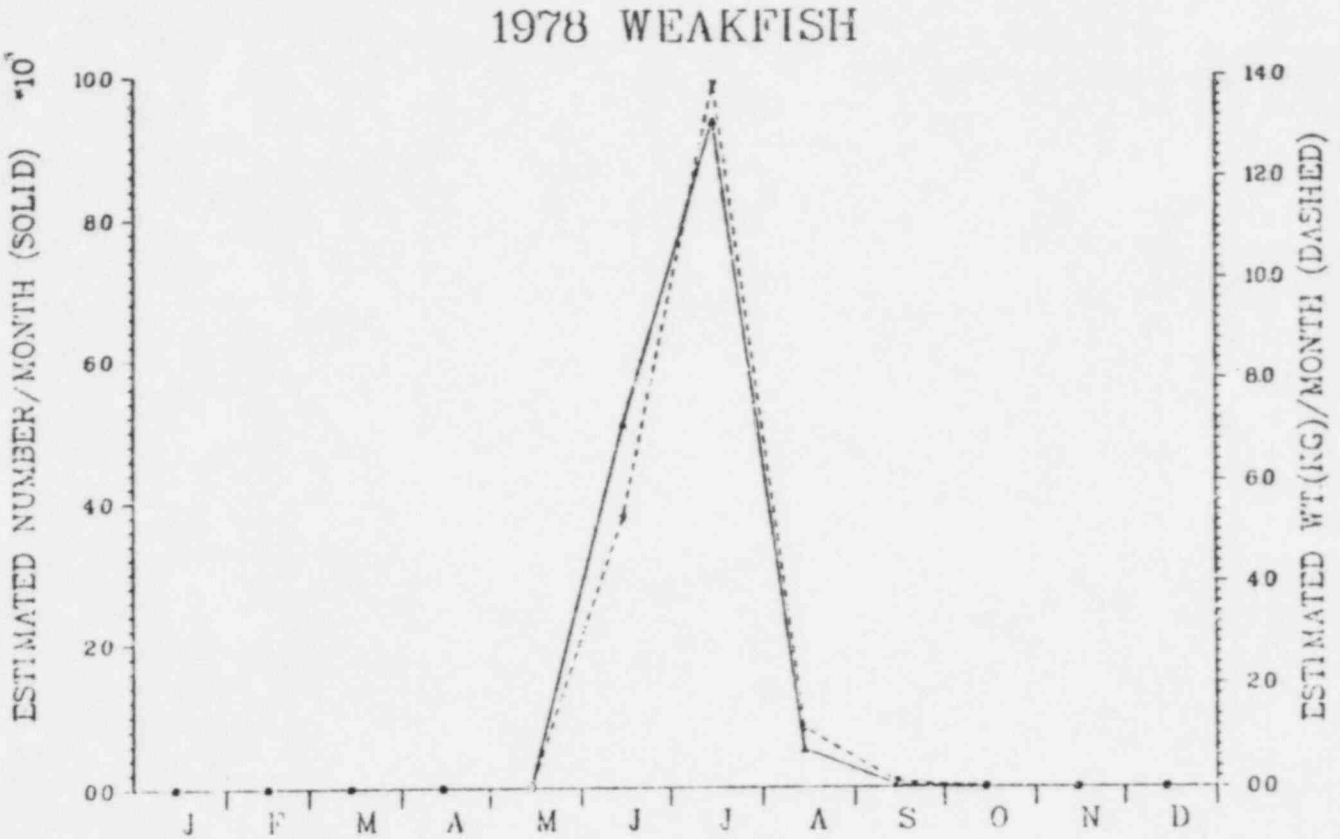
MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED WEAKFISH

SALEM SWS - 1977

FIGURE 5.1 - 12



HOPE CREEK GENERATING STATION
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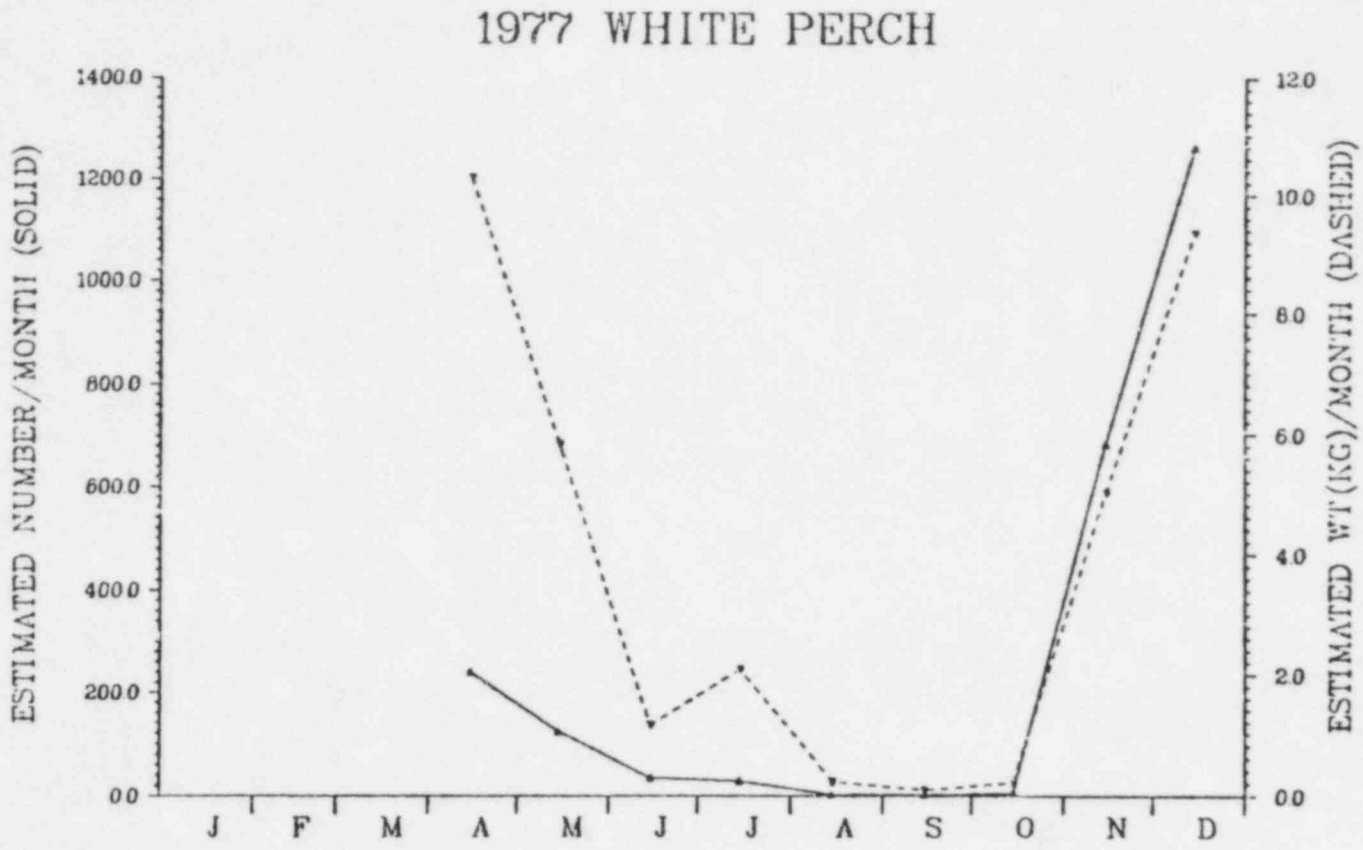
MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED WEAKFISH
SALEM SWS - 1978

FIGURE 5.1 - 13



HOPE CREEK GENERATING STATION
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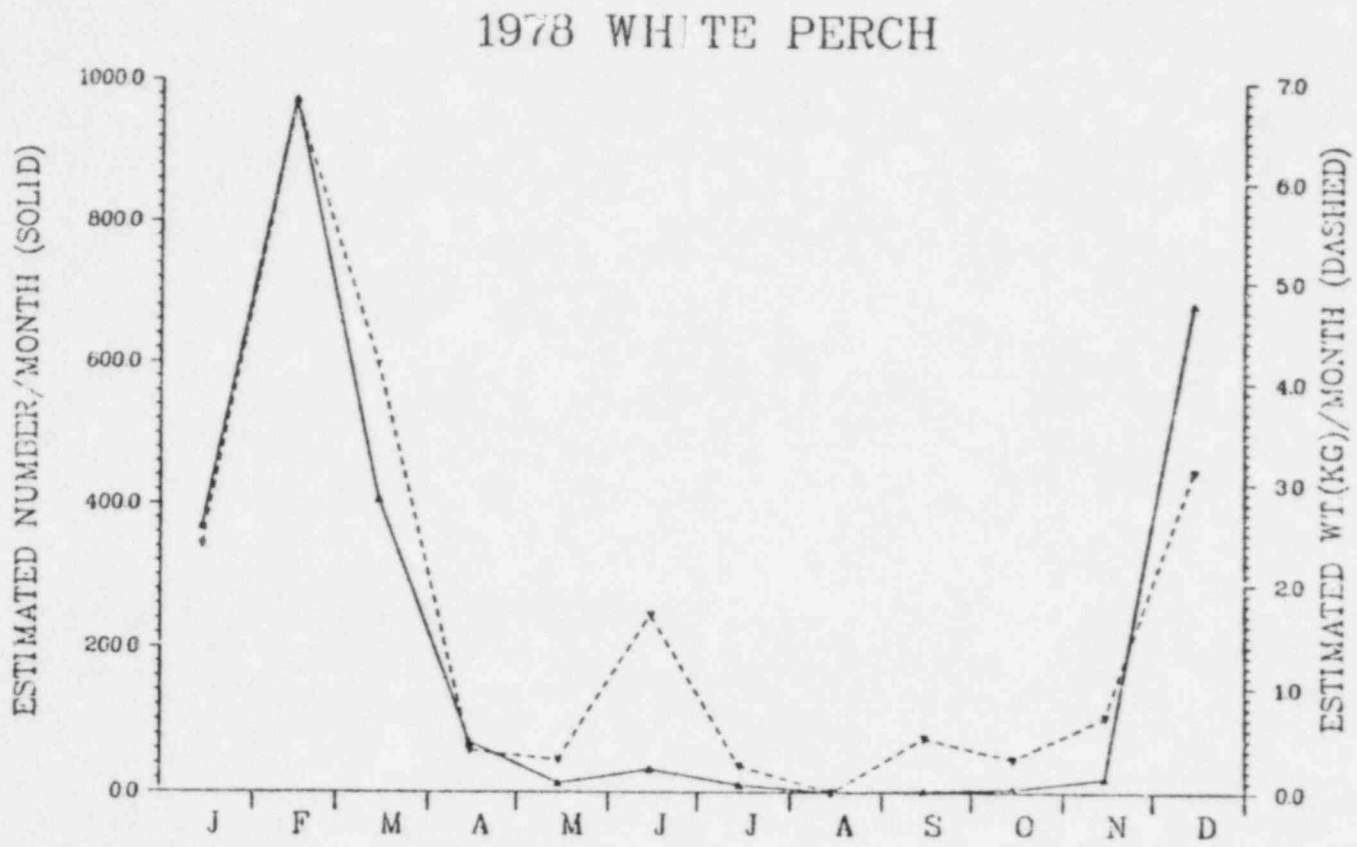
OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED WHITE PERCH

SALEM SWS - 1977

FIGURE 5.1 - 14



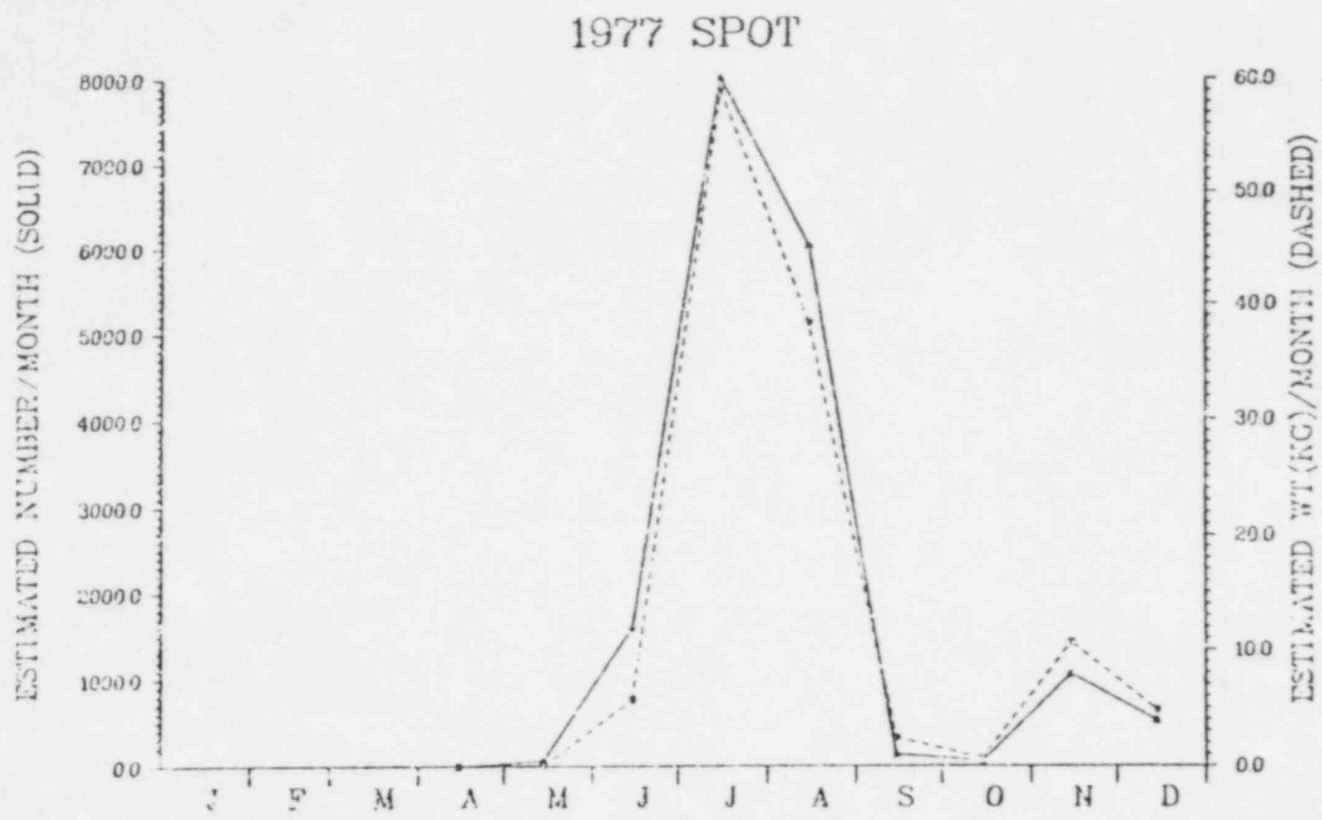
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED WHITE PERCH

SALEM SWS - 1978

FIGURE 5.1 - 15



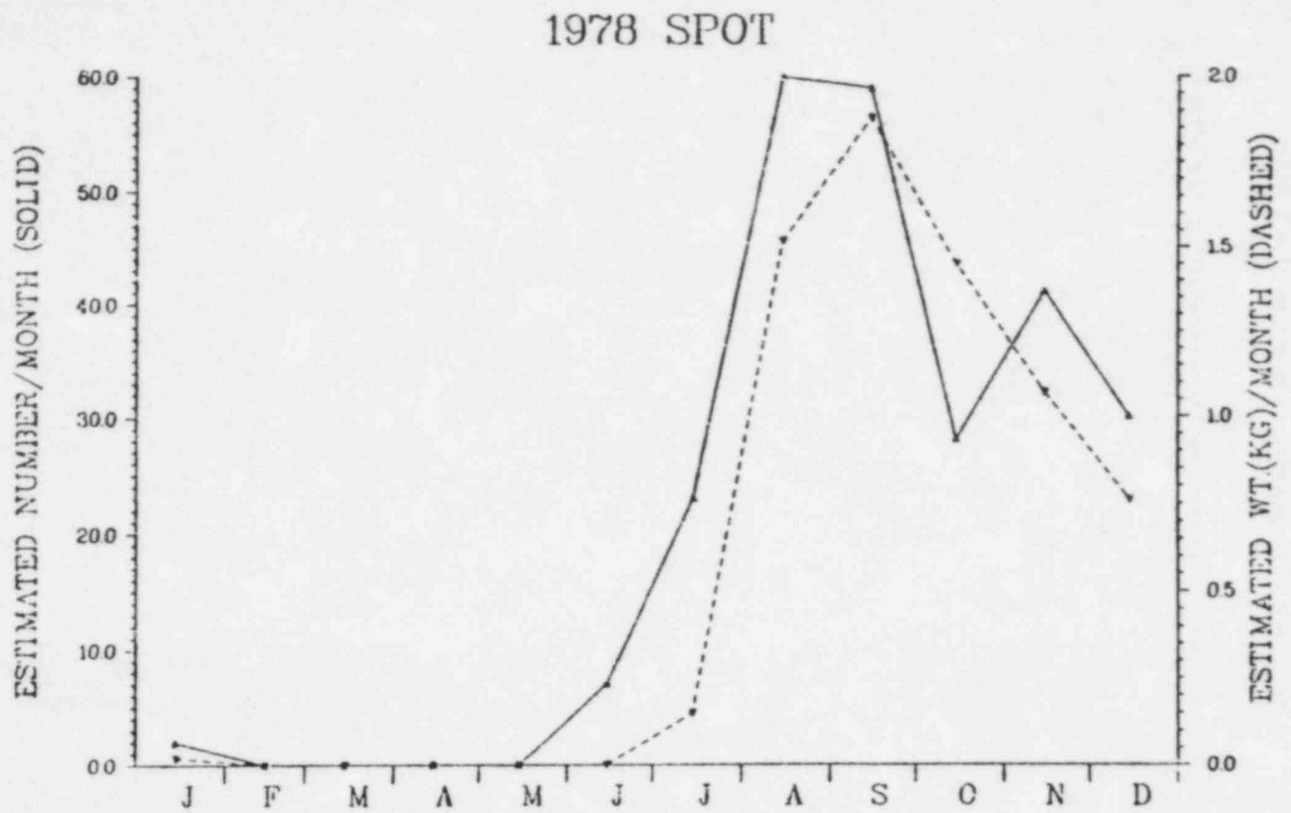
HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED SPOT

SALEM SWS - 1977

FIGURE 5.1 - 16



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

MONTHLY ESTIMATED NUMBER AND WEIGHT OF IMPINGED SPOT

SALEM SWS - 1978

FIGURE 5.1 - 17

5.2 RADIOLOGICAL IMPACT FROM ROUTINE OPERATION

The radiological impacts from the routine operation of HCGS have been evaluated; no adverse effects on man and the environment have been identified. The source terms used were those presented in Section 3.5.

5.2.1 EXPOSURE PATHWAYS

5.2.1.1 Pathways to Biota other than Man

Pathways of radiological impacts to biota other than man can be traced by following the fate of effluents released from the plant.

Airborne releases result in immersion and inhalation doses in addition to doses resulting from effluent removal processes. The doses from the effluent removal processes include direct exposure from nuclides deposited on the ground or in sediments. They also include internal doses from ingestion of vegetation containing radionuclides which were deposited on the plant or incorporated into the plant via the root system, either from nuclides deposited on the ground or from irrigation with water containing radionuclides. An additional dose is received by ingesting water containing deposited activity.

Liquid releases result in immersion and ingestion doses to aquatic organisms as well as doses resulting from effluent removal processes. The effluent removal process doses include direct radiation from radionuclides deposited in sediments and ingestion of vegetation containing radionuclides.

Once incorporated into the food web by these methods, additional internal doses to fauna result from ingestion of other fauna containing, and sometimes concentrating, radionuclides.

Finally, all organisms are also exposed to direct exposure from radioactivity contained within the plant (i.e. N-16).

Figure 5.2-1 illustrates these pathways.

5.2.1.2 Pathways to Man

The pathways to man are the same as for predatory land animals in the food web. Section 5.2.1.1, above, describes these pathways.

It is useful to note specific items in the pathways which are particularly important for understanding the pathways of radiological impact to man. One particularly important pathway is that followed by radioiodine deposited on vegetation.

The vegetation is then eaten by cattle. The radioiodine is transferred to the cattle's milk and then ingested by man. Direct radiation doses from liquid effluents result from activities near the shore, such as fishing or picnicking. Liquid immersion doses to man result from recreational activities, such as swimming and boating. The direct external dose to man also includes that from transport of fuel and waste and can result in the exposure of persons many miles from the reactor.

Figure 5.2-2 illustrates these pathways.

5.2.2 RADIOACTIVITY IN ENVIRONMENT

The gaseous and liquid effluents released by the station are then transported through the environment where they deliver a dose of radiation to living beings. This section presents the models used to describe that transport.

5.2.2.1 Atmospheric Models

Section 2.3 describes the atmospheric transport and diffusion models. Section 2.3 also presents annual concentration (X/Q), depleted X/Q and deposition (D/Q) at selected distances from the plant. No decay is assumed during plume travel; therefore, no decayed X/Q is presented.

5.2.2.2 Surface Water Transportation Models

Radionuclide concentrations in the Delaware estuary were estimated by calculating dilution factors via a variable cross section area model presented in Section E of the attachment to the Concluding Statement of the Position of the Regulatory Staff - ALAP (RM-50-2) (Reference 5.2-1). The equations used are representative of flared estuaries as shown in Figure 5.2-3. Not accounting for delay, the dilution factor is:

$$DF = \left[\frac{r}{r_o}\right] \pm \left[\frac{Qr_o}{A_o E}\right] \qquad \text{(Equation 5.2-1)}$$

where

DF = Dilution factor = Concentration at point of exposure/ Concentration at point of discharge.

r = Distance from start of estuary to point of exposure (feet).

r_o = Distance from start of estuary to discharge point (feet).

Q = Fresh water input to estuary (cubic feet per second).

A_o = Cross-sectional area of estuary at discharge point (square feet).

E = Tidal mixing coefficient (square feet per second).

The tidal mixing coefficient is estimated as

$$E = 1680\ V_{max}^{4/3} \qquad \text{(Equation 5.2-2)}$$

where

V_{max} = Peak tidal velocity at point of exposure.

The sign of the exponent in Equation 5.2-1 is positive for exposure points upstream, and negative for downstream points. Distances (r, r_o) were obtained by measurement using standard U.S. Geological Survey 7.5 minute maps. Fresh water input (Q) was determined by summing the flow rates of streams and rivers entering the estuary upstream of each point of exposure. These flow rates were obtained from U.S. Department of the Interior Water Resources Data for Pennsylvania (Reference 5.2-2), New Jersey (Reference 5.2-3) and Delaware (Reference 5.2-4). The cross-sectional area at the discharge point (A_o) was obtained from shore-to-shore depth profiles supplied by the U.S. Army Corps of Engineers, Philadelphia District Office. Tidal mixing coefficients were calculated using peak tidal velocities obtained from U. S. Department of Commerce Tidal Current Tables.

For the purpose of calculating liquid doses, the Delaware estuary was divided into ten subregions: five upstream and five downstream of Artificial Island. Dilution factors were calculated for each of these subregions. Table 5.2-1 presents dilution factors and input data for each region.

Travel time through the Delaware estuary to the subregions around Artificial Island is a function of tidal velocity. For exposure points upstream and downstream of Artificial Island, Equation 5.2-3 was used to calculate travel times.

$$T_D = D/V \qquad \text{(Equation 5.2-3)}$$

where

D = Distance from discharge to point of exposure (feet).

V = Average flood tide velocity (feet per second) normalized over a 24-hour cycle.

Table 5.2-4 presents travel times for each subregion.

5.2.2.3 Surface Water Sediment Uptake Models

The transport model described above does not take credit for depletion through deposition on sediments. Measurements taken for the adjacent Salem Generating Station have confirmed that that is the appropriate course of action, since there is no significant sediment uptake.

5.2.2.4 Water-Use Models

It is not expected that HCGS will affect water use in adjacent areas; therefore, no water-use model was developed.

5.2.2.5 Groundwater Models

As Section 2.4 discusses, the only connection between the surface water and underground aquifers is through sand drains to the Vincentown Formation. This aquifer and underlying ones are downgradient from potable water supplies. Any radioactivity reaching the aquifer would travel to the river or bay. Thus, there is no need for a separate groundwater model.

5.2.3 RADIOLOGICAL IMPACT TO BIOTA OTHER THAN MAN

Depending on the pathway and the radiation source, terrestrial and aquatic biota will receive doses about the same or somewhat higher than man receives. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is agreed that the limits established for humans are also conservative for other species.

Experience shows that it is the maintenance of population stability that is crucial to the survival of a species, and that species in most ecosystems suffer high mortality rates from natural causes. Although the existence of extremely radiosensitive biota is possible, and whereas increased radiosensitivity in organisms may result from environmental

interactions with other stresses (e.g., heat, biocides, etc.), no biota have yet been discovered that show a significantly increased sensitivity (in terms of increased morbidity or mortality) to radiation exposure at the exposure levels predicted for HCGS.

Furthermore, at all the plants for which an analysis of radiation exposure to biota other than man has been made, there have been no cases of exposures that can be considered significant in terms of harm to the species, or that approach the exposure limits for members of the general public given in 10 CFR Part 20. (Reference 5.2-5). The BEIR Report (Reference 5.2-6) concludes that the evidence indicates that no other living organisms have been identified that are likely to be significantly more radiosensitive than man. Thus, no measurable radiological impact on populations of biota is expected from the radiation and radioactivity released to the biosphere as a result of the routine operation of HCGS.

5.2.4 DOSE RATE ESTIMATES FOR MAN

This section contains estimates for dose rates to man from the effluents calculated in Section 3.5. Section 5.2.2 presents the atmospheric and hydrologic parameters used. Sections 2.1.2 and 5.2.1 discuss the population distribution and exposure pathways, respectively.

Dose rates from gaseous effluents were calculated using the computer code GASPAR while those from liquid effluents were calculated using the computer code LADTAP. These two codes use the methodology described in Regulatory Guide 1.109 (Reference 5.2-7). Dose rates from direct radiation from the plant were calculated using the computer code SKYSHINE. Maximum dose rates at the northern site boundary (901 meters) were calculated to be 1.23 mrem per year. The northern boundary was chosen since it is the closest land boundary.

The following tables present results from these calculations:

a. Table 5.2-2 Annual Maximum Individual Dose Commitments due to Gaseous and Liquid Effluents

b. Table 5.2.3 Appendix I Annual Maximum Individual and Population Dose Commitments

c. Table 5.2.4 Annual Total-Body U.S. Population Dose Commitment

5.2.5 SUMMARY OF ANNUAL RADIATION DOSES

Tables 5.2-3 and 5.2-4 present comparisons between the annual radiation doses expected from HCGS and the applicable design objectives of Appendix I to 10 CFR 50.

REFERENCES

5.2-1 U.S. Atomic Energy Commission, Concluding Statement of Position of the Regulatory Staff, (RM-50-2), February 20, 1974.

5.2-2 U.S. Department of the Interior Geological Survey, Water Resources Data for Pennsylvania - Part 1, 1975.

5.2-3 U.S. Department of the Interior Geological Survey, Water Resources Data for New Jersey - Part 1, 1975.

5.2-4 U.S. Department of the Interior Geological Survey, Water Resources Data for Maryland and Delaware - Part 1, 1975.

5.2-5 B. G. Blaylock and J. P. Witherspoon, "Radiation Doses and Effects Estimated for Aquatic Biota Exposed to Radioactive Releases from LWR Fuel Cycle Facilities," Nuclear Safety, 17 (1976), p. 351.

5.2-6 BEIR National Academy of Sciences, National Research Council, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, November, 1972.

5.2-7 USNRC, Regulatory Guide 1.109, Calculation of Annual Doses to Man from Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I, NRC, Washington, D. C., October, 1977.

TABLE 5.2-1

ARTIFICIAL ISLAND DILUTION FACTORS AND TRANSIT TIMES

	Region									
	1	2	3	4	5	6	7	8	9	10
r_o (10^3 m)	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5
(10^3 ft)	238	238	238	238	238	238	238	238	238	238
r (10^3 m)	5	19	35	52	64	80	95	111	127	143
(10^3 ft)	16	63	116	169	211	264	311	364	417	470
Q (m^3/sec)	467	470	473	487	487	488	488	541	541	541
(ft^3/sec)	16,475	16,587	16,713	17,184	17,213	17,217	17,217	19,100	19,100	19,100
A_o (10^3 m^2)	7	7	7	7	7	7	7	7	7	7
(10^3 ft^2)	260	260	260	260	260	260	260	260	260	260
E (m^2/sec)	393	447	268	317	317	367	420	199	199	177
(ft^2/sec)	4,233	4,807	2,885	3,408	3,408	3,953	4,518	2,142	2,142	1,908
Dilution Factor[1]	14,700	64	44	4.8	1.7	1.5	2.6	32	99	511
D (m)	67,592	53,108	37,015	20,921	8,047	8,047	22,531	38,624	54,718	70,811
(ft)	221,760	174,240	121,440	68,640	26,400	26,400	73,920	126,720	179,520	232,320
V (m/sec)	0.06	0.06	0.06	0.05	0.08	0.08	0.09	0.07	0.06	0.06
(ft/sec)	0.20	0.21	0.19	0.18	0.25	0.25	0.28	0.24	0.21	0.19
Travel Time (hr)	250	160	120	70	20	20	50	100	160	230
					Upstream HCGS	Downstream				

(1) Dilution factors do not include initial dilution discussed in Section 3.5.2.2.3.

TABLE 5.2-2

ANNUAL MAXIMUM INDIVIDUAL DOSE COMMITMENTS DUE TO GASEOUS AND LIQUID EFFLUENTS (mRem unless noted)

		RADIOIODINE AND PARTICULATES IN GASEOUS EFFLUENTS		
LOCATION	PATHWAY	TOTAL BODY	HIGHEST ORGAN	THYROID
Nearest(1) farm residence milk cow and meat animal at 35 miles NW	Ground deposit	7.64E-4	8.98E-4 (skin)	7.64E-4
	Inhalation (infant)	1.63E-4	6.17E-2 (thyroid)	6.17E-2
	Milk (infant)	1.76E-2	4.57E-11 (thyroid)	4.57E-1
	Vegetables (child)	1.13E-2	6.74E-2 (thyroid)	6.74E-2
	Meat (adult)	1.76E-3	8.37E-3 (bone)	3.64E-3
TOTALS				

		LIQUID EFFLUENTS		
		TOTAL BODY	BONE	LIVER
Nearest fish at outfall	Fish ingestion (adult)	2.14E-2	2.09E-1	4.40E-2

	NOBLE GASES IN GASEOUS EFFLUENTS			
	TOTAL BODY	SKIN	GAMMA AIR DOSE (mrads)	BETA AIR (mrads)
Nearest residence 3.5 miles NW	1.70E-2	3.60E-2	2.57E-2	2.27E-2

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

TABLE 5.2-3

APPENDIX I ANNUAL MAXIMUM INDIVIDUAL AND POPULATION DOSE COMMITMENTS(1)

	APPENDIX I DESIGN OBJECTIVES	CALCULATED DOSES
Liquid Effluents		
Dose to total body from all pathways	3 mrem	0.0382 mrem
Dose to any organ from all pathways	10 mrem	0.272 mrem (bone)
Noble Gas Effluents (at nearest actual resident)		
Gamma dose in air	10 mrad	0.0257 mrad
Beta dose in air	20 mrad	0.0227 mrad
Dose to total body of an individual	5 mrem	0.0494 mrem
Dose to skin of an individual	15 mrem	0.0672 mrem
Radioiodines and Particulates(2)		
Dose to any organ from all pathways	15 mrem	0.608 mrem (thyroid)

	POPULATION DOSES WITHIN 80 km (50 mi)	
	TOTAL BODY	THYROID
	Annual Dose	
Natural Radiation Background(3)	490000 man-rem	
Liquid Effluents	0.297 man-rem	0.743 man-rem
Noble Gas Effluents	0.874 man-rem	0.874 man-rem
Radioiodines and Particulates	0.702 man-rem	9.58 man-rem

(1) Appendix I Design Objectives from Sections II.A, II.B, II.C and II.D of Appendix I, 10 CFR Part 50, considers dose to maximum individual and population per reactor unit. From Federal Register, 40, p. 19442, May 5, 1975.

(2) Carbon-14 and tritium have been added to this category.

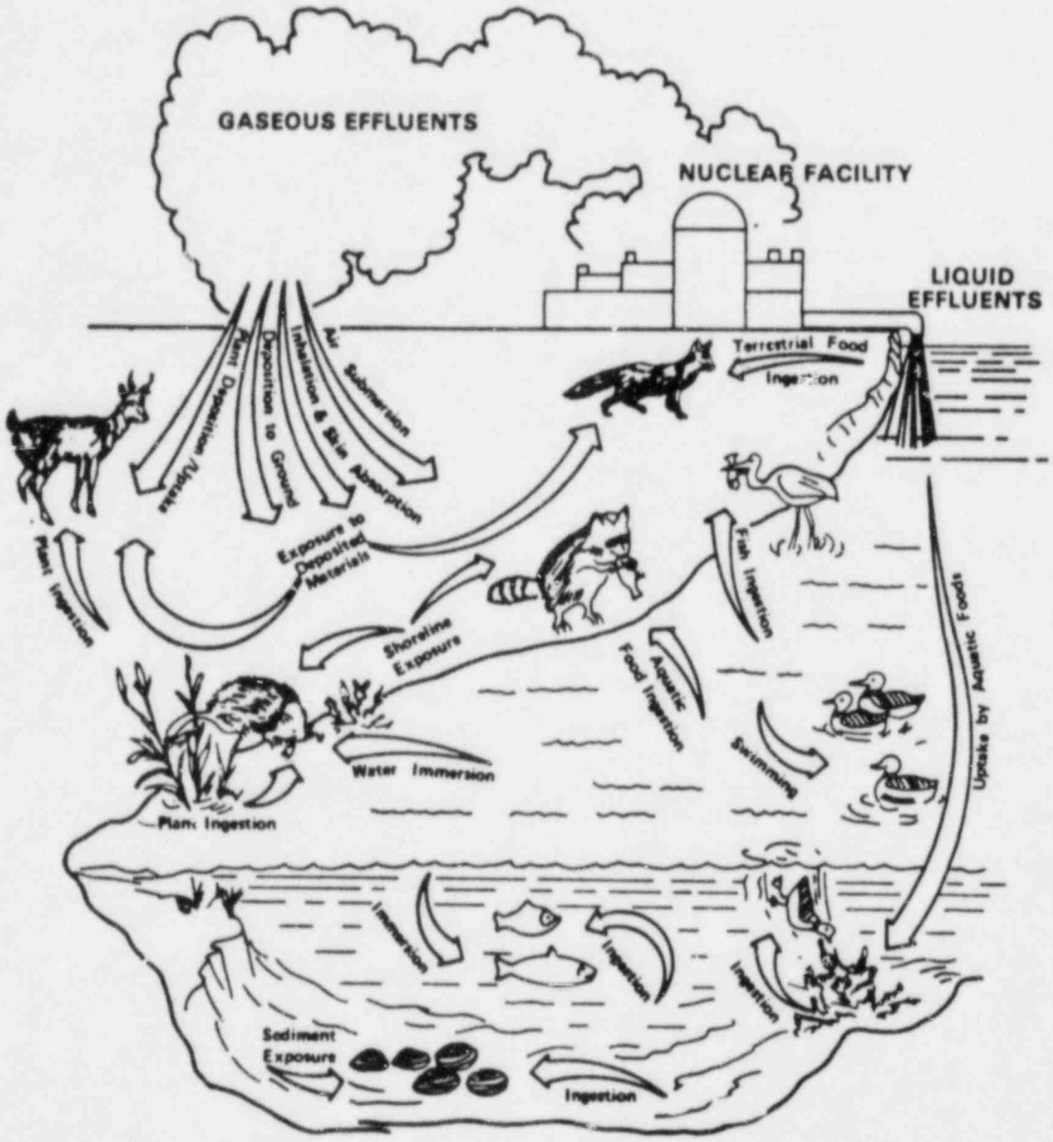
(3) "Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1 (June, 1972); using the average terrestrial plus cosmic background (82 mrem per year for the Hope Creek area) and year 2010 projected population of 5970000.

TABLE 5.2-4

ANNUAL TOTAL-BODY U.S. POPULATION DOSE COMMITMENT

CATEGORY	U.S. POPULATION-DOSE COMMITMENT (man-Rem)
Natural background radiation[1] (man-rem/yr)	28,400,000
General Public	
Gas and particulates	16.2
Liquid effluents	2.39
Transportation of fuel and waste	3

(1) Using the average U.S. background dose (102 mrem per year) and year 2010 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Dept. of Commerce, Bureau of the Census, Series P-25, No. 541, February, 1975.

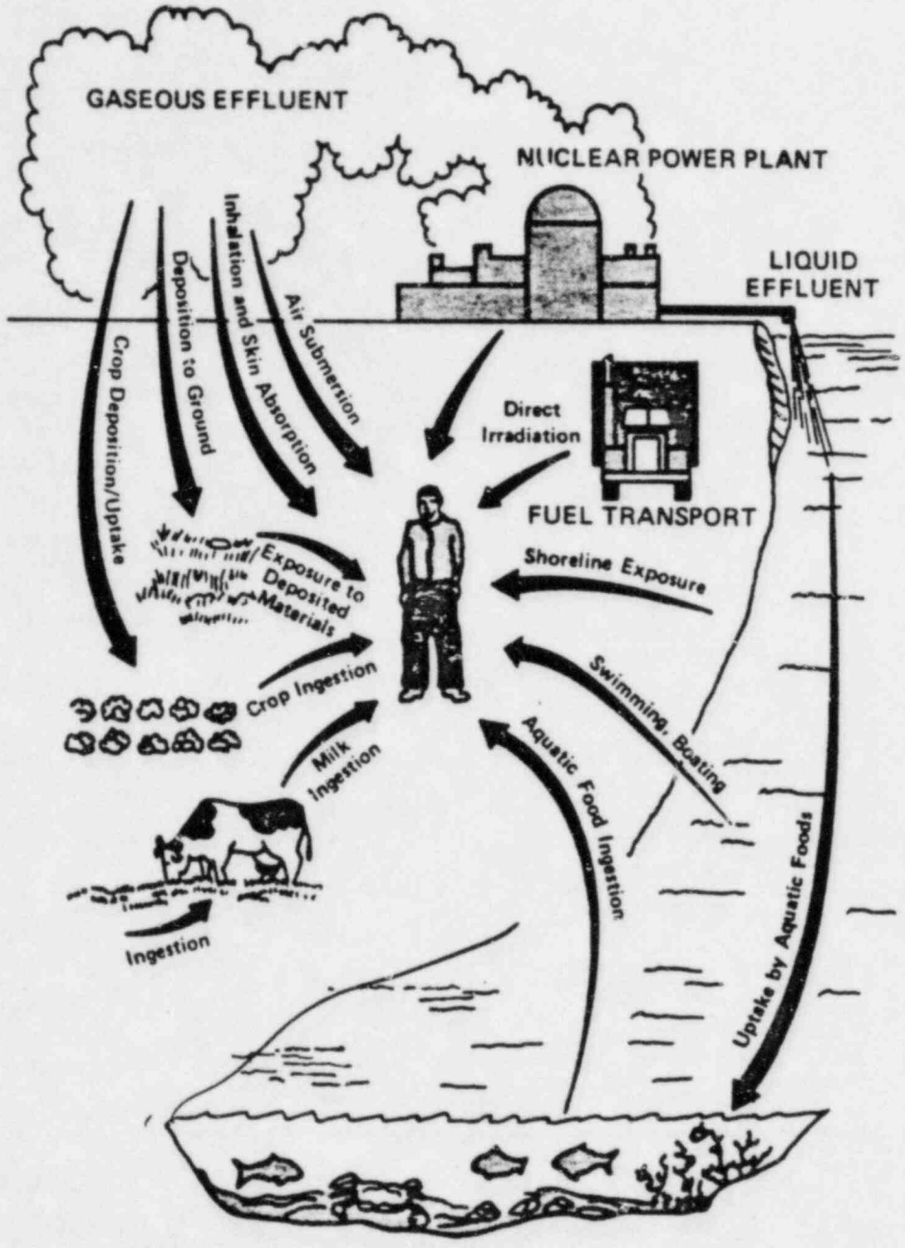


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

PATHWAYS TO BIOTA
OTHER THAN MAN

FIGURE 5.2 - 1

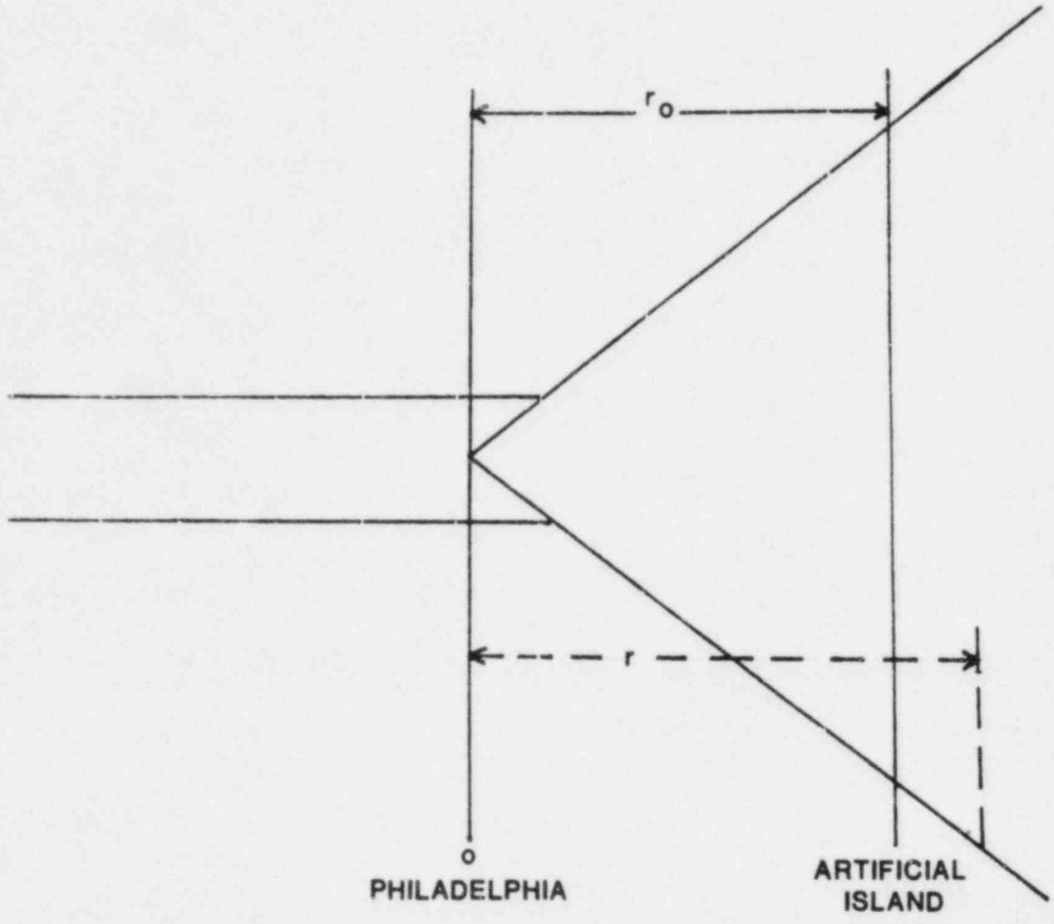


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

PATHWAYS TO MAN

FIGURE 5.2 - 2



HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT
OPERATING LICENSE STAGE

FLARED ESTUARY

FIGURE 5.2 - 3

5.3 EFFECTS OF CHEMICAL OR BIOCIDE DISCHARGES

5.3.1 SURFACE WATER

HCGS uses the Delaware River to assimilate liquid discharges from the chemical and biocide systems described in Section 3.6. The DRBC and NJDEP require that specific stream quality objectives for Zone 5 of the Delaware be met within 1100 meters (3,500 feet) of the discharge (mixing zone). Table 5.1.1 provides these water quality objectives.

PSE&G controls station discharges to meet these objectives and the discharge limitations imposed by the EPA and DRBC (see Section 5.1.1). A description of chemical and biocide discharge effects on the Delaware River follows:

5.3.1.1 Oily Water, Low Volume Waste Water

At the construction permit stage, PSE&G planned a chemical waste treatment system. Publication of revised effluent limitations (Table 5.1-2) on November 19, 1982, has prompted PSE&G to reevaluate the system as well as several alternatives. The precise method for treatment and/or disposal has not been determined. However, if the chosen system requires discharge of an effluent into the Delaware River, that effluent will meet all current limitations. Any treatment works will be licensed by the New Jersey Department of Environmental Protection.

5.3.1.2 Cooling Tower Blowdown

As Section 3.4 describes, a natural draft cooling tower is the major feature of the station's heat dissipation system. The service water system obtains make-up water from the Delaware River to replace evaporative losses and cooling tower blowdown.

Make-up water requires treatment with chlorine (see Section 3.6.1) prior to its use in both service and circulating water systems in order to control biofouling. Similarly, sulfuric acid prevents deposition of calcium carbonate (scaling) when added to circulating water.

The EPA regulates the concentration of residual chlorine (biocide) in cooling tower blowdown (see Table 5.1-2). Free available chlorine (FAC) in cooling tower blowdown may not exceed 0.5 milligram per liter as a one-day maximum or 0.2 milligram per liter as a 30-day average. Additionally, daily chlorination is limited to two hours each day (see Table 5.1-2).

Cooling tower blowdown flow averages approximately 80,900 liters per minute (21,360 gallons per minute) over an average month at full power operation.

In order to meet make-up water chlorine demand and maintain an effective FAC residual in the service and circulating water systems, HCGS utilizes a maximum of 145,600 kilograms (390,000 pounds) of chlorine (as Cl_2) annually (400 kilograms (1,100 pounds) per day).

The release of FAC should not have a significant impact on Delaware River water quality. The chlorine, which is added as sodium hypochlorite, exists in the dissolved state as hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). These species disperse, and are diluted, as in the near field of the thermal plume (see Section 5.1.2). Dilution alone of the chlorinated effluent assures a minimal effect on Delaware River water quality. If the station releases 0.5 milligram per liter of FAC, under conditions of least dilution (August, during ebb tide on the river bottom), the FAC concentration at the end of the 1070 meter (3,500 foot) mixing zone would be less than 0.01 milligram per liter.

It should also be considered that the EPA limits to two hours the time during which any measurable chlorine residual is allowed. Additionally, dilution does not account for ambient river chlorine demand, which further reduces chlorine levels. It can be seen that both regulation and physical factors (dilution, chlorine demand, etc.) protect river quality.

If all chlorine is converted (reduced) to Cl^-, the river loading of 0.2 milligram per liter of the ion within the plume is negligible compared to ambient (median) river chloride levels (3,725 milligrams per liter). If it is assumed that the cooling tower creates two cycles of river water concentration, the combination of reduced chlorine and concentrated chlorides would generate a chloride concentration of only 3,982 milligrams per liter at the boundary of the plume (during the period of least dilution).

The use of sulfuric acid to control scaling should not affect river water quality. HCGS utilizes an average of 1,550 kilograms (4,150 pounds) of sulfate daily and discharges a concentration of approximately 1,029 milligrams per liter (assuming doubling of ambient river water sulfates by cooling tower).

At the boundary of the plume during the period of least dilution, the sulfate concentration would be 543 milligrams per liter (ambient river level is approximately 507 milligrams per liter).

In like fashion, the other chemical constituents of cooling tower blowdown, as Table 3.4-2 describes, disperse and are diluted within the plume to levels well within stream quality standards.

5.4 EFFECTS OF SANITARY WASTE DISCHARGES

The HCGS sewage treatment system discharges an average of 110,500 liters (29,200 gallons) and a maximum of 193,000 liters (51,000 gallons) each day to the Delaware River. Sewage plant effluent quality meets limitations imposed by the NJDEP (NPDES Permit No. NJ0025411 for HCGS, discharge No. 62B) and the DRBC. Table 3.7-1 provides typical discharge limitations.

Prior to approval of any facility discharge to Zone 5 of the Delaware River, both the NJDEP and the DRBC must determine that zone-specific stream quality objectives are not contravened (see Table 5.1-1). Approval of the HCGS sanitary waste facility by both agencies assures that, through proper operation of the sewage treatment system, the sanitary waste discharge will have minimal impact on Delaware River water quality.

PSE&G monitors plant outfall prior to its discharge into the north storm drain (see Figure 3.3-1) (see Section 6.1.1.1). Additionally, a waste sludge holding tank retains sludge generated by the treatment process for eventual off-site removal by a licensed waste disposal contractor.

The sewage plant discharge is released gradually into the Delaware River. Maximum (based on 193,000 liters per day (51,000 gallons per day)) facility release is 134.0 liters (35.4 gallons) per minute. The Delaware River provides an assimilative capacity which far exceeds the demand of the treated sewage. With allocation for the HCGS sanitary system discharge considered, the DRBC estimates that 11,400 kilograms (25,000 pounds) of biochemical oxygen demand assimilative capacity is still available in Zone 5 (Reference 5.4-1).

The above shows that, through proper facility operation, the sanitary waste discharge will have no impact on the Delaware River.

REFERENCES

5.4-1 Personal communication between PSE&G and DRBC, October 21, 1982.

5.5 EFFECTS OF OPERATION AND MAINTENANCE OF THE TRANSMISSION SYSTEMS

Section 3.9 and this section discuss the status of the HCGS transmission system as it will exist at the time of initial HCGS operation. Consistent with the rest of this Environmental Report, the transmission system is discussed in the present tense, as if the changes had already occurred. At the time of this submittal (March, 1983), the transmission line arrangement remains as discussed in Section 8.2 of the Salem FSAR (Reference 5.5-6).

Two preexisting transmission lines have been disconnected from Salem Generating Station and routed into HCGS. A third line, 305 meters (1000 feet) long, connects HCGS to Salem Generating Station. In order to replace transmission capacity diverted from Salem Generating Station, the Salem - New Freedom portion of the Salem - Deans line has been added to the transmission facilities. Since this portion of the line has been constructed as a result of HCGS, an assessment of its operation and maintenance appears in Section 5.5.4.

5.5.1 HOPE CREEK - NEW FREEDOM 500 KILOVOLT TRANSMISSION LINE

The former Salem - New Freedom North line has been disconnected from Salem Generating Station, routed into HCGS, and redesignated Hope Creek - New Freedom (Figures 3.9-3 and 3.9-5). Operation and maintenance of this line were discussed and documented during the operating license stage of Salem Generating Station (Reference 5.5-1).

5.5.2 HOPE CREEK - KEENEY 500 KILOVOLT TRANSMISSION LINE

The former Salem - Keeney line has been disconnected from Salem Generating Station, routed into HCGS, and redesignated Hope Creek - Keeney (Figures 3.9-4 and 3.9-5). Operation and maintenance of this line were discussed and documented during the operating license stage of Salem Generating Station (Reference 5.5-1).

5.5.3 HOPE CREEK - SALEM TRANSMISSION LINE

The 305 meter (1000 foot) transmission line lies within the PSE&G site boundary and crosses areas containing HCGS and Salem Generating Station buildings and structures (Figure 3.9-5). Operation and maintenance activities for the line, due to its size and location, are minimal.

5.5.4 SALEM - DEANS 500 KILOVOLT TRANSMISSION LINE (SALEM - NEW FREEDOM PORTION)

The operation and maintenance of the transmission line running from the Artificial Island site to the New Freedom switching station were discussed (as the Hope Creek - New Freedom line) during the construction permit stage. A summary of these activities, including any changes since the construction permit stage, appears below.

Operation

As Section 3.9 notes, the applicant, due to balanced transmission line loading practices, does not anticipate any ground currents; however, all transmission towers are grounded, and equipped with lightning shield wires. The minimum conductor clearance to the the ground is 10 meters (33 feet) at 100°C (212°F), which meets the National Electric Safety Code (NESC), Section 23, requirements (Reference 5.5-2). The typical maximum electric field beneath the line and one meter (three feet) above the ground is approximately five kilovolts per meter; it is typically less than two kilovolts per meter at the edge of the ROW. Experience with approximately 487 kilometers (303 miles) of 500 kilovolt lines in New Jersey and previous assessments of extra high voltage (EHV) transmission lines (References 5.5-3 and 5.5-4) indicate that the 500 kilovolt Salem - Deans line portion should not produce any significant health or other risks.

The line design follows standard utility guidelines set forth in the EPRI Transmission Line Reference Book (Reference 5.5-5), which provides design procedures for radio and television interference, audible sound and corona loss. Audible sound levels at the edge of the right-of-way are within the 50 dbA limit stipulated in New Jersey law (NJSA 13:1G1-23) and regulations (NJAC 7:29-1.2a). Corona loss from high voltage transmission lines is controlled by properly designed conductors, conductor spacing, insulators and line hardware; for example, a critical spacing and bundling of two conductors per phase reduces the concentrated electrical field normally found around a single conductor. Ozone production believed to be associated with high-voltage transmission lines was discussed during the construction permit stage and mentioned in the FES.

Consistent with the Construction Permit Stage FES (Reference 5.5-1), the applicant has taken steps to preserve right-of-way vegetation, and to design and locate line support structures so as to reduce the lines' visual effect upon the

general landscape. These steps consist of the following practices which PSE&G applies generally to all new overhead transmission lines:

a. Available railroad and other rights-of-way are utilized wherever practical and feasible. Potential problems with railroad signal devices caused by inductive coupling are minimized by keeping the line parallel to, but off of, the railroad right-of-way, or by replacing the signal system with a shielded cable system where actual use of the railroad right-of-way is advantageous.

b. Structures are located wherever practical and feasible in accordance with the topography so as to minimize their appearance.

c. When structures are painted, appropriate colors are selected to maintain an acceptable appearance with respect to the surrounding areas.

d. Non-uniform clearing of right-of-way to minimize the removal of existing growth is standard procedure. The maximum number of mature trees which will not constitute a hazard for structures or conductors is allowed to remain standing.

e. Landscaping by means of planting low growing species as required.

f. Wherever practical and feasible, special uses of the right-of-way for farming, recreational and other appropriate purposes are permitted.

As stated during the construction permit stage and confirmed in several recent field surveys conducted by PSE&G personnel, land uses along the transmission line right-of-way are returning to their pre-construction states. Prime and secondary farmlands located beneath transmission lines are producing crops which include corn, pole beans, peppers, apples and peaches (see Table 3.9-1). Pastures located beneath transmission lines are maintained for grazing animals. Hardwood and pine forests beneath the line are periodically trimmed to maintain an adequate distance from the conductors. The farmland, pasture and woodland areas traversed by access roads and immediately beneath each transmission tower (12 by 6 meters (40 by 20 feet)) are kept clear, and cannot return to their previous usage.

The visual contrast of access roads located in woodland areas is greater than for those located in either pastures or farmland; however, in order to minimize this contrast, roads have been constructed in winding rather than straight paths, where possible.

The Salem - New Freedom portion of the Salem - Deans line runs parallel to the Hope Creek - New Freedom line. Since new towers and conductors are generally adjacent to and similar in design to pre-existing towers and conductors, the effects of the Salem - New Freedom portion on the appearance of the surrounding area are minimized.

The applicant has identified historic, archeological, scenic and cultural areas, within two kilometers of either side of the line, that are listed or proposed to be listed on the National Registry of National Landmarks and the National Register of Historic Places. Section 2.6 gives a description of the sites; their locations appear on Figure 3.9.3.

Maintenance

Maintenance of the Salem-New Freedom portion of the Salem-Deans Transmission line consists primarily of conductor repair and insulator replacement. Maintenance personnel perform this work upon discovery of such damage during periodic line inspections. Maintenance personnel and equipment have access to towers and conductors by means of access roads.

Trees beneath the line are trimmed in order to maintain a minimum 4.6 meter (15 foot) distance to the conductors. The use of chemical herbicides to control growth, including Tordon 1-5-5, which was assessed during the construction permit stage, is not planned.

REFERENCES

5.5-1 U.S. Nuclear Regulatory Commission, Final Environmental Statement Related to Operation of Salem Nuclear Generating Station Units 1 and 2, Docket Nos. 50-272 and 50-311, April, 1973.

5.5-2 ANSI, National Electrical Safety Code, Institute of Electrical and Electronics Engineer, Inc., N.Y., N.Y. (1981), pp. 138-217.

5.5-3 N.Y. Public Service Commission, transcript from hearing on health and safety of EHV power lines, 1977.

5.5-4 U.S. Environmental Protection Agency, Evaluation of Health and Environmental Effects of Extra High Voltage (EHV) Transmission (ORP/SEPD 80-13), June, 1980.

5.5-5 General Electric Company, Transmission Line Reference Book 345 kV and Above, Electrical Power Research Institute, Palo Alto, Ca. (1975), pp. 122-278.

5.5-6 PSE&G, Salem Generating Station, Units 1 and 2, Updated Final Safety Analysis Report, Docket Nos. 50-272, 50-311.

5.6 OTHER EFFECTS

The operating effects of HCGS on the environment, other than those previously discussed, appear below.

5.6.1 HISTORIC RESOURCES

The operation of HCGS should not cause any significant impact to any structures listed on the National Register of Historic Places, although most of the listed areas within 16 kilometers (10 miles) of the site are within potential sight distance, depending on local surroundings, of the HCGS cooling tower, and its plume, when present. Site visits on January 17 and 18, 1983, disclosed that many of the historic properties are surrounded by structures and vegetation which completely screen them from view of the cooling tower. Other sites have a partially obstructed view, e.g., the Hancock House in Hancocks Bridge and the Samuel and Sarah Nicholson House. Still other sites have a distant view of the cooling tower, e.g., Fort Mott, Fort Delaware, and the Thomas Sutton House in Woodland Beach, Delaware. The sites at which HCGS is most visible are those directly across the Delaware River in Port Penn and Taylor's Bridge, Delaware; however, prior to construction of HCGS, Salem Generating Station has been within clear view of these sites.

The sites listed or eligible to be listed on the National Register of Historic Places within two kilometers (1.2 miles) of either side of the Salem - New Freedom portion of the Salem - Deans line are within potential sight distance of the line; however, a site visit on January 17, 1983, by PSE&G personnel, revealed that only the Hancock House has an unobstructed view of this transmission line and the Hope Creek - New Freedom line which existed previously (see Section 3.9).

5.6.2 SOUND LEVELS

The operational sound levels generated at HCGS should not produce an adverse impact on the surrounding environment nor a nuisance to residences within an eight kilometer (five mile) radius.

The cooling tower produces noise resembling that of a waterfall (by water falling onto the fill and into the basin, and by the flow of air through the tower). Noise level at 1000 meters (3280 feet) from the center line of the tower is estimated to be 46 dbA, which is well within the acceptable range cited by the NJDEP (Reference 5.6-1) and the U.S. Department of Housing and Urban Development (Reference 5.6-2).

The noise generated by the transformers and the transmission lines is also well below applicable Federal and State standards (see Section 2.7).

Sound generated by the turbines, generator, motors and pumps is attenuated by the buildings containing them.

5.6.3 AIR QUALITY

Nonradioactive plant emissions from HCGS are estimated to be below the de minimus criteria established by the EPA (Reference 5.6-3), which apply to new sources. See Section 3.7 for a listing of air pollutants emitted. Emissions from equipment such as diesel generators, heating boilers and fuel and chemical storage tanks are in such minor amounts as to cause no significant effects. All air pollution control systems were designed to meet State emission standards (Reference 5.6-4), and have NJDEP permits to operate (see Chapter 12). Deposition of particulates (salt) in the drift from the cooling tower is estimated to be very small (see Section 5.1.4).

5.6.4 GROUNDWATER EFFECTS

Section 2.4.2 provides data on the withdrawal of water from groundwater formations for purposes of site dewatering and production use.

Dewatering during facility construction consisted of the removal of water from the Shallow (riverbed sands) and Vincentown Formations. Although flow patterns were altered during dewatering operations, these changes are transient. Aquifer flows should return to normal when dewatering ceases, as they did in the Salem Generating Station's dewatering process.

HCGS has been licensed (see Chapter 12) to withdraw water for production use from two wells in the Upper Raritan formation. The DRBC, which regulates major water diversions within the Delaware Basin, has approved the wells, taking into account area groundwater conditions. PSE&G does not expect withdrawal from HCGS production wells No. 1 and 2 to adversely affect the Upper Raritan formation.

No waste streams from HCGS will be disposed of through underground injection. Thus, no impact on groundwater will result from such operations.

5.6.5 FLOODPLAIN EFFECTS

As described in Section 2.4.1.1, the most recent FEMA maps for Lower Alloways Creek, New Jersey, describe the 100 year flood as reaching an elevation of 2.7 meters (nine feet) above MSL. Final plant grade at HCGS averages 3.8 meters (12.5 feet) above MSL. Thus, the station should not alter the floodplain, nor should receding water carry with it significant amounts of debris associated with the facility.

REFERENCES

5.6-1 Noise Control for Industrial and Commercial Operations, New Jersey Administrative Code, Title 7, Chapter 29-1.2.

5.6-2 United States Housing and Urban Development (HUD), Noise Abatement and Control Departmental Policy Implementation Responsibilities and Standards, Circular 1390.2, Charge 1, September, 1971.

5.6-3 40 CFR 52.21.

5.6-4 New Jersey Administration Code 7, Chapter 27, Bureau of Air Pollution Control, Subchapter 8.

5.7 RESOURCES COMMITTED DURING OPERATION

No significant irreversible or irretrievable commitments of resources result from station operation. Some resources, such as uranium, land and water, are consumed or permanently committed, but quantities are small compared to supplies.

Section 4.3 describes resources committed during construction.

5.7.1 MATERIALS INVOLVED

Uranium is the principal natural resource material irretrievably consumed in plant operation. Other materials consumed include fuel cladding, reactor control elements, replaceable reactor core components, chemicals used in processes such as water treatment and ion exchanger regeneration, ion exchange resins, and minor quantities of materials used in maintenance and operation. Except for the uranium isotopes U-235 and U-238, the consumed resource materials have widespread usage; therefore, their use in station operation is reasonable compared with their use in other industries. The major use of the natural isotopes of uranium is for production of useful energy.

The reactor is fueled with uranium enriched in the isotope U-235. After use in the plant, the fuel elements still contain U-235 slightly above the natural concentration. This slightly enriched uranium could be separated from plutonium and other radioactive materials in a chemical reprocessing plant, and be available for recycling through the gaseous diffusion plant, but until such recycling becomes available through federal government facilities, the fuel is stored in the spent-fuel pool at the HCGS site or at long-term storage facilities. The HCGS storage pool has a capacity of 22.5 years (based on an 18-month refueling cycle, and using high-density fuel racks). Scrap material containing valuable quantities of uranium is also recycled through appropriate steps in the fuel production process. Fissionable plutonium recovered in the chemical reprocessing of spent fuel can be used as fuel in power reactors.

If the unit operates at an average 80 percent capacity factor over 40 years, about 5,100 metric tons (5,621 tons) of natural uranium in the form of U_3O_8 will be required to fuel the plant.

The Department of Energy resources estimate indicates that sufficient uranium resources exist within the United States to fuel all operating reactors, reactors under construction and

reactors being planned, for their full 40-year lifetime at U_3O_8 cost (1978 dollars) of $30 per pound or less. Resource categories designated "reserves" and "probable potential," the two most certain resource categories, can supply these quantities (Reference 5.7-1).

The 5,100 metric tons (5,621 tons) of mined natural uranium required to fuel the HCGS reactor consist of about 35 metric tons (38.6 tons) of U-235, with the balance consisting of U-238. In the power plant itself, fission and transmutation will consume about 25 metric tons (27.6 tons) of U-235 and approximately 25 metric tons (27.6 tons) of U-238. This process will produce about 8 metric tons (8.8 tons) of recoverable fissionable plutonium. Estimates for the additional irretrievable losses of uranium in other portions of the fuel cycle amount to about 0.75 metric ton (0.82 ton) of U-235 and 60 metric tons (66.1 tons) of U-238. A net residue of about 5,000 metric tons (5,512 tons) of uranium depleted to about 0.2 percent of U-235 would remain. In the long term, this stock of depleted uranium may be utilized as feed material in other reactor fuel cycles. In consideration of the reserves of all depletable fuels, uranium consumption in the proposed operation is a reasonably productive use of this resource (Reference 5.7-2).

5.7.2 WATER AND AIR RESOURCE IMPACTS

Sections 5.1 and 5.2 discuss the expected releases of chemicals and radioactive materials, and their consequences. It is necessary, in plant operation, to use both air and water resources to assimilate these discharges. The more significant commitment of these resources is the consumptive use of between 36,300 liters per minute (9,600 gallons per minute) and 49,000 liters per minute (13,000 gallons per minute) of water from the Delaware River. This water is evaporated by the cooling towers to the atmosphere, but it is recycled in the environment through the hydrologic cycle. The Merrill Creek Reservoir will provide compensatory water as required by the DRBC; therefore, such a commitment is neither irreversible nor irretrievable. There are no irreversible or irretrievable commitments of air resources.

5.7.3 LAND RESOURCE IMPACTS

About 62 hectares (153 acres) of Artificial Island are completely committed to the construction and operation of HCGS for the 40 years that the plant will be licensed to operate. Most of the area could be restored for other purposes (see Section 5.8).

5.7.4 ENVIRONMENTAL RESOURCE IMPACTS

Although impingement and entrainment of fish and other invertebrates occur, because of the large population of these organisms in Delaware Bay and the dynamic response of the estuary, PSE&G expects plant operation to cause no significant environmental losses.

REFERENCES

5.7-1 D. L. Hetland, Potential Uranium Resources, Grand Junction Office, U. S. Dept. of Energy, Grand Junction, ID, October, 1978.

5.7-2 USNRC, Final Environmental Statement Related to the Project Hope Creek Generating Station, Units 1 and 2, PSE&G, Docket Nos. 50-354 and 50-355, Washington, D. C., February, 1974.

5.8 DECOMMISSIONING AND DISMANTLING

5.8.1 GENERAL

Specific detailed plans for the decommissioning of a nuclear power plant are not normally developed at the operating license stage; however, there are several options available from which a satisfactory decommissioning plan can be developed during the life of the plant, allowing sufficient lead time to take full advantage of the state of technology in order to minimize environmental impact. At the appropriate time in the future, PSE&G will make a final determination on the most appropriate decommissioning plan, based upon current information, that balances the intended future use of the site, safety standards, environmental goals and economic considerations.

The design of HCGS has emphasized reliability and ease of maintenance. Accordingly, those components and systems that need periodic maintenance have been arranged and designed for easy handling. These design objectives will facilitate component maintenance and replacement, and, near the end of the useful life of the plant, will also facilitate the removal or encapsulation of plant equipment.

5.8.2 DECOMMISSIONING ALTERNATIVES

At the present time three primary decommissioning alternatives and two combination alternatives for light water reactors have received serious consideration. The sources and levels of radiation and the resulting occupational doses to personnel, the chemical and physical characteristics of the contamination, the physical access to components and equipment, and the availability of advanced dismantling technology will all influence the choice of method of decommissioning. Consideration will also be given to the environmental acceptability of the alternatives, and to the land use objectives for the site at the time of decommissioning. The following is a brief description of these decommissioning alternatives.

a. Mothballing places the station in a state of protective storage. In general, the station is left intact except that all fuel assemblies and radioactive fluids and wastes are removed from the site. Adequate radiation monitoring, environmental surveillance and appropriate security procedures are established, including control of all access to the site, reporting of any abnormal occurrences, maintaining logs, and submitting status reports to the appropriate regulatory agencies under a possession-only license, to ensure that the health and safety of the public are preserved.

b. Entombment entails the shipping of all fuel assemblies, radioactive fluids and wastes, and certain selected components off the site, followed by the sealing of all remaining highly radioactive or contaminated components within a structure integral with the biological shield. The plant structures provide integrity over the period that significant quantities of radioactivity remain with the material in the entombment. An appropriate and continuing environmental and access control surveillance program is established under a possession-only license.

c. Prompt Removal/Dismantling involves the removal from the site of all fuel assemblies, radioactive fluids and wastes, and other materials having activity above accepted unrestricted levels. The station owner then has unrestricted use of the site with no requirement for a possession-only license. If the station owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed.

d. Mothballing - Delayed Removal/Dismantling Combination involves initial mothballing of the station as described in Part a above. Dismantling is delayed a sufficient period to allow the gamma radiation levels caused by activated materials in the work environment - most importantly, Co-60 and Fe-55 - to decay to sufficiently low levels to permit manual removal of the activated materials. If prompt dismantlement were performed, these activated materials, with the possible exception of the reactor vessel and internal parts, would require remote handling. This delay will reduce the level of man-rem radiation exposure received below that incurred by prompt dismantlement. It will also reduce the cost of dismantlement since the use of remote handling equipment is minimized.

e. Entombment - Delayed Removal/Dismantling Combination involves initial entombment of the structure as described in Part b, and eventual dismantlement as described in Part d, above.

5.8.3 DECOMMISSIONING COSTS

The Atomic Industrial Forum (AIF) (References 5.8-1 and 5.8-2) and the NRC in NUREG-0586 (Reference 5.8-3) have estimated costs of decommissioning for various alternatives on a per unit, per site basis. Table 5.8-1 contains these estimates. Actual costs will be influenced by regulations currently under development, as well as by the means of financing them.

Only the alternatives of mothballing and entombment would result in a long-term commitment of the immediate land on which the power plant structures were built (as would, of course, conversion to a new nuclear or fossil system). Dismantlement, mothballing or entombment with delayed dismantlement could permit the return of much of the site to unrestricted use at the time of dismantlement.

REFERENCES

5.8-1 AIF/NESP-009, "An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives," November, 1976.

5.8-2 G. D. Calkins, "Status of NRC Decommissioning Program," AIF Conference on Environmental Regulation of the Nuclear Industry: A New Decade, May 18-21, 1980. These estimates include $12 million for building demolition for each alternative and a 25 percent contingency factor.

5.8-3 NUREG-0586, "Draft Generic Environmental Input Statement on Decommissioning of Nuclear Facilities," January, 1981. These estimates include an annual maintenance charge for surveillance and security ($2,200,000 for the mothballing alternative, and $40,000 for the entombment alternative).

TABLE 5.8-1

ESTIMATED DECOMMISSIONING COSTS (PER UNIT)

ALTERNATIVE	AIF (MILLIONS 1975 DOLLARS)[1]	NRC (MILLIONS 1978 DOLLARS)
Mothballing	2.5	45[3]
Entombment	7.6	27[3]
Dismantlement	31.2	56[3]
Mothballing, Delayed Dismantlement	31.5	71[2]
Entombment, Delayed Dismantlement	24.8	53[2]

(1) Reference 5.8-1.
(2) Reference 5.8-2.
(3) Reference 5.8-3.

5.9 THE URANIUM FUEL CYCLE

The environmental effects of the uranium fuel cycle, which include the effects of the mining and milling of the uranium ore, the conversion of the ore into UF_6, enrichment, fabrication into fuel elements, reprocessing, transportation and management of the resulting nuclear waste, are all items evaluated in Summary Table S-3 of 10 CFR 51. Table S-3 of 10 CFR 51 is reproduced in this report as Table 5.9-1.

TABLE 5.9-1

EFFECTS OF THE URANIUM FUEL CYCLE(1)

(From Table S-3 of 10CFR51)

ENVIRONMENTAL CONSIDERATIONS	TOTAL	MAXIMUM EFFECT PER ANNUAL FUEL REQUIREMENT OR REFERENCE REACTOR YEAR OF MODEL 1,000 MWe LWR
NATURAL RESOURCES USE		
Land (acres):		
Temporarily committed(2).....	100	
Undisturbed area.....	79	
Disturbed area.....	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed.....	13	
Overburden moved (millions of MT)...	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons):		
Discharged to air.....	160	= 2 percent of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies.....	11,090	
Discharged to ground.....	127	
Total.....	11,377	<4 percent of model 1,000 MWe LWR with once-through cooling.
Fossil Fuel:		
Electrical energy (thousands of MW-hour).....	323	<5 percent of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT)...	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf).....	135	<0.4 percent of model 1,000 MWe energy output.
EFFLUENTS - CHEMICAL (MT)		
Gases (including entrainment):(3)		
SO_x.....	4,400	
NO_x(4).....	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons.....	14	
CO.....	29.6	
Particulates.....	1,154	
Other Gases:		
F.....	0.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards - below level that has effects on human health.

(1) In some cases where no entry appears, it is clear from the background documents that the matter was addressed and that, in effect, the Table should be read as if a specific zero entry had been made; however, there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Rn-222 from the uranium fuel cycle or estimates of Tc-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings. Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248); and in the record of the final rule-making pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor, which are considered in Table S-4 of §51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

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

(3) Estimated effluents based upon combustion of equivalent coal for power generation.

(4) 1.2 percent from natural gas use and process.

TABLE 5.9-1 (Continued)

ENVIRONMENTAL CONSIDERATIONS	TOTAL	MAXIMUM EFFECT PER ANNUAL FUEL REQUIREMENT OR REFERENCE REACTOR YEAR OF MODEL 1,000 MWe LWR
EFFLUENTS - CHEMICAL (MT) - (Cont'd)		
HCl	0.014	
Liquids:		
$SO^{=}_4$	9.0	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3 - 600 cfs NO_3 - 20 cfs Fluoride - 70 cfs
NO^{-}_3	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^{-}	8.5	
Na^{+}	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions (thousands of MT)	240	From mills only - no significant effluents to environment.
Solids	91,000	Principally from mills - no significant effluents to environment.
EFFLUENTS - RADIOLOGICAL (CURIES)		
Gases (including entrainment):		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium (thousands)	16.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	0.83	
Tc-99		Presently under consideration by the Commission.
Fission products and transuranics	0.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling-included tailings liquor and returned to ground - no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production.
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants - concentration 10 percent of 10 CFR 20 for total processing of annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning - buried at land burial facilities. 600 Ci comes from mills - included in tailings returned to ground. Approximately 50 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository.
Effluents - thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

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CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

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CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

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CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL ENVIRONMENTAL PROGRAMS

6.1.1 SURFACE WATERS

6.1.1.1 Physical and Chemical Parameters

Thermal

Section 5.1.2 gives a prediction of the size and dispersion characteristics of the thermal plume from HCGS. Appendix A describes in detail the modeling technique used.

Delaware River water temperatures used in the thermal study are based on hourly readings obtained from Salem Generating Station's circulating water system.

Bathymetry

As part of a general bathymetry study being performed for the Salem Generating Station, PSE&G has surveyed the area near the HCGS site twice each year. Data for all surveys are collected with a Raytheon Model DE-719B Fathometer mounted on a survey vessel. Sounding stations are located in the field using a Motorola Mini-Ranger III horizontal positioning system. Table 6.1-1 gives specifications for these instruments.

For each general survey, parallel tracks are established at 100 meter (330 foot) intervals. Data are recorded every 50 meters (164 feet) along these transects. The most recent survey near the HCGS site (see Figure 2.4-10) employed 20 meter (66 foot) separations between the transects. Soundings were taken every 10 meters (33 feet) along these transects.

At the conclusion of each survey, depth recordings are read to the nearest 0.03 meter (0.1 foot), and transcribed for computer card punching. Depth measurements are corrected for surface wave action and the subsequent movement of the survey craft as measurements are recorded. A computer program corrects for tide and instrumentation errors before final plots are produced.

Tidal Characteristics

Delaware River tidal variations near HCGS are based on measurements obtained from Reedy Island (Reference 6.1-1). Data used to determine the range of current speed and direction and volume of contributory freshwater discharges into the Delaware are obtained from USGS monitoring stations along the river. Yearly U.S. Geological Survey (USGS) reports (see Reference 6.1-2) provide frequency and methods of monitoring.

Chemical Parameters

PSE&G implemented programs to monitor chemical parameters of the Delaware River in the area of Artificial Island in 1971; these programs became a part of the Salem Environmental Technical Specifications (Reference 6.1-3). Monthly samples are obtained from three points (see Figure 6.1-1). Location 1 is near the circulating water discharge from Salem Generating Station, at a depth of 3 meters (10 feet). Location 2 is next to the circulating water system intake, at a depth of 2.4 meters (8 feet). Location 3 is outside and downstream of the Salem mixing zone, at a depth of 1.5 meters (5 feet). During incoming and slack tides, location 3 is adjacent to buoy N4R, approximately four kilometers (2.5 miles) north of the Salem discharge. During outgoing and low slack tides, the sample is obtained next to buoy R8L, three kilometers (two miles) south of the Salem discharge.

Parameters monitored include suspended solids, pH, dissolved oxygen, specific conductance, turbidity, chloride, sulfate, nitrate, kjeldahl nitrogen, phosphate, ammonia, calcium, magnesium, sodium, potassium, iron and copper. Section 2.4 discusses water quality data acquired through this program.

Field sampling and sample preservation techniques are carried out in accordance with the EPA's "Methods for Chemical Analysis of Water and Wastes" (Reference 6.1-4) and the American Public Health Association's "Standard Methods for the Examination of Water and Waste Water," 14th edition (Reference 6.1-5). Similarly, laboratory procedures follow procedures from these same authorities.

6.1.1.2 Ecological Parameters

Since early 1968, Ichthyological Associates (IA) has conducted an extensive program to monitor aquatic life in the vicinity of HCGS (see Table 2.2-1). The studies were initially of an inventory nature, but by 1970 they developed into a baseline program.

Annual progress reports (References 6.1-6 through 6.1-15) and annual operating reports (References 6.1-16 and 6.1-17) contain the detailed procedures for each study.

The preoperational program can be broken down into five studies; a summary of each appears below.

PHYSICAL AND CHEMICAL MONITORING

Investigators obtained relevant physical and chemical data on surface waters by taking grab samples or by placing instrument probes directly in the water. Bottom samples were collected with Kemmerer, Niskin or Van Dorn water bottles.

Water temperature (to the nearest 0.1°C) and dissolved oxygen (to the nearest 0.1 part per million) were determined with a Yellow Springs Instrument Company Model (YSI) No. 51 dissolved oxygen meter. Air temperature (to the nearest 0.5°C) was measured with a mercury bulb field thermometer. Salinity, determined from 50 milliliters of water returned to the lab in a plastic vial, was measured (to the nearest 0.5 part per thousand) with an American Optical Corporation refractometer. Water transparency (to the nearest 2.5 centimeter) was measured with a Secchi disc. All instruments were regularly calibrated against known standards.

PLANKTON - DETRITUS MONITORING

Sampling Schedule: From 1973 through 1976, samples were taken at eight stations in the study area (Figure 2.2-6). From early 1975 through 1976, to better balance the sampling design, two additional stations were sampled. For a complete description of schedules, gear and procedures, refer to the annual reports.

From July through December, 1973, pigment study chlorophyll samples were collected monthly near the surface and/or bottom at all stations, conditions permitting. Beginning in January, 1974, two replicate samples were collected at each station biweekly. Additionally, from May through October, 1975, samples were taken at about two-hour intervals during a 12-hour period at the three stations located on a transect extending west from Artificial Island.

From April through December, 1973, a qualitative taxonomic study was done on aliquots from surface pigment samples collected at a station just offshore of Artificial Island.

Quantitative examination of surface samples collected at the other two stations on the transect began in 1974. Surface and bottom samples were examined during 1975 and 1976.

Productivity samples analyzed for carbon fixation were taken monthly from April through June, 1973 at depths of 0.0, 0.5, 1.0 and 2.0 meters (0.0, 1.6, 3.3, and 6.6 feet) at the same station. Beginning in July, 1973, samples were also taken at the western station on the same transect. Beginning in July, 1984, samples were collected bimonthly at both stations on the same day.

Water temperature, dissolved oxygen, salinity and transparency were measured with each collection.

From July through September, 1974, additional pigment and taxonomic samples were taken downbay near Ship John Shoal (about 17 kilometers (11 miles) south of Artificial Island). These samples were obtained concurrently with those taken near Artificial Island.

Field and Laboratory Techniques: All samples were collected with an 8.1-liter Van Dorn bottle.

Chlorophyll a and phaeo-pigments were extracted with 90 percent acetone. Light absorption was measured before and after acidification at 665 and 750 nanometers (after Reference 6.1-18) on a spectrophotometer.

Sample aliquots for taxonomic studies were preserved with Lugol's solution (Reference 6.1-19). Taxa were enumerated to the lowest practicable level, typically genus or species, in a Palmer-Maloney cell with a Nikon (Model SKE) compound microscope at 200X magnification. The annual reports contain the taxonomic keys used during these studies.

Samples for productivity studies were suspended at their collection depths for a four-hour incubation period, typically between 1000 and 1400 Hour; dissolved oxygen was measured either by Winkler titration (Reference 6.1-20) or with a biochemical oxygen demand (B.O.D.) probe, and converted to carbon equivalents (milligrams carbon per cubic meter per hour).

Data Reduction: Preliminary analysis of the pigment and productivity data indicated that the log 10 transformation was the best mode for further analysis. The best model for expressing the relationship between log 10 transformed chlorophyll a concentrations (1973-1976 data, depths combined) and the physical and chemical parameters (e.g., water

temperature and salinity) was a stepwise multiple regression procedure (maximum R^2 option; Reference 6.1-21). Using this model, a contour plot of chlorophyll a distributions as a function of water temperature and salinity was generated. Previous analysis had indicated that Secchi disc readings, which are relatively constant throughout the year, did not contribute significantly to the model. A similar model and contour plot were generated for surface net productivity values.

AQUATIC INVERTEBRATE FAUNA MONITORING

The early years of each invertebrate program were of an inventory nature. Sampling frequency, location, gear type, and in some cases, objectives, were modified as the program developed. A reference species collection is available; the collection was verified when required. The annual reports contain taxonomic species keys.

Zooplankton

Sampling Techniques and Schedule: From 1968 through 1970, 0.5-meter nets (0.5-millimeter mesh) were deployed biweekly to collect macroinvertebrate plankton samples in eight river zones near Artificial Island. During 1971 and 1972, in an effort to collect the microzooplankton (less than 0.5 millimeter), the 0.5-meter net was replaced with a Clarke-Bumpus plankton sampler fitted with a 0.08-millimeter mesh net. Samples were collected biweekly to monthly at 8 to 19 stations. Although the Clarke-Bumpus sampler was successful in filtering the microzooplankton, net clogging caused by detritus proved to be a serious problem, which necessitated a gear change. In 1973, a pump filter system fitted with a 0.08-millimeter mesh net, modified after Icanberry and Richardson (Reference 6.1-22), was employed. It allowed quantitative sampling and constant monitoring of detritus levels. Sample duration was shortened accordingly. Macroinvertebrates were collected coincidently with ichthyoplankton using a 0.5-meter net.

The standardized quantitative phase of the zooplankton program was initiated in 1973 and continued through 1976. This consisted of three discrete studies including area-wide microzooplankton and macroinvertebrate studies and a station-specific, time-duration microzooplankton study. These studies provided spatial and temporal data on the abundance and distribution of both micro and macroinvertebrate plankton within a region of the Delaware River from 12 kilometers (eight miles) north to eight kilometers (five miles) south of Artificial Island.

In the area-wide microzooplankton study, samples were collected at a total of 22 locations (Figure 2.2-8); between 11 and 16 stations were sampled yearly. The monthly station-specific, time-duration study provided data on the vertical (surface, mid and bottom) distribution of microzooplankton at three stations located on a transect opposite Appoquinimink River during four consecutive tidal stages over a 12-hour period. In the macroinvertebrate plankton study, samples were collected at a total of 10 stations; between five and seven stations were sampled yearly. Surface and bottom data were collected during daylight and darkness, biweekly to monthly. Data obtained from 1974 through 1976 form the basis for quantitative discussion of marcroinvertebrate plankton.

From 1971 to 1973, larval crab were collected at between 9 and 11 stations yearly from about eight kilometers (five miles) north to eight kilometers (five miles) south of the southern tip of Artificial Island. Surface, mid and bottom samples were collected during daylight and darkness between once and twice each month from June through October (daylight sampling through December in 1971). In 1971, all samples were collected with a 0.5-meter (0.5-millimeter mesh) plankton net. In 1972 and 1973, the 0.5-meter net and 9-foot bottom trawl fitted with a 0.5-millimeter mesh liner were used.

Laboratory Techniques: From each microzooplankton sample, two to five subsamples were examined in a Sedgewick Rafter counting cell under a compound microscope. Densities were expressed as number per cubic meter of water filtered (n/m^3).

Macroinvertebrate plankton samples were sorted completely or subsampled with a Folsom Plankton Splitter and/or Hensen-Stempel pipette, depending on sample density and amount of detritus present. Specimens were enumerated under a dissection microscope with density expressed as number per 100 cubic meters of water filtered ($n/100m^3$). Length-frequency data for selected macroinvertebrates were generated.

Benthos

Sampling Techniques and Schedule: The benthos was studied from June 1969, through 1976. Several types of exploratory gear (Ekman, Peterson, and Ponar grab samplers and KB core sampler) were employed through 1970 to inventory fauna and sediment type near Artificial Island. Based on sampling efficiency, the Ponar grab, which samples an area of 0.05 square meter to a depth of approximately 15 centimeters, was selected as the most suitable sampling device for the region.

The standardized quantitative phase of benthos study was initiated in June, 1971. From 1971 through 1974, 20 to 30 stations were sampled during daylight on a monthly to bimonthly basis (Figure 2.2-8). Three replicate grabs were taken at each station. Analysis showed that data from 14 stations, 10 of which were sampled monthly, were used to describe local distribution and abundance. Ten of the original 14 stations were sampled intensively from 1974 through 1976. Data from the other four are used for qualitative reference.

Laboratory Techniques: Each grab sample was washed in a No. 35 U.S. Standard sieve with 0.5-millimeter mesh. Rose bengal was added to facilitate recovery of organisms, which were separated from extraneous material (sand, gravel, detritus, etc.) in enamel pans, and preserved in 40-percent isopropyl alcohol. Specimens in each sample were sorted to the lowest taxon practicable and tallied accordingly. Densities were expressed as number per square meter (n/m^2).

Blue Crab

Sampling Techniques and Schedule: From 1968 through 1970, juvenile and adult blue crab were collected, and the carapace width of random subsamples measured, as part of the fisheries trawl program. Trawls were hauled on the river bottom and creek zones semi-monthly.

In 1971, the program was expanded to include all crabs collected in the fisheries trawl program. These were counted, measured, sexed, and categorized as to maturity and stage of growth. Additionally, the local commercial crab fishery was annually surveyed for information on daily landings (number of bushels), effort expended (number of pots tended), location of effort, and the number of "peelers" (molting crabs) taken. Annual reports contain these commercial data. Data were collected weekly to monthly from an area extending from approximately 16 kilometers (10 miles) north to 16 kilometers (10 miles) south of Artificial Island.

AQUATIC VERTEBRATE FAUNA MONITORING

Samples were taken with a variety of gear, including surface and bottom trawls, various seines, staked and drifted gill nets, trap nets (1968 only), and one-meter and 0.5-meter plankton nets. The widest assortment of gear was used during the early years to ensure adequate sampling of most habitats to inventory the species present. Because of tidal variation, weather-related non-predictability of passive gear retrieval (staked nets, traps, etc.) and local bottom conditions, not

all gear could be used in scheduled quantitative sampling programs. Eventually, standardized trawling and seining were as established as being the most suitable and dependable methods for defining the structure and behavior of the fish community. Table 2.2-2 shows chronology of primary gear deployment. The annual reports contain details of the program, including a listing of taxonomic keys.

Sampling Techniques and Schedules: Semi-balloon otter trawls were used in the river and tidal tributaries because of their capture efficiency in deeper waters. In the inventory phase, 7.6-meter and 4.9-meter trawls were fished in the river at surface and bottom during the day and the night. Tidal tributaries were sampled on the bottom with 4.9-meter and 2.7-meter trawls during daylight. Intensive sampling, as often as weekly, evidenced that a biweekly sampling schedule would adequately describe temporal trends. In 1970 the standardized trawl program was initiated.

Biweekly sampling in the river employed a 4.9-meter bottom trawl during daylight in 21 to 27 zones from 14.5 kilometers north to 16.1 kilometers south of Artificial Island. Night bottom trawling was done in five to eight zones annually. Trawls were hauled for 10 minutes, with the tide, at boat speeds of three to four knots. Onshore and offshore hauls were made in each zone. Local tidal tributaries were sampled with five-minute hauls of the 2.7-meter trawl. Beginning in 1973, twenty-minute hauls were made in five additional deepwater zones located in or near the shipping channel.

Seines were used to sample fishes in the shallow waters of the shore zone. In the inventory phase, 68.6, 22.9, 7.6 and 3.0-meter seines were fished during day and night at locations throughout the study area. The standardized seine program was initiated in 1970. It involved fishing a 7.6 by 1.2-meter, 0.6-centimeter mesh bag seine and a 3.0 by 1.2-meter, 0.3-centimeter mesh flat seine during daylight, generally biweekly, at seven to ten stations, and at night at selected stations. The smaller seine was used at 6 o 12 stations in local tidal tributaries. In 1974, samplin_ effort was further standardized to include one 27 to 37-meter haul with the larger seine and three six-meter hauls with the smaller seine to allow semi-quantitative spatial and temporal comparison.

A day-night program of simultaneous seining and trawling was initiated in 1971, as a semi-quantitative supplement to the standard seine and trawl programs. Its purpose was to evidence distributional differences between day and night, inshore and offshore, and east and west sides of the river.

Four types of gear were used at each of two sites. The shallow inshore zone was sampled with a 3.0 by 1.2-meter, 0.3-centimeter mesh flat seine and a 7.6 by 1.2-meter, 0.6-centimeter mesh bag seine. The intermediate zone was sampled with a 68.6 by 3.0-meter, 1.3-centimeter mesh bag seine. The deeper offshore waters were sampled with a 4.9-meter semi-balloon otter trawl towed at the bottom. A standard sampling effort consisted of four or five hauls with the smaller seines, one haul with the larger seine, and two five-minute trawl hauls. Generally, day and night samples were taken within 24 hours of each other, at the same tidal stage.

Gill nets with stretched mesh size ranging from 1.3 to 14.0 centimeters (0.5 to 5.5 inches) were fished throughout the river and in tidal tributaries during day and night in the inventory period. Nets were anchored, staked and drifted. During the scheduled monitoring period, three 0.3-centimeter (1/8-inch) and five 1.3-centimeter (0.5-inch) nets were drifted in the river to sample the larger-size classes and the more pelagic species that are less susceptible to capture by trawl. Effort was concentrated in spring to sample immigrating species, such as the anadromous river herrings which pass through the area during that season. Nets were also fished in mid-summer to sample older age groups of summer resident species, and in fall to sample the new year class of anadromous species as they emigrated past Artificial Island and out of the estuary.

The procedure for processing the catch of young and adults was the same for all gear. When fewer than 200 specimens of a species were taken, all were enumerated, and up to 30 were measured to the nearest millimeter. When more than 200 specimens of a species were taken, the sample was estimated, and a subsample of 30 was measured. Fork length (FL) was the standard measured. Fish with convex caudal fins were measured by total length (TL). Dissolved oxygen, water temperature and salinity were measured at surface with each seine collection, and at surface and bottom with each collection by other gear. For a more detailed description of procedures, see the annual reports.

Early life stages (eggs and larvae) have been sampled annually since 1971 with 0.5-meter, 0.5-millimeter mesh conical plankton nets. Earlier, 1.0-meter nets and a specially adapted 2.7-meter bottom trawl were also tried and found less suitable. Samples were taken simultaneously at surface and bottom at 9 to 11 stations in the river. Bottom nets were

fitted with 17-kilogram depressors to keep them fishing about 0.6 meters above bottom. All tows were made with the tide for five minutes. In 1973, nets were fitted with flow meters, and abundance was expressed as density (number of organisms per cubic meter of water filtered - n/m^3). Effective 1974, replicate samples were taken at selected stations. Middepth samples were taken at three deepwater stations. Samples were taken at least monthly, and more frequently during periods of greatest ichthyoplankton abundance (June through August). Specimens were preserved in the field and brought to the laboratory, where they were identified to the lowest practicable taxonomic level, and counted.

Data Reduction: The following statistics were used to describe the data: n = number of specimens, T = number of trawl hauls, n/T = number of specimens per trawl haul, n/c = number of specimens per seine collection, n/m^3 = number of specimens per cubic meter of water filtered.

6.1.2 GROUNDWATER

As Section 2.4.2 describes, HCGS does not discharge any wastes into subsurface formations; therefore, the station will not adversely affect water quality in the area via contamination.

If accidental spills occur at the site, local groundwater supplies should not be affected, since normal gradients in the shallow aquifers are south-south west towards the Delaware River. Data obtained from a network of piezometers and observation wells placed in various formations throughout the site area support this (see Figure 2.4-3). Section 2.4.2 describes aquifer flow characteristics near the station.

HCGS obtains its water for non-cooling purposes from the Upper Raritan formation. Observation wells and facility production wells were used to determine the water quality and physical characteristics of this aquifer (see Figure 2.4-12).

Water analyses were carried out in accordance with Standard Methods for the Examination of Water and Wastewater, 14th Edition, 1975. Physical parameters of the aquifer were based on field and laboratory data. Porosity and effective porosity were based on sieve analyses and methodology reported in Todd (Reference 6.1-23). Aquifer pump test data were used in a Theis non-leaky artesion aquifer curve to calculate storage coefficients, permeability and coefficient of transmissability.

6.1.3 AIR

The following section describes the program for obtaining rolocal air quality data along with local and regional meteorology. The HCGS on-site meteorological collection program is in conformance with Regulatory Guide 1.23, Revision 0. This section also discusses the models used for prediction of dispersion of gaseous effluents to a distance of 80 kilometers (50 miles) from the station, and any alteration of the local climate.

Table 6.1-2 presents local air quality data (1980) measured in the vicinity of the plant. An examination of the data shows that the air quality in the region, except for the one-hour ozone measurements, is well within the National and New Jersey Ambient Air Quality Standards. NJDEP continues to gather data from the monitoring locations at Vineland, Penns Grove and Salem, New Jersey.

Instruments located on a 91 meter (300 foot) tower at Artificial Island provide local (on-site) meteorology. Regional meteorology is available on an hourly basis from Wilmington, Delaware National Weather Service Station (NWS), located 24 kilometers (15 miles) north of the plant.

Section 5.1.4 gives any alterations of the local climate caused by station cooling tower operation. This section also addresses icing, fogging, and changes in precipitation patterns.

6.1.3.1 Meteorology

Sections 2.3.1.1 and 2.3.2 report the sources of meteorological data used in the atmospheric transport models. The meteorological data base consisted of five years of hourly data, from January 1, 1977, through December 31, 1981.

Section 2.3.2 includes a description of the meteorological instruments. The performance specifications meet the

requirements listed in Regulatory Guide 1.23, Revision 0. The instruments and associated recorders are calibrated by an outside contractor once per quarter year. The data analysis procedures include a requirement for surveillance of all hourly averaged data by a consulting meteorologist. After erroneous or missing data are identified, the data base is written to a computer tape. The data tape is updated every six months. Instrument and recorder calibrations are reviewed, and the consulting meteorologist incorporates any changes on a semiannual basis.

6.1.3.2 Models

Section 2.3.5 describes the models used to derive diffusion estimates, both short and long term. The models follow the methodology presented in Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion for Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," and Regulatory Guide 1.145. Section 2.3.5 also provides dispersion estimates out to 80 kilometers (50 miles) from the plant.

6.1.4 LAND

6.1.4.1 Geology and Soils

During the construction permit stage, PSE&G had presented geological and soils information related to HCGS. The applicant has since conducted several site and vicinity geologic and soil investigations from 1974 through 1982 to supplement this information.

These additional investigations included foundation engineering studies and soil property surveys of the Vincentown Formation and overlying fill layers. Dames and Moore, a PSE&G consultant, has conducted several site and vicinity boring programs during which approximately 50 borings were taken. This information, in conjunction with earlier studies, gives a greater definition to the geologic and soil characteristics of the site and its vicinity.

Borings were drilled and soil samples were taken at continuous 1.5 meter (5 foot) intervals. Sampling devices included the Osterberg, split spoon and Dames and Moore U-type samplers. Blow counts were recorded for split spoon samples. All samples were logged visually, classified according to the Unified Soil Classification System, and transferred to a certified laboratory for additional testing.

The tests evaluated engineering properties of the soils, and aided in the classification of the various strata encountered. Strength and deformation tests included triaxial compression and consolidation tests. Index property tests included moisture and density determinations, Atterberg limits and particle size analyses.

The FSAR lists details of all investigations. Section 2.5 of this document includes a summary of this information.

6.1.4.2 Land Use and Demography

See Sections 2.1.2 and 2.1.3.

6.1.4.3 Ecological Parameters

Monitoring programs for terrestrial species emphasized the important species in the area. Diamondback terrapin, osprey and bald eagle had special programs devoted to their distribution and nesting. General monitoring programs were performed for vegetation, amphibians, reptiles, waterbirds and mammals.

Diamondback terrapins were studied at nesting beaches from 1975 through 1982 during the summer months. Information collected included number of nests observed, predation on nests and hatchlings, number of tracks, and length and width of turtles. The annual environmental operating reports - nonradiological for Salem Generating Station for 1977 through 1981 (References 6.1-25 through 6.1-29) present these data.

A joint study observed both osprey and bald eagle. Bald eagles are uncommon in the area, and are not known to nest in the vicinity. Osprey nests in the transmission towers near the site were studied between 1974 and 1982. Known osprey nests were monitored by helicopter from April through August of each year. Investigators recorded the number of adults, nests, eggs, nestlings and fledglings. The NJDEP performed occasional banding of fledglings.

General programs for other bird species, amphibians, reptiles, mammals and vegetation have been performed since 1974. Bird studies started in June of 1974, and have continued to the present, covering an area within eight kilometers (five miles) of the site. Most of the effort has been directed toward waterbirds, with observations taken from boats on the tidal creeks and Delaware River.

Inventory type studies, field observations, and trapline surveys were conducted for amphibians, reptiles, and mammals from 1972 through 1973. Supplemental information was obtained from prior published surveys of the area. The study area extended to a 16 kilometer (10 mile) radius around the site.

Vegetation studies were conducted from 1972 through 1974 to determine distribution and relative abundance of vascular plants. Investigators recorded species observed within 15 kilometers (9 miles) of the site in 1972. In 1974 a detailed list of the species within eight kilometers (five miles) on the New Jersey side of the Delaware River was compiled.

6.1.5 OFF-SITE RADIOLOGICAL MONITORING PROGRAM

Since 1968, an off-site radiological environmental monitoring program (REMP) has been conducted for the area near the HCGS site. Due to the proximity of HCGS and Salem Generating Station, a common REMP is conducted for both stations. Starting in December, 1972, a more extensive REMP was initiated with the purpose of identifying and quantifying the concentration of various radioactive elements in the different environmental media surrounding Salem Generating Station. The Annual Environmental Operating Reports - Radiological, for Salem Generating Station for 1976 through 1981 (References 6.1-30 through 6.1-35) present these data.

6.1.5.1 Program Objective

The objectives of the preoperational radiological environmental monitoring program are:

a. To fulfill the requirements of the radiological surveillance sections of the Environmental Technical Specifications for Salem Generating Station.

b. To determine the statistical variation in the concentration of radionuclides in critical pathways.

c. To establish baseline data for comparison with future operational data.

d. To implement the guidance provided in the USNRC Branch Technical Position, Rev. 1, entitled "An Acceptable Radiological Environmental Monitoring Program."

The selection of sample locations is based on site meteorological, hydrological, and geographical constraints imposed by local demography and land use (see Figures 6.1-2 and 6.1-3).

Sample locations chosen are consistent with the USNRC Branch Technical Position cited above. Sample locations are divided into two basic classes, indicator and control stations. Indicator stations are selected where they could be expected to manifest a station effect if one existed. All control locations are located sufficiently far from the station to be unaffected by plant operation. In this manner, investigators could compare fluctuations in the level of radionuclides and direct radiation at an indicator station location to fluctuations, if any, at a control location to determine if the station was the cause of the fluctuations.

6.1.5.2 Preoperational and Operational Programs

The operational REMP for the Salem Generating Station began in December, 1976 after Unit 1 achieved criticality. Table 6.1-3 describes the program currently in operation. Until HCGS is operational, the current operational REMP for the Salem Generating Station suffices as the preoperational REMP for the HCGS site for purposes of determining any radiological environmental impact caused by HCGS. This same program will continue when HCGS becomes operational, since the current REMP for Salem Generating Station meets the requirements for an operational REMP.

6.1.5.3 Expected Pathways

The goal of the radiological monitoring program is to determine whether any significant increases have occurred in the concentration of radioactive materials in the critical pathways as well as to determine if there is an increase in the radioactive inventory of long-lived radionuclides. During the months when cows are in pasture, the critical pathway is the air-grass-milk-man pathway. During those months when cows are not in pasture, the air-broadleaf-vegetation-man pathway predominates. The selection of sample type is based upon these established critical pathways for the transfer of radionuclei from the environment to man, as well as upon experience of the preoperational phase of the program conducted for Salem Generating Station. Section 5.2.1 also described exposure pathways to man.

6.1.5.4 Physical Characteristics of Samples

Low volume air samplers collect air particulates on Schleicher-Schuell No. 25 glass fiber filters. TEDA charcoal cartridges, connected in series behind the air particulate filters, absorb iodine from the air. Air sample volumes are measured with calibrated dry-gas meters corrected to standard temperature and pressure.

Precipitation collects on a 95 square inch rain gauge. Samples are taken monthly and transferred to new polyethylene bottles. Upon collection, the rain gauge is rinsed with distilled water to include residual particulates in the precipitation samples. Results of subsequent analyses are corrected for the increase in volume. Tritium results are also corrected for the tritium content of the distilled water.

Ambient radiation levels in the environment are measured with energy-compensated calcium sulfate, thermoluminescent dosimeters (TLDs). Packets containing four TLDs each are placed around the Artificial Island site at various distances and are exposed on a monthly or quarterly basis.

Monthly well and potable water samples are taken in new two-gallon polyethylene bottles. Separate raw and treated potable water samples are composited daily by personnel of the local water company. The water company draws its water from Laurel Lake and adjacent wells, which should not be influenced by liquid discharge from the site.

A consultant collects surface water samples in new polyethylene bottles and delivers them to PSE&G for transportation to its laboratory for analysis. Sample containers are rinsed twice with the sample medium prior to collection. Edible fish and crabs are taken by net, sealed in a bag or jar and shipped frozen. Benthos and sediment are taken with a bottom grab sampler.

Milk samples are taken in new polyethylene bottles and shipped fresh. Food products, fodder crops, game and bovine thyroid samples are taken and sealed in plastic bags or jars. Perishable samples are frozen at the time of sampling without any preservatives.

The sensitivities of the analytical procedures used are consistent with the USNRC Branch Technical position on the conducting of environmental surveillance programs and are provided in the Salem Environmental Technical Specifications (ETS). The sensitivities of the analytical measurements were selected to verify that the measurable concentrations of radioactive materials are not higher than those expected based on effluent monitoring and modeling.

The sensitivity requirements listed in the ETS are sufficiently low to permit the discerning of doses which are a fraction of the doses in 10 CFR 50, Appendix I for the predicted critical pathways. It should be noted that deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability or the malfunction of automatic sampling equipment.

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TABLE 6.1-1

PERFORMANCE SPECIFICATIONS
FOR BATHYMETRIC INSTRUMENTS

RAYTHEON Model DE719B Fathometer	
Depth Range	0 to 16.5 m (0 to 55 ft)
Sounding Rate	534 soundings/min
Voltage Input	12 VDC
Current Input	2.5 Amps
Accuracy	± 0.5% ± 1 in. of indicated depth
Operating Frequency	208 KHz
Transducer	Barium Titanate - Model 2QQT5HAD
Motorola Mini-Ranger III Horizontal Positioning System	
Range	37 Km (20 mi) line of sight
Accuracy	± 3 m (10 ft) probable
Frequency	5450 to 5600 MHz
Coding	Four selectable codes using pulse spacing

TABLE 6.1-2

AIR QUALITY DATA FOR THE GENERAL REGION(1)

POLLUTANT	MONITORING SITE(2)	MAXIMUM OBSERVED (ppm)	STANDARD (ppm)
SULFUR DIOXIDE			
3-Hour Average	Penns Grove	0.143	0.50 (Secondary)(3)
24-Hour Average	Penns Grove	0.051	0.14 (Primary) (3)
			0.10 (Secondary)(4)
12-Month Average	Penns Grove	0.011	0.03 (Primary) (3)
			0.02 (Secondary)(4)
PARTICULATES			
Annual Geometric Mean	Salem	50.4(6)	75 (Primary) (3)(6)
			60 (Secondary)(3)(6)
24-Hour Average	Salem	82.0(6)	260 (Primary) (3)(6)
			150 (Secondary)(3)(6)
CARBON MONOXIDE			
1-Hour Average	Penns Grove	14.1	35 (Primary) (3)
			35 (Secondary)(3)
8-Hour Average	Penns Grove	7.2	9 (Primary) (3)
			9 (Secondary)(3)
OZONE			
Max. Daily 1-Hr.	Vineland	0.144	0.12 (Primary) (3)
			0.12 (Secondary)(3)
1-Hour Average	Vineland	0.144	0.08 (Primary) (4)
			0.08 (Secondary)(4)
NITROGEN DIOXIDE			
12-Month Average	Vineland	0.019	0.05 (Primary) (3)
			0.05 (Secondary)(3)
NITRIC OXIDE			
12-Month Average	Vineland	0.013	NA
SMOKE SHADE			
Daily Average	Penns Grove	1.31(5)	NA

(1) See Reference 6.1-24.
(2) Monitoring site chosen by closest available data.
(3) National and New Jersey Ambient Air Quality Standards.
(4) New Jersey Ambient Air Quality Standard.
(5) Smoke Shade Data given in COHS.
(6) ug/m3.

TABLE 6.1-3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
(Preoperational and Operational Program)

EXPOSURE PATHWAY	STATION CODE	LOCATION[3]	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
I. AIRBORNE				
(a) Particulates	2S2	0.4 mi NNE of vent	Sample collected every week along with filter change using a low volume air sampler	Gross beta analysis performed on[2] each weekly sample
	10D1	3.9 mi SSW of vent		Gamma scan analysis performed on a sample composited over a calendar quarter
	16E1	4.1 mi NNW of vent		
	1F1	5.8 mi N of vent		
	2F2	8.7 mi NNE of vent		
	3H3[1]	110 mi NE of vent		

(1) Control station.
(2) Gamma spectrometry is performed if gross beta exceeds ten times the control station value.
(3) 1.61 km = 1 mile.

EXPOSURE PATHWAY	STATION CODE	LOCATION[3]	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
(b) Iodine	2S2	0.4 mi NNE of vent	A TEDA impregnated charcoal flow-through cartridge is connected to air particulate air sampler and is collected weekly	Iodine 131 analyses are performed weekly
	10D1	3.9 mi SW of vent		
	16E1	4.1 mi NNW of vent		
	2F2	NJ; 8.7 mi NNE of vent		
	3H3[1]	110 mi NE of vent		

(1) Control station.
(3) 1.61 km = 1 mile.

TABLE 6.1-3 (Continued)

EXPOSURE PATHWAY	STATION CODE	LOCATION[3]	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
II. SOIL				
	2S2	0.4 mi NNE of vent	10 soil plugs to a depth of 15 cm (6 in.) over an area of 2.3 m^2 (25 ft^2) are composited and sealed in a plastic bag at each location[4]. A sample will be collected from each location once every 3 years	Gamma spectrometry performed on collection
	5D1	3.5 mi E of vent		SR-90 analyses on one sample from each location on collection
	10D1	3.9 mi SSW of vent		
	2E1	4.4 mi NNE of vent		
	16E1	4.1 mi NNW of vent		
	1F1	5.8 mi N of vent NJ; 8.7 mi NNE of vent		
	2F1	5 mi NNE of vent		
	3G1[1]	16.6 mi NE of vent		
	3H3[1]	10 mi NE of station		

(1) Control station.
(2) Gamma spectrometry is performed if gross beta exceeds ten times the control station value.
(3) 1.61 km = 1 mile.
(4) Soil samples are taken in accordance with procedures outlined in HASL-300 (Rev. 5/73). If a suitable sample cannot be obtained at a location, a sample is obtained from a new location. The NRC is notified in writing of the new sample location.

EXPOSURE PATHWAY	STATION CODE	LOCATION	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
III. DIRECT				
	2S2	0.4 mi NNE of vent	Four dosimeters will be collected from each location monthly and quarterly	Gamma dose-monthly Gamma dose-quarterly
	5S1	1.0 mi E of vent		
	6S2	0.2 mi EES of vent		
	7S1	0.12 mi SE of vent		
	10S1	0.14 mi SSW of vent		
	11S1	0.09 mi Sw of vent		
	5D1	3.5 mi E of vent		
	10D1	3.9 mi WNW of vent		
	14D1	3.4 mi WNW of vent		
	2E1	4.4 mi NNE of vent		
	3E1	4.1 mi NE of vent		
	13E1	4.2 mi NE of vent		
	16E1	4.1 mi NNW of vent		
	1F1	5.8 mi N of vent		
	2F2	8.7 mi NNE of vent		
	5F1	8.0 mi E of vent		
	6F1	6.4 mi ESE of vent		
	7F2	9.1 mi Se of vent		
	11F1	5.2 mi SW of vent		
	13F1	9.8 mi W of vent		
	3G1 (1)	17 mi NE of vent		
	2H1 (1)	34 mi NNE of vent		
	3H1 (1)	32 mi NE of vent		
	3H3 (1)	110 mi NE of vent		

(1) Control station.

TABLE 6.1-3 (Continued)

EXPOSURE PATHWAY	STATION CODE	LOCATION	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
	4D2	3.7 mi ENE of vent	Four dosimeters will be collected from each location quarterly	Gamma dose-quarterly
	9E1	4.2 mi S of vent		
	11E2	5.0 mi SW of vent		
	12E1	4.4 mi WSW of vent		
	2F5	7.4 mi NNE of vent		
	3F2	5.1 mi NE of vent		
	3F3	8.6 mi NE of vent		
	10F2	5.8 mi SSW of vent		
	12F1	9.4 mi WSW of vent		
	13F2	6.5 mi W of vent		
	13F3	9.3 mi W of vent		
	14F2	6.6 mi WNW of vent		
	15F3	5.4 mi NW of vent		
	16F2	8.1 mi NNW of vent		
	16G1 (1)	14.8 mi NNW of vent		
	1G3 (1)	18.5 mi N of vent		
	10G1 (1)	11.6 mi SSW of vent		

(1) Control station.

TABLE 6.1-3 (Continued)

EXPOSURE PATHWAY	STATION CODE	LOCATION[3]	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
IV. WATER				
(a) Surface	11A1	Approximately 200m (650 ft) SW of vent	Two-gallon [4] sample to be collected monthly providing winter icing conditions allow sample collection	Gamma scan on each monthly Sample Tritium analyses are done monthly
	12C1[1]	2.5 mi WSW of vent		
	7E1	1 mi W of Mad Horse Creek; 4.5 mi SE of vent		
	1F2	7.1 mi N of vent		
	16F1	6.9 mi NNW of vent at the mouth of the C&D canal		
(b) Ground	4S1	On-site	Two-gallon grab sample is collected monthly	Gamma scan on samples composited over a calendar quarter
	5D1	3.5 mi E of vent		
	3E1[1]	4.0 mi NE of vent		
(c) Drinking	2F3 (raw)	Salem Water Co.; 8 mi NNE of vent	50 ml aliquot is taken daily and composited to a monthly sample of two gallons	Gross beta monthly Gamma scan - QC Tritium analyses are done monthly
	2F3 (treated)			

(1) Control station.
(3) 1.61 km = 1 mile.
(4) 2 gallons = 7.6 liters.

EXPOSURE PATHWAY	STATION CODE	LOCATION(3)	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
V. AQUATIC				
(a) Benthos	7E1	1 mi W of Mad Horse Creek; 4.5 mi SE of vent	A benthos sample consisting of benthic organisms and associated sediment is taken semiannually	Gamma spectrometry of each sample semiannually; SR-90 semiannually on sediment
	12C1(1)	2.5 mi WSW of vent		
	11A1	Outfall area; 200m (650 ft) SW of vent		
VI. INGESTION				
(a) Milk	15F1	5.2 mi NW of vent	Four gallon grab sample of fresh milk is collected from each farm semimonthly. Collected weekly if calculated dose exceeds 15 mrem to child's thyroid	Gamma scan semimonthly; I-131 monthly, I-131 weekly if calculated dose exceeds 15 mrem to child's thyroid
	2F4	6.3 mi NNE of vent		
	5F1	6.5 mi E of vent		
	14F1	5.5 mi WNW of vent		
	3G1(1)	16.6 mi NE of vent		
(b) Fish	11A1	Outfall area; 200m (650 ft) SW of vent	Two key samples of fish are sealed in plastic bag or jar and frozen semiannually or when in season	Gamma scan of edible portion on collection
	12C1(1)	2.5 mi WSW of vent		

(1) Control station.
(3) 1.61 km = 1 mile.

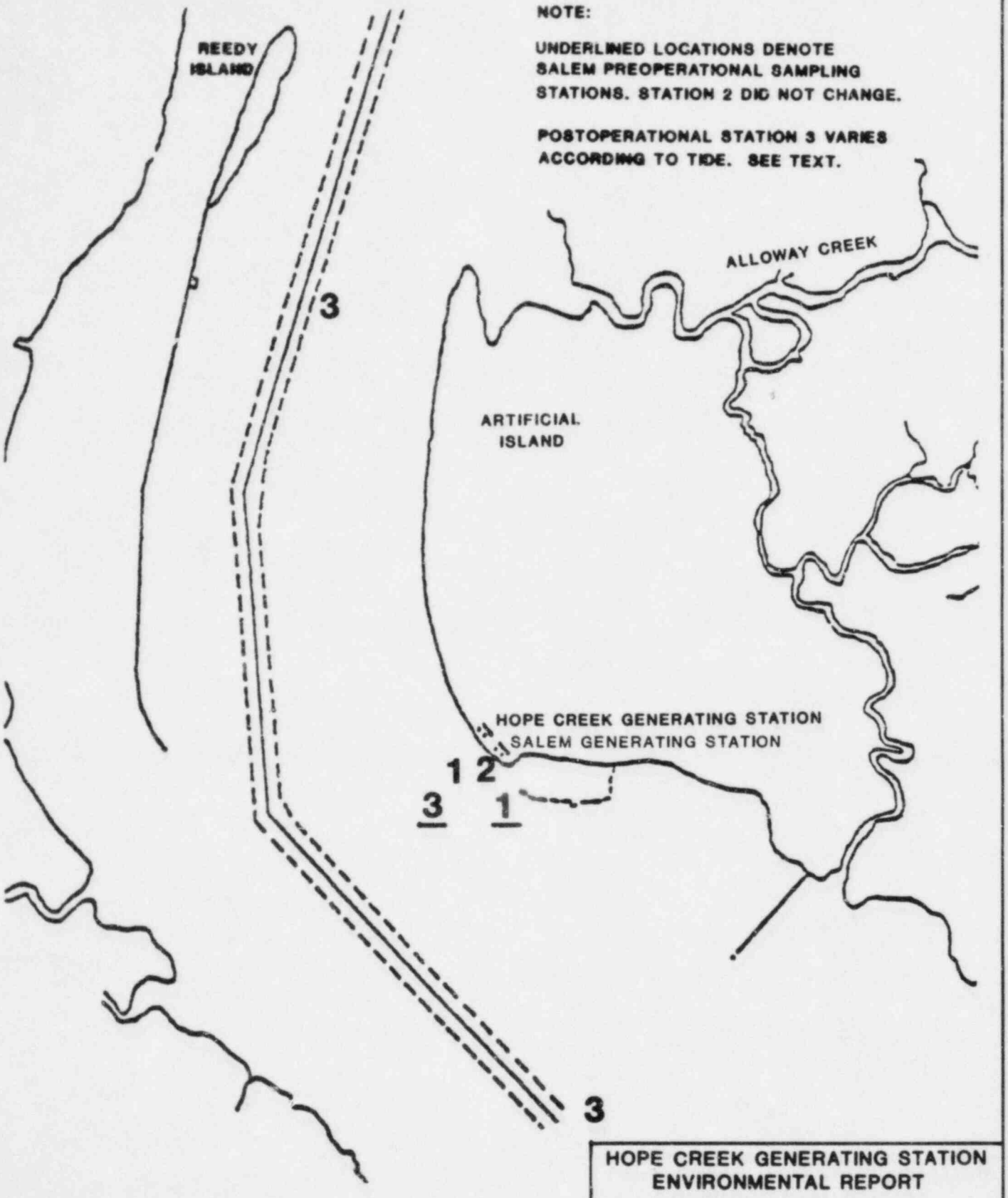
EXPOSURE PATHWAY	STATION CODE	LOCATION	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
VI. INGESTION				
(c) Crab	11A1	Outfall area; 200m (650 ft) SW of vent	Two keys samples of crab are sealed in a plastic bag or jar and frozen semiannually or when in season	Gamma scan of edible portion on collection
	12C1(1)	West bank opposite Artificial Island 2.5 mi SWS of vent		
(d) Fruits or Vegetation	1G1(1)	10.2 mi N of vent	Samples are collected during the normal harvest season, sealed in plastic, and frozen if perishable. Sufficient sample is collected to yield 500 grams of dry weight	Radioiodine determination of green leafy vegetables on collection
	2E1	4.45 mi NNE of vent		
	2F1	3 mi NNE of vent		Gamma scan on collection

(1) Control station.

TABLE 6.1-3 (Continued)

EXPOSURE PATHWAY	STATION CODE	LOCATION(3) (4)	COLLECTION METHOD AND FREQUENCY	TYPE AND FREQUENCY OF ANALYSES
VI. INGESTION				
(e) Game		Station vicinity east side of estuary	Muskrats are skinned and frozen semiannually	Gamma scan on edible portion only on collection
		West side of estuary, (1) 3-5 mi from vent		
		Within (10 mi) of station	Beef portion of cow is sampled and frozen semiannually(5)	

(1) Control station.
(3) 1.61 km = 1 mile.
(4) Location given at time of collection.
(5) This sample is subject to availability of slaughtered cow.

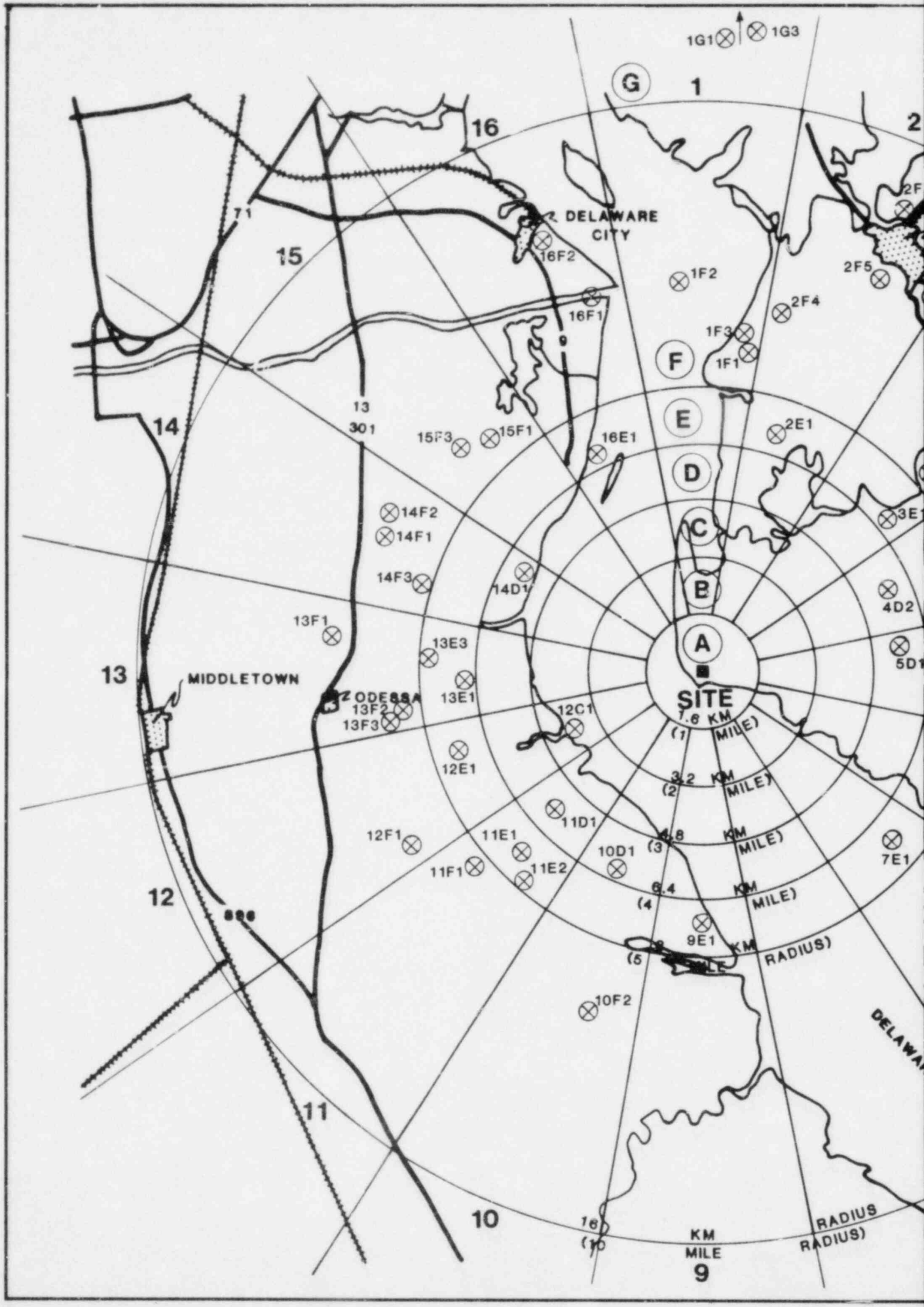


HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

WATER QUALITY SAMPLING STATIONS

FIGURE 6.1 – 1


1G1
1G3
G
1
2
16
15
14
13
12
11
10
9
DELAWARE CITY
16F2
16F1
1F2
2F5
2F4
1F3
1F1
F
E
D
C
B
A
SITE
1.6 KM (1 MILE)
3.2 KM (2 MILE)
4.8 KM (3 MILE)
6.4 KM (4 MILE)
(5 RADIUS)
16 KM (10 MILE RADIUS)
15F3
15F1
16E1
2E1
14F2
14F1
14F3
14D1
4D2
13F1
13E3
13E1
MIDDLETOWN
13F2
13F3
12C1
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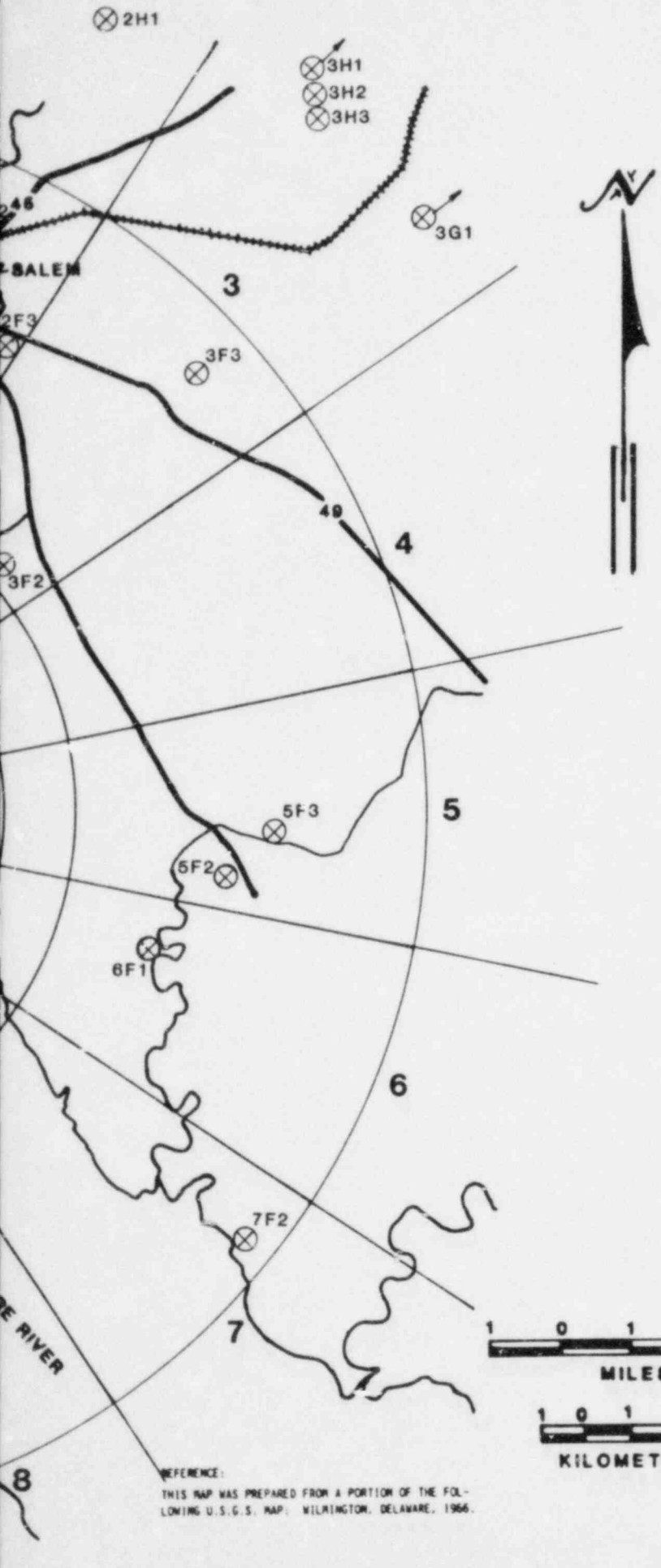
9E1
10F2
14
301



REFERENCE:
THIS MAP WAS PREPARED FROM A PORTION OF THE FOLLOWING U.S.G.S. MAP: WILMINGTON, DELAWARE, 1966.

PRC APERTURE CARD

Also Available On Aperture Card

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

OFF SITE
RADIOLOGICAL
SAMPLING LOCATIONS

FIGURE 6.1 - 2

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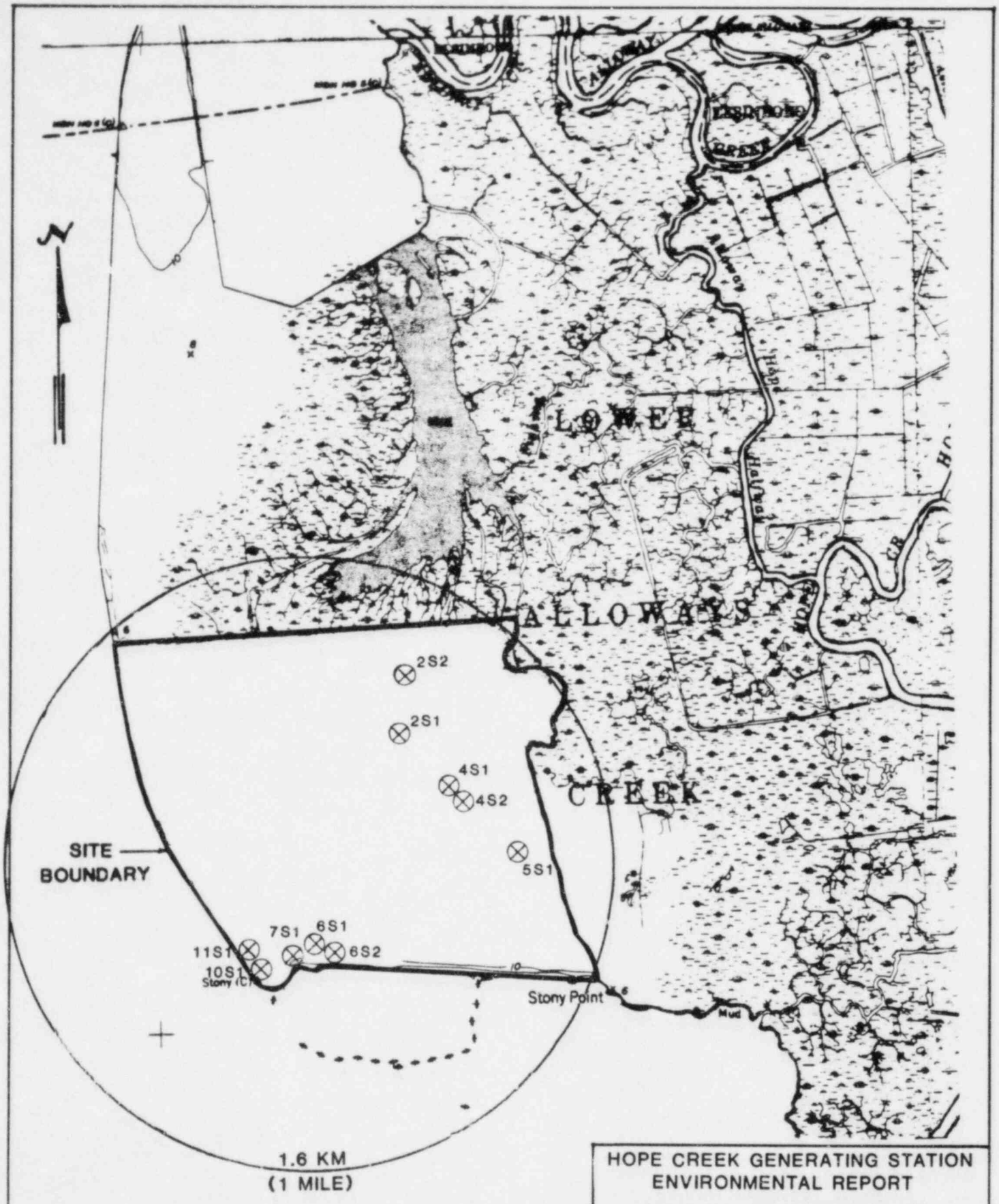

HOPE CREEK GENERATING STATION
ENVIRONMENTAL REPORT

OPERATING LICENSE STAGE

ON-SITE RADIOLOGICAL
SAMPLING LOCATIONS

FIGURE 6.1 - 3

6.2 PROPOSED OPERATIONAL MONITORING PROGRAM

As indicated, there are no differences between the ongoing preoperational radiological environmental monitoring program and the operational program due to the fact that a common radiological environmental monitoring program is conducted for Salem Generating Station and Hope Creek Generating Station.

See Sections 13.2, 13.4, 13.5, 13.9, and 13.13 which describe PSE&G's compliance with nonradiological environmental monitoring requirements set at the construction permit stage.

6.3 RELATED ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

Several agencies have established environmental surveillance programs in the vicinity of HCGS. The NRC has established a network of thermoluminescent dosimeters (TLD) surrounding Salem Generating Station and HCGS.

The NRC has also contracted with the NJDEP to provide for the collection and analysis of air, milk, water and food product samples. The State compiles the results obtained from this program and compares them to PSE&G results.

6.4 PREOPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING DATA

PSE&G has summarized results obtained in its preoperational environmental radiological monitoring program. This summary appears in Table 6.4-1. This table is based on data obtained for the period from 1973 to 1976 and represents the environmental levels existing in the region surrounding the HCGS reactor before the operation of any nuclear reactors at the Artificial Island site.

TABLE 6.4-1

SUMMARY OF RADIONUCLIDE CONCENTRATIONS IN ARTIFICIAL ISLAND PREOPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLES

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
AQUATIC ENVIRONMENT						
Surface Water						
H-3	259	222	<80	600±100	213±165	pCi/l
Alpha (Sol)	136	6	<1.5	33±32	-	pCi/l
Alpha (Insol)	136	5	<1.5	3.3±1.0	-	pCi/l
Alpha (Tot)	123	22	<1.5	27±20	-	pCi/l
Beta (Sol)	136	136	3.8±2.5	120±16	42±52	pCi/l
Beta (Insol)	136	14	<3.0	4.8±3.2	-	pCi/l
Beta (Tot)	123	123	3.3±2.7	110±11	32±45	pCi/l
K-40	136	136	0.20±0.02	120±12	41±63	pCi/l
Sr-89	65	5	<0.37	1.5±0.8	-	pCi/l
Sr-90	77	20	<0.28	1.6±0.4	-	pCi/l
Gamma	259					
K-40		200	<6	200±30	48±64	pCi/l
ZrNb-95		2	<0.4	1.9±0.6	-	pCi/l
Cs-137		2	<0.5	0.86±56	-	pCi/l
Ra-226		9	<0.9	4.0±1.4	-	pCi/l
Solids	136	136	160±16	14000±1400	5748±7137	mg/l
Chlorides	136	136	32±3	17000±1700	3345±5567	mg/l
Edible Fish Flesh						
H-3 (Aqueous)	28	15	<80	460±78	165±206	pCi/l
H-3 (Organic)	19	17	<130	480±69	285±205	pCi/l
H-3 (Organic)	8	4	<80	390±80	158±230	pCi/kg(dry)
Sr-89	9	0	<4.1	<100	-	pCi/kg(wet)
Sr-90	12	1	<4.1	67±11	-	pCi/kg(wet)
Gamma	31					
K-40		31	1000±100	13000±1000	2914±4351	pCi/kg(wet)
Cs-137		5	8.7±6.6	11±6	-	pCi/kg(wet)
Ra-226		1	<4	130±80	-	pCi/kg(wet)
Edible Fish Bone						
Sr-89	18	3	100±60	100±70	-	pCi/kg(wet&dry)
Sr-90	18	14	<24	940±100	335±614	pCi/kg(wet&dry)
Blue Crab - Edible Hard Shell (Flesh)						
H-3 (Aqueous)	8	7	<80	330±71	180±168	pCi/l
H-3 (Organic)	2	2	95±78	420±120	259±455	pCi/l
H-3 (Organic)	4	1	<80	90±80	-	pCi/kg(dry)
H-3 (Total Tritium)	7	5	<80	420±60	219±259	pCi/l
Sr-89	10	0	<6.0	<51	-	pCi/kg(wet)
Sr-90	10	7	<5.1	150±26	40±103	pCi/kg(wet)
Gamma	16					
K-40		16	960±384	12000±1000	2835±5048	pCi/kg(wet&dry)
ZrNb-95		1	<5	120±12	-	pCi/kg(wet)
Ra-226		3	<10	33±19	-	pCi/kg(wet)

TABLE 6.4-1 (Continued)

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
Blue Crab - Edible (Cont'd) Soft Shell (Total)						
H-3 (Aqueous)	4	3	<80	320±110	190±197	pCi/l
H-3 (Organic)	2	0	<140	<220	-	pCi/l
H-3 (Oryanic)	2	1	<80	130±80	105±71	pCi/kg(dry)
H-3 (Total Tritium)	4	3	<80	500±68	230±373	pCi/l
Sr-89	6	1	<7.5	<26	-	pCi/kg(wet)
Sr-90	8	5	<7.8	39±6	21±24	pCi/kg(wet)
Gamma	7					
K-40		7	770±462	3000±300	2024±1359	pCi/kg(wet)
Ra-226		1	<10	37±15	-	pCi/kg(wet)
Blue Crab - Nonedible Hard Shell (Shell)						
Sr-89	8	3	<57	210±170	-	pCi/kg(dry)
Sr-90	8	8	330±30	990±87	614±511	pCi/kg(dry)
Prey Fish						
Sr-89	16	2	<5.8	320±22	-	pCi/kg(wet&dry)
Sr-90	16	8	<4.8	65±11	28±40	pCi/kg(wet&dry)
Gamma	29					
K-40		29	970±100	13000±1000	4604±6667	pCi/kg(wet&dry)
ZrNb-95		2	<3	17±5	-	pCi/kg(wet)
Cs-137		1	<2	42±38	-	pCi/kg(wet)
Ra-226		1	<5	13±9	-	pCi/kg(wet)
Benthos						
Sr-89	12	1	<44	<36000	-	pCi/kg(dry)
Sr-90	12	5	<120	<30000	-	pCi/kg(dry)
Gamma	4					
K-40		2	<1	6.9±1.8	3.4±5.0	pCi/g(dry)
Mn-54		1	<0.03	0.13±0.09	-	pCi/g(dry)
Nb-95		2	<0.09	0.11±0.08	0.11±0.13	pCi/g(dry)
Ru-106		1	<0.3	0.91±0.65	-	pCi/g(dry)
Cs-137		1	<0.07	<0.1	-	pCi/g(dry)
Ra-226		4	0.26±0.08	0.48±0.16	0.38±0.18	pCi/g(dry)
Th-232		4	0.52±0.13	1.2±0.4	0.80±0.61	pCi/g(dry)
Zooplankton						
Sr-89	8	2	<0.21	4.6±4.4	-	pCi/g(dry)
Sr-90	8	5	<0.51	<4.9	1.3±2.9	pCi/g(dry)
Gamma	20					
Be-7		1	-	3.0±2.8	-	pCi/g(dry)
K-40		3	<3	110±80	-	pCi/g(dry)
ZrNb-95		2	<0.09	<10	-	pCi/g(dry)
Ra-226		1	<0.2	<30	-	pCi/g(dry)

TABLE 6.4-1 (Continued)

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
Sediment						
Sr-89	12	0	<0.03	<1.0	-	pCi/g(dry)
Sr-90	16	4	<0.03	0.32±0.05	-	pCi/g(dry)
Gamma	41					
Be-7		3	<0.01	2.3±0.3	-	pCi/g(dry)
K-40		41	3.4±0.4	21±2	15±23	pCi/g(dry)
Nb-95		8	<0.01	2.6±0.6	-	pCi/g(dry)
Zr-95		1	<0.02	0.70±0.30	-	pCi/g(dry)
Ru-103		1	<0.01	0.31±0.13	-	pCi/g(dry)
Ru-106		2	0.03±0.02	0.30±0.17	-	pCi/g(dry)
Sb-125		8	0.05±0.04	0.27±0.12	-	pCi/g(dry)
Cs-137		35	<0.01	0.40±0.04	0.15±0.22	pCi/g(dry)
Ce-144		2	<0.1	0.48±0.14	-	pCi/g(dry)
Ra-226		41	0.28±0.04	1.2±0.1	0.76±0.43	pCi/g(dry)
Th-232		41	0.21±0.11	1.3±0.1	0.84±0.54	pCi/g(dry)
ATMOSPHERIC ENVIRONMENT						
Air Particulates						
Alpha	1045	788	<0.16	7.8±3.1	1.1±2.8	10^{-3}pCi/m^3
Beta	1588	1585	<5.0	920±24	74±280	10^{-3}pCi/m^3
Sr-89	60	18	<0.15	4.7±0.5	-	10^{-3}pCi/m^3
Sr-90	60	46	<0.20	3.0±0.3	0.9±1.6	10^{-3}pCi/m^3
Gamma	127					
Be-7		127	12±7	330±33	109±126	10^{-3}pCi/m^3
Mn-54		31	<0.1	2.6±0.4	-	10^{-3}pCi/m^3
Zr-95		80	<0.3	44±5	5±15	10^{-3}pCi/m^3
Nb-95		90	<0.1	84±8	13±39	10^{-3}pCi/m^3
Ru-103		74	<0.4	27±4	4±13	10^{-3}pCi/m^3
Ru-106		60	<0.9	46±4	-	10^{-3}pCi/m^3
Sb-125		55	<0.4	6.2±0.8	-	10^{-3}pCi/m^3
Cs-137		122	<0.2	11±1	2.2±4.7	10^{-3}pCi/m^3
BaLa-140		3	<0.4	22±8	-	10^{-3}pCi/m^3
Ce-141		38	<0.2	46±5	-	10^{-3}pCi/m^3
Ce-144		99	<1	120±15	19±54	10^{-3}pCi/m^3
Ra-226		26	<0.6	16±7	-	10^{-3}pCi/m^3
Th-232		24	<0.5	3.1±0.8	-	10^{-3}pCi/m^3
Air Iodine						
I-131	519	20	<0.72	42±4	-	10^{-3}pCi/m^3
Precipitation						
H-3	63	49	<80	610±90	216±290	pCi/l
Alpha	63	6	<0.45	4.7±1.8	-	pCi/l
Beta	63	57	<3.0	71±8	19±36	pCi/l
K-40	35	32	<0.01	0.52±0.05	0.13±0.21	pCi/l
Sr-89	16	7	<0.43	5.6±1.2	-	pCi/l
Sr-90	20	12	<0.48	3.8±1.1	1.5±2.2	pCi/l
Gamma	22					
Be-7		16	0.75±0.22	79±74	29±45	pCi/l
K-40		3	<5	18±5	-	pCi/l
ZrNb-95		9	<0.4	9.5±1.0	-	pCi/l
Ru-103		2	0.48±0.29	3.4±0.5	-	pCi/l
Cs-137		1	<0.5	1.2±0.4	-	pCi/l
BaLa-140		1	<0.4	2.2±0.9	-	pCi/l
Ce-144		1	<3	6.2±2.2	-	pCi/l

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TABLE 6.4-1 (Continued)

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
TERRESTRIAL ENVIRONMENT						
Well Water						
H-3	144	23	<40	380±77	-	pCi/l
Alpha	144	4	<1.0	9.6±2.5	-	pCi/l
Beta	144	126	<2.1	38±6	9±10	pCi/l
K-40	134	134	1.1±0.1	19±2	7.8±7.6	pCi/l
Sr-89	24	1	<0.49	<2.1	-	pCi/l
Sr-90	24	3	<0.36	0.87±0.52	-	pCi/l
Gamma	39					
Be-7		3	32±7	45±9	-	pCi/l
K-40		10	<0.5	30±14	-	pCi/l
ZrNb-95		2	<0.4	2.0±0.7	-	pCi/l
Ra-226		1	<0.8	2.0±1.2	-	pCi/l
Potable Water (raw & treated)						
H-3	94	73	<80	350±80	179±173	pCi/l
Alpha	94	16	<0.53	2.7±1.3	-	pCi/l
Beta	94	63	<2.6	9.0±3.4	4.2±3.0	pCi/l
K-40	84	84	0.50±0.10	10±1	1.7±2.2	pCi/l
Sr-89	24	3	<0.33	1.1±0.9	-	pCi/l
Sr-90	28	10	<0.26	2.1±1.2	-	pCi/l
Gamma	32					
Ra-226		1	<0.8	1.4±1.0	-	pCi/l
Milk						
Sr-89	177	35	<0.55	14±2	-	pCi/l
Sr-90	193	169	<0.23	12±3	3.5±7.5	pCi/l
I-131	167	44	<0.03	65±6	-	pCi/l
Gamma	270					
K-40		270	800±100	2000±200	1437±440	pCi/l
I-131		5	<0.4	63±14	-	pCi/l
Cs-137		147	<0.4	14±11	3.0±5.1	pCi/l
Ra-226		9	<0.9	<30	-	pCi/l
Food Products						
Sr-89	29	3	<2.5	10±6(1)	-	pCi/kg(wet)
Sr-90	45	24	<1.5	24±6(1)	7±11	pCi/kg(wet)
Gamma	52					
K-40		52	70±50	4800±480	2141±1628	pCi/kg(wet)
Cs-137		7	<1	59±3	-	pCi/kg(wet)
Fodder Crops (dry)						
Gamma	41					
Be-7		21	0.80±0.30	9.3±0.9	-	pCi/g(dry)
K-40		41	2.9±0.5	80±8	22±33	pCi/g(dry)
Co-58		3	<0.02	0.07±0.05	-	pCi/g(dry)
ZrNb-95		18	<0.02	8.5±4.8	-	pCi/g(dry)
Zr-95		3	4.3±0.4	6.3±0.6	-	pCi/g(dry)
Nb-95		3	3.0±0.3	4.2±0.4	-	pCi/g(dry)
Ru-103		4	0.09±0.02	1.3±0.1	-	pCi/g(dry)
RuRh-106		14	<0.01	2.5±0.2	-	pCi/g(dry)
I-131		3	<0.01	0.53±0.06	-	pCi/g(dry)

(1) Additional eggplant sampled 10/13/76 reported in units of pCi/kg(dry). Results were: Sr-89, <55 pCi/kg(dry); Sr-90, 32±24 pCi/kg(dry). (These data not included in ranges, or average).

TABLE 6.4-1 (Continued) (Page 5 of 6)

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
Fodder Crops (dry) (Continued)						
Gamma						
I-133		3	<0.02	0.46±0.11	-	pCi/g(dry)
Cs-137		6	<0.01	0.11±0.02	-	pCi/g(dry)
BaLa-140		3	<0.02	3.1±0.3	-	pCi/g(dry)
Ce-141		4	0.28±0.03	5.1±0.5	-	pCi/g(dry)
Ce-144		5	<0.1	1.4±0.3	-	pCi/g(dry)
Ra-226		1	<0.04	0.10±0.04	-	pCi/g(dry)
Th-232		3	<0.07	0.39±0.08	-	pCi/g(dry)
Fodder Crops (wet)						
Gamma	5					
Be-7		4	0.47±0.17	4.7±0.5	2.0±3.7	pCi/g(wet)
K-40		5	2.9±0.5	16±2	7±11	pCi/g(wet)
ZrNb-95		1	-	0.30±0.02	-	pCi/g(wet)
Zr-95		4	0.28±0.04	1.9±0.2	1.4±1.5	pCi/g(wet)
Nb-95		4	0.04±0.02	0.36±0.04	0.27±0.30	pCi/g(wet)
Mo-99		4	<0.01	2.2±0.2	1.1±1.9	pCi/g(wet)
Ru-103		4	0.04±0.02	0.59±0.05	0.31±0.46	pCi/g(wet)
I-131		4	<0.01	2.4±0.2	1.1±2.0	pCi/g(wet)
I-132		4	0.23±0.06	1.4±0.1	0.79±0.96	pCi/g(wet)
Te-132		4	<0.01	1.8±0.2	0.7±1.5	pCi/g(wet)
I-133		4	<0.01	0.37±0.05	0.19±0.31	pCi/g(wet)
Ba-140		4	0.50±0.22	2.8±0.3	1.8±2.0	pCi/g(wet)
La-140		4	0.13±0.03	3.0±0.3	1.8±2.4	pCi/g(wet)
Ce-141		4	0.06±0.03	1.1±0.1	0.77±0.96	pCi/g(wet)
Ce-144		1	<0.08	0.45±0.25	-	pCi/g(wet)
Np-239		3	0.72±0.20	3.2±0.3	2.0±2.5	pCi/g(wet)
Game						
Sr-89	11	1	<90	<1800	-	pCi/kg(dry)
Sr-90	11	11	32±16	1800±600	294±540	pCi/kg(dry)
Gamma	16					
K-40		16	1600±200	27000±800	4444±12124	pCi/kg(wet&dry)
RuRh-106		1	<10	66±55	-	pCi/kg(wet)
Cs-137		1	<3	620±50	-	pCi/kg(wet)
Ra-226		1	<6	1000±100	-	pCi/kg(wet)
Th-232		2	20±10	140±40	-	pCi/kg(wet)
Thyroid						
Gamma	7					
K-40		1	<400	1800±600	-	pCi/kg(wet)
I-131		1	<30	89±1	-	pCi/kg(wet)

TABLE 6.4-1 (Continued)

MEDIUM AND ANALYSIS PERFORMED	NUMBER OF SAMPLES ANALYZED	NUMBER ABOVE MDL	MINIMUM	MAXIMUM	AVERAGE ± 2 SIGMA	UNITS
Soil						
Sr-90	21	18	<0.03	1.1±0.1	0.26±0.50	pCi/g(dry)
Gamma	30					
Be-7		4	0.18±0.13	21±10	-	pCi/g(dry)
K-40		30	3.4±0.4	24±2	10±8	pCi/g(dry)
Mn-54		2	<0.01	0.01±0.01	-	pCi/g(dry)
ZrNb-95		1	<0.02	0.02±0.02	-	pCi/g(dry)
Zr-95		2	0.03±0.02	0.06±0.04	-	pCi/g(dry)
Nb-95		3	0.07±0.02	0.09±0.02	-	pCi/g(dry)
Sb-125		4	0.05±0.04	0.27±0.07	-	pCi/g(dry)
Cs-137		29	<0.1	2.8±0.3	0.8±1.5	pCi/g(dry)
Ce-144		2	<0.09	0.51±0.12	-	pCi/g(dry)
Ra-226		30	0.27±0.05	1.5±0.2	0.87±0.65	pCi/g(dry)
Th-232		30	0.14±0.06	1.4±0.1	0.74±0.58	pCi/g(dry)
DIRECT RADIATION						
Gamma Dose	3872 M	3872	2.07±0.14	7.28±0.36	4.62±1.53	mrad/std.mon.
	1256 Q	1256	1.07±0.24	5.66±0.54	4.42±1.18	mrad/std.mon.
	260 SA	260	2.83±0.10	5.21±0.22	4.30±1.15	mrad/std.mon.

CHAPTER 7

ENVIRONMENTAL EFFECTS OF ACCIDENTS

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CHAPTER 7

ENVIRONMENTAL EFFECTS OF ACCIDENTS

TABLES

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CHAPTER 7

ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 STATION ACCIDENTS INVOLVING RADIOACTIVITY

This section is intended to respond to the requirements of the National Environmental Policy Act (NEPA) as interpreted by the U.S. Nuclear Regulatory Commission in its statement of interim policy regarding accident considerations, which was published in the Federal Register on June 13, 1980 (45 FR 40101). This statement withdrew the proposed Annex to Appendix D of 10 CFR 50, which was originally published in the Federal Register on December 1, 1971 (36 FR 22851), and suspended the rulemaking procedures associated with it. It also put forward the Commission's interim policy that

> ...Environmental Impact Statements shall include consideration of the site-specific environmental impacts attributable to accident sequences that can result in inadequate cooling of the reactor fuel and in melting of the reactor core. In this regard, attention shall be given both to the probability of occurrence of such releases and to the environmental consequences of such releases.

In particular, Environmental Reports at the Construction Permit or Operating License stage, submitted on or after July 1, 1980, must contain an analysis of the consequences of Class 9 accidents.

The principal purpose of this section, therefore, is to carry out a risk assessment of Class 9 accidents, that is, hypothetical severe accidents involving melting of the core. These accidents of exceedingly low probability of occurrence result from the postulated failure of a combination of redundant emergency safety systems, and hence, are beyond the design basis limits for nuclear power plants. This section does not consider the consequences of less severe accidents, generally designated Classes 1-8 (in order of increasing severity). These accidents were defined in the proposed annex to Appendix D of 10 CFR Part 50; as noted above, this annex has been withdrawn. The reason why the present work does not include a consideration of Class 1-8 accidents is that they are judged to be small contributors to public risk. This judgment is based in part on the

Reactor Safety Study (RSS) (Reference 7.1-1) and in part on a published risk assessment of Class 3-8 accidents (Reference 7.1-2). The Class 3-8 study estimated risk to the public using a methodology that is similar to that used in the RSS. Extensive use was made of Licensee Event Reports (LERs). A technique known as "partial failure analysis" was used to treat a continuous spectrum of potential failure modes. The results of the study showed that Class 3-8 accidents are smallcontributors to public risk relative to Class 9 accidents.

Since Reference 7.1-2 is a risk assessment of Class 3-8 accidents for a pressurized water reactor (PWR), it is pertinent to determine whether the results are applicable to HCGS (a comparable study has not been carried out for a BWR). However, (i) the Class 3-8 source terms given in the proposed annex to Appendix D of 10 CFR 50 are virtually the same for the PWR and BWR; (ii) Reference 7.1-2 concluded that the 10 CFR 50 accident classification scheme is reasonably representative for PWRs: there is no reason to believe otherwise for a BWR; and (iii) the RSS conclusion applies equally to PWRs and BWRs. Hence, the conclusion that Class 3-8 accidents are small contributors to public risk is a valid one for the HCGS BWR.

Details of the Class 9 Consequence analysis are given in Appendix C. In Section 2.0 of Appendix C, the identification of the risk dominant accident sequences is described, and the frequencies of the risk dominant accident sequences are derived. The set of accident sequences has been derived specifically for the HCGS BWR by analogy with completed BWR risk assessments and analyses, in particular those of other BWR4's with Mark I containments, i.e., the WASH-1400 Peach Bottom analysis, the rebaselined BWR (Reference 7.1-3) and the Interim Reliability Evaluation Program (IREP) study of Brown's Ferry (Reference 7.1-4). Extensive use was also made of the Limerick Probabilistic Risk Assessment (Reference 7.1-5). Section 3.0 of Appendix C contains a brief review of containment failure modes and probabilities, and Section 4.0 describes how the magnitudes of the source terms were calculated. (Throughout this chapter and Appendix C "source term" refers to the magnitude of the release of fission products to the environment and associated phenomenological characteristics such as the time of release, the duration, the warning time and the sensible heat content of the plume).

Section 5.0 of Appendix C contains a brief description of the methods used to carry out the Class 9 consequence analysis, in which the code CRAC2 (Reference 7.1-6) was the principal tool. The input data for CRAC2 is briefly reviewed. Section 6.0 of Appendix C contains a summary of the results of the CRAC2 analysis. Section 7.0 contains a description of a liquid pathways analysis. Finally, Section 8.0 of Appendix C contains a discussion about public risk, 9.0 contains a brief description of uncertainties, and 10.0 presents conclusions.

In conclusion, Appendix C considers the potential environmental impacts of Class 9 accidents at HCGS. These cover a broad spectrum of possible low probability accidental radioactive releases into the atmosphere or into groundwater. The environmental impacts that are considered include potential radiation exposures to individuals and to the population as a whole, the risk of early and latent health effects, and potential economic consequences of the accidental contamination of the environment. In Appendix C it is shown that some of these impacts could be severe, but the likelihood oftheir occurrence, and hence, the public risk, are judged to be small.

REFERENCES

7.1-1 U.S. Nuclear Regulatory Commission, Reactor Safety Study, An Assessment of Accident Risk in U.S. Commercial Nuclear Power Plants, (WASH-1400, NUREG-75/014), 1975.

7.1-2 R.E. Hall, A. Buslik, M. Chun, A. Coppola, R. Denning, J.M. Dickey, R. Dykhuizen, T. Krieger, R. Kudnik, E. Lofgren and S. Mitra, A Risk Assessment of a Pressurized Water Reactor for Class 3-8 Accidents, Brookhaven National Laboratory, (BNL-NUREG-50450), 1979.

7.1-3 U.S. Nuclear Regulatory Commission, Reactor Accident Source Terms: Design and Siting Perspectives, (NUREG-0773, draft), 1982.

7.1-4 U.S. Nuclear Regulatory Commission, Interim Reliability Evaluation Program: Analysis of the Browns Ferry, Unit 1, Nuclear Plant, (NUREG/CR-2802), 1982.

7.1-5 Philadelphia Electric Company, Probabilistic Risk Assessment, Limerick Generating Station, (Docket Nos. 50-352 and 50-353), 1981.

7.1-6 L.T. Ritchie, J.D. Johnson and R.M. Blond, Calculation of Reactor Accident Consequences, Version 2, Sandia National Laboratories, (SAND81-1994, NUREG/CR-2324), 1982.

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVITY

The transportation of nuclear fuel to and radioactive wastes from the station is within the scope of paragraph (g) of Section 51.20 of 10 CFR Part 51; the environmental risks, therefore, are those set forth in Summary Table S-4 of 10 CFR Part 51 (see Table 3.8-1).

7.3 OTHER ACCIDENTS

In addition to accidents with the potential to release radioactivity to the environs, accidents may occur as a result of station operation that although they do not involve radioactive materials have consequences that may affect the environment. Accidents such as chemical explosions, fires, and leakage or rupture of vessels containing oil or toxic materials, should be evaluated for significant environmental impact potential. This section discusses these possible accidents and their associated effects on the environment.

HCGS is located in a rural area consisting of marshes, meadowlands and some farmland. There are no major manufacturing or chemical plants within eight kilometers (five miles) of the site. All such facilities are beyond 13 kilometers (eight miles); these facilities would not interfere with the operation of HCGS. Also, there are no military bases or missile sites within 16 kilometers (10 miles) of the site; there are no pipelines within 16 kilometers (10 miles) of the site; there are no major harbors, railway yards or airports within 16 kilometers (10 miles) of the site (the only "harbor facility" of any significance is the Getty Oil Company pipeline terminal in Delaware City, 14.5 kilometers (nine miles) NNW of the site); and there are no railroads within eight kilometers (five miles) of the site. The only major transportation route within eight kilometers (five miles) of the site is the Intracoastal Waterway, 2.4 kilometers (1.5 miles) west of the island. There are no petroleum wells, mines or hard rock quarries within 16 kilometers (10 miles) of the site. There is no known movement of high explosives in the vicinity of Artificial Island, with the exception of flammable materials transported on the Delaware River.

Based on the above information, the applicant has concluded that the only events that should be evaluated for significant environmental impact potential relate to the traffic on the Delaware River and to chemicals stored at the Salem Generating Station site and the HCGS site.

7.3.1 RIVER TRAFFIC HAZARDS

The potential hazards presented by the Delaware River traffic are those in which flammable vapor dispersion, toxic vapor dispersion, fires, explosions, collisions with the intake structure, and liquid spills cause HCGS to add to or aggravate the environmental impact of the original accidents. The waterfront structure, by virtue of its proximity to the river, is more vulnerable to the effects of waterborne hazards.

The possibility of a ship or barge colliding with the intake structure was studied, and an estimate of resulting damage was made. The possibility of blockage of the intake structure due to a marine accident was also studied. The remaining plant equipment and structures important to safety are located over 240 meters (800 feet) from the river; therefore, most of the river traffic accidents considered would have no effect on them.

PSE&G has performed detailed studies of hazards of ship transportation of chemicals and liquified gases. A report entitled "Analysis of Potential Effects of Waterborne Traffic on the Safety of Control Room and Water Intakes at Hope Creek Generating Station" (Reference 7.3-1) was submitted on October 2, 1974 to the NRC. The report was updated in 1982; it provides analyses that support the conclusion that the probability of a flammable vapor cloud reaching the nuclear facilities at Artificial Island is sufficiently low, such that accidents occurring from the waterborne transportation of hazardous materials need not be considered in the design basis of the nuclear facilities at Artificial Island.

7.3.2 TOXIC CHEMICALS

Accidents involving the release of toxic chemicals from HCGS storage facilities and nearby mobile and off-site stationary sources were considered.

Chemicals listed in Regulatory Guide 1.78, paragraph C-2, are considered to be hazardous. An analysis was performed to determine the effects, if any, of the chemicals stored both at HCGS and at Salem Generating Station. Table 7.3-1 shows the hazardous chemicals stored at the Salem Generating Station. Table 7.3-2 shows estimates of hazardous chemical traffic in the vicinity of the HCGS plant. Table 7.3-3 shows the chemicals stored at the HCGS site.

An analysis of Salem Generating Station control room habitability, performed for a postulated hazardous chemical release occurring at the site or within an eight kilometer (five mile) radius of the station, demonstrated that the Salem Generating Station control room personnel are adequtely protected against the effects of accidental release of toxic chemicals. A similar analysis performed for the HCGS control room reached the same conclusion regarding the HCGS control room personnel (Reference 7.3-3). With control room integrity assured, HCGS could safely shut down, avoiding any augmented environmental impact.

7.3.3 COLLISIONS WITH THE INTAKE STRUCTURE

Since HCGS is located near a navigable waterway, the probability and potential effects of collisions against the plant cooling water intake structures were considered.

The kinetic energy levels associated with the postulated rammings have been determined to be of the same order of magnitude as those from major collisions (Reference 7.3-1); from ship collision studies, however, it can be argued that the expected structural damage from ship rammings of the intake structure will be, mostly, damage to the ship structure, and furthermore, that the damage will not be extensive enough to block the intake with structural rubble (Reference 7.3-1). A further qualitative comparison of the seismic design input and the inertial loadings of the intake structure and its components caused by rammings indicates that the intake structure will likely suffer only from local damage from the ramming accident, and its operation will not be impaired.

Our analysis (References 7.3-2 and 7.3-3) has concluded that blockage of the intake structure opening by a runaway ship or barge is not possible. Under the most extreme low water conditions assumed in the design of the facility, consideration of the main intake area showed that the required blockage (97 percent of the area in the extreme low water condition) could not be accomplished by a conventional vessel with hull curvature, nor by any barge currently transiting the Delaware River near the Artificial Island site (Reference 7.3-3). With the uninterrupted flow of service water thus assured, collisions with the intake structure need not be considered as a design basis event for HCGS.

7.3.4 LIQUID SPILLS

The accidental release of oil or liquids which may be corrosive, cryogenic or coagulant was considered in order to determine if the potential exists for such liquids to be drawn into the service water intake structure and circulating water systems, or otherwise to affect the plant's safe operation.

Petroleum, oil products and cryogens, floating on the Delaware River surface due to a spill upstream, could approach the intake structure. The service water intake has a curtain wall extending several feet underwater, so these materials are excluded from entry into the service water supply line, even if the materials get past the intake surface skimmers. The most severe possible condition occurs at the design low water level condition, with water surface at plant elevation 76 feet. At this level, the service water pump intake is still submerged by four feet. Thus, floating liquid spills need not be considered as design basis events for HCGS.

There are no known coagulants shipped on the Delaware River. The only corrosive of potential concern is sulfuric acid. As discussed in Section 7.3.2 above and in Reference 7.3-3, the probability of unacceptable concentrations of sulfuric acid entering the intake is estimated to be about 10^{-9} occurrences per year. As a result, these types of liquid spills need not be considered as design basis events for HCGS.

7.3.5 STORAGE AND USE OF FLUIDS

The plant's fluids systems are designed to minimize the possibility of liquid spills. Inside the buildings, tanks are located in concrete vaults, and piping is routed in a manner that minimizes leakage. The plant has an equipment and floor drainage system that consists of radioactive and non-radioactive drainage and collection systems. Together, these systems drain waste, oily waste, chemical (acid/caustic) waste, sanitary waste, plant storm drainage and radioactive waste. The radioactive waste drainage system is segregated from the nonradioactive system to prevent transfer of radioactive contamination to the nonradioactive liquid wastes and to uncontrolled access areas.

Equipment and floor drainage systems are provided throughout the plant to collect liquid wastes and spills from their sources and transfer them to sumps or tanks following selective collection.

Outside the buildings, tank areas are diked and provided with catch basins, and are able to contain a spill from the largest tank on site.

The transformer areas in front of the building are protected against oil spills because the transformers are installed on concrete slabs with curbs. Drains are provided for disposal of rainwater and oil.

7.3.6 CONCLUSIONS

The analysis performed to determine the probability of hazardous events resulting from station operation, and the mitigating measures described above, provide assurance that no significant additional environmental effects from HCGS will result from accidents such as chemical explosion, fires, leakage, rupture of vessels containing oil or toxic materials, or river traffic.

REFERENCES

7.3-1 "Analysis of Potential Effects of Waterborne Traffic on the Safety of the Control Room and Water Intakes at Hope Creek Generating Station," A. D. Little, Inc. (September, 1974), pp. 7 and 8.

7.3-2 Ibid., p. 8.

7.3-3 "An Update on the Analysis of Potential Effects of Waterborne Traffic on the Safety of the Control Room and Water Intakes at Hope Creek Generating Station," A. D. Little, Inc., December, 1982.

TABLE 7.3-1

HAZARDOUS CHEMICALS STORED AT
SALEM GENERATING STATION

Name of Chemical	SULFURIC ACID	NITROGEN
Type of Source	On-site Mobile	On-site
Human Detection Threshold (mg/m^3)	1	Asphyxiant
Maximum Allowable Two-minute Concentration (mg/m^3)	2	Asphyxiant
Maximum Quantity of Chemical Involved	1) 30,000 l (8000 gal) 2) 737 metric tons (812 short tons)	1) 1900 l (500 gal) 2) 1 Bottle= 8.5 m^3 (300 ft^3)
Maximum Continuous Release Rate	N/A	N/A
Vapor Pressure	N/A	2300 psi for bottle
Fraction of Chemical Flashed and Rate of Boiloff when Spilling Occurs	N/A	1) 100% 2) 100%

TABLE 7.3-2

ESTIMATES OF HAZARDOUS CHEMICAL TRAFFIC
IN THE VICINITY OF HCGS[1]

CHEMICAL	THOUSANDS OF METRIC TONS/YR (SHORT TONS/YR)	VESSEL TRIPS/YR
Acetaldehyde	negligible	-
Acetone	negligible	-
Acrylonitrile	negligible	-
Anhydrous Ammonia	76 (84)	12
Aniline	negligible	-
Benzene (+ Toluene)	261 (288)	29
Butadiene	90 (100)	12
Butane	negligible	-
Carbon Dioxide	negligible	-
Carbon Monoxide	negligible	-
Chlorine	negligible	-
Ethyl Chloride	negligible	-
Ethyl Ether	negligible	-
Ethylene Dichloride	45 (50)	10
Fluorine	negligible	0
Formaldehyde	negligible	-
Helium	negligible	-
Hydrogen Cyanide	negligible	-
Hydrogen Sulfide	negligible	-
Methanol	36 (40)	12
Nitrogen	negligible	-
Sodium Hydroxide	220 (242)	30-50
Sulfur Dioxide	negligible	-
Sulfuric Acid	66 (73)	90
Vinyl Chloride	168 (185)	15
Xylene	45 (50)	5

(1) Estimates are based primarily on 1979 statistics, but updated with more current information where available.

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Part 1, 1979.

TABLE 7.3-3

CHEMICALS STORED AT THE HCGS SITE

Name of Chemical	Sulfuric Acid	Sodium Hydroxide	Nitrogen	Carbon Dioxide	Hydrogen	Sodium/ Hypochloride
Type of Source	On-site	On-site	On-site	On-site	On-Site	On-Site
Human Detection Threshold (mg/m^3)	1	N/A	Asphyxiant	-	-	-
Maximum Allowable Two-minute Concentration (mg/m^3)	2	N/A	Asphyxiant	1840		
Quantity at Site	52,000 gal (197,000 l)	37,000 gal (140,000 l)	18,600 gal (70,680 l)	27 tons (25 metric tons)	13,780 ft^3 at 30 psi (390 m^3)	12,000 gal (45,600 l)
Maximum Continuous Release Rate	N/A	N/A	N/A	N/A	-	-
Vapor Pressure	N/A	N/A	(liquid)	(liquid)	30 psi	(liquid)
Fraction of Chemical Flashed and Rate of Boiloff when Spilling Occurs	N/A	N/A	100%	100%	N/A	N/A

CHAPTER 8

ECONOMIC AND SOCIAL EFFECTS OF STATION CONSTRUCTION AND OPERATION

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CHAPTER 8

ECONOMIC AND SOCIAL EFFECTS OF STATION CONSTRUCTION AND OPERATION

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CHAPTER 8

ECONOMIC AND SOCIAL EFFECTS OF STATION CONSTRUCTION AND OPERATION

8.1 BENEFITS

8.1.1 DIRECT BENEFITS

The major benefit which HCGS will provide is safe, economical and reliable electric energy. HCGS has a capacity of 1067 megawatts, and will produce an average of over 6.1 billion kilowatt-hours per year during the first five full years of operation.

The operation of HCGS will provide substantial production cost savings compared to system operation without HCGS. A production cost analysis estimates these savings to vary from about $250 million to $460 million during the first five full years of operation.

The production cost analysis is based upon the operation of the Pennsylvania-New Jersey-Maryland Interconnection (PJM), of which both PSE&G and Atlantic Electric are members. The operation of PJM as if it were a single company allows for the most economic operation of all member-owned generating capacity. Generating units are dispatched economically, except to allow for reliability constraints and transmission limitations. System load and capacity forecasts are those reported in the MAAC Regional Reliability Council Coordinated Bulk Power Supply Program Report, dated April 1, 1982, sent to the U.S. Department of Energy.

Table 8.1-1 summarizes the results of the production cost analysis for 1987 through 1991. Along with the system savings estimated with HCGS in operation, HCGS energy produced and capacity factor are provided.

Production cost savings with HCGS in operation are due to reduced expenditures for fuel and interchange. Variable operating and maintenance (O&M) costs actually increase with HCGS in service. This is because interchange purchase is included as a fuel cost with no associated O&M. In addition to the savings shown in Table 8.1-1, the operation of HCGS avoids other costs, including costs to return inoperative units to service, and additional fixed O&M to keep these and other units in service beyond scheduled retirement dates.

If HCGS were not in operation, replacement energy would be produced using coal and oil as fuels. For 1987-1991, replacement energy is estimated to be 54 percent coal-fired and 46 percent oil-fired. Most of this replacement energy would be purchased from other utilities. Table 8.1-2 shows the percentage breakdown of internally generated and imported energy by production source. Also provided are fuel and variable O&M rates for HCGS and replacement sources. As previously mentioned, bulk power purchase and interchange is viewed as a fuel cost with no consideration of the actual breakdown of fuel and O&M costs incurred by other companies.

8.1.2 INDIRECT BENEFITS

The operation of HCGS generates the following benefits:

8.1.2.1 State and Local Taxes

The major taxes paid by PSE&G and Atlantic City Electric Company to the State of New Jersey and local governments are Gross Receipts and Franchise Taxes, and Real Estate Taxes. Other taxes are paid through various payroll taxes (Federal Insurance Contributions Act, Unemployment Insurance, etc.), sales taxes on purchases of equipment not directly related to production, transmission and distribution of electricity or gas, and motor vehicle taxes. Taxes are not paid to county governments. Customers do not pay sales taxes on electrical energy purchased.

Gross Receipts and Franchise Taxes

The inventories of all public utilities' personal property, such as meters, poles, wires, transformers, conduit, pipes, generating equipment, gas manufacturing equipment, etc., whether on public or private property, are the basis for distribution of New Jersey gross receipts and franchise taxes to the municipalities. The inventories of these properties, as they exist on July 1, are filed with the Public Utility Tax Bureau in Trenton prior to September 1 of each year. Gross receipts and franchise taxes fall into three categories:

a. Gross Receipts Tax - Utilities pay a gross receipts tax to the state in lieu of personal property assessments. This tax is based on the total revenues from the sale of gas and electricity; it is levied at the rate of 7.5 percent. The state then distributes tax revenues to various municipalities according to the proportion of the total value of utility property in a municipality to the total value of utility property in the state, within certain statutory limitations.

The state distributes this tax revenue to all municipalities where equipment is located, not just within the utilities' service areas.

b. Franchise Tax - The franchise tax is a tax paid to the state for the privilege of PSE&G and Atlantic Electric exercising their franchises in the public streets. It is levied at the rate of five percent on taxable gross revenues (74 percent of total electric gross revenues). The taxable amount of gross revenues for franchise tax purposes is determined yearly by multiplying total gross revenues by the percentage that the miles of lines located on public property bear to the total miles. The state then distributes the franchise tax to various municipalities in the proportion the amount the public value of utility property in a municipality bears to the total public value in the state, within certain statutory limitations. This tax is paid primarily to municipalities within the utilites' service areas, although there are few cases where the utilities use public streets outside the service area, and in those cases franchise taxes are distributed to the municipalities involved.

c. Surtax - The surtax is equal to 12.5 percent of the total gross receipts and franchise tax paid; the surtax is paid to the state for general state use.

Based on the above, about 12.5 percent of the revenues produced by the sale of electricity from HCGS would be paid to the state government in Gross Receipts and Franchise Taxes. Based on an estimated average price of electricity of 11.8¢ per kilowatt-hour in 1987, these taxes for the owners would amount to about $94 million in 1987, and $163 million per year, levelized over the life of the generating station.

The amount of money that any one municipality can receive through these taxes is limited by various constraints, one of which is a cap equal to $700 per capita. This cap would apply to Lower Alloways Creek, since Salem Generating Station is located in that municipality; therefore, the state would not allocate most of the tax revenue to Lower Alloways Creek, but would channel it into the Municipal Assistance Fund for distribution primarily to the larger inner core cities of Newark, Jersey City, Camden, Elizabeth, Trenton and Paterson.

Real Estate Taxes

Land and buildings, as commonly understood, are subject to property tax. The Township of Lower Alloways Creek has no local or school tax levies. A property tax (one of the lowest in the state) is collected to pay Lower Alloways Creek's share of county taxes. The local tax rate for Lower Alloways Creek is estimated to be $1.23 per $100 of assessed value, in 1987. Based on this rate, a 1987 land tax of $6581 is estimated for 107 acres at $5000 per acre. Estimating an improvement assessment of $63.6 million, the corresponding tax would be $782,280. The total tax revenue for 1987 attributable to HCGS is therefore roughly $789,000. The levelized lifetime property tax revenue to be expected from HCGS is estimated to be about $1.4 million per year.

Revenues to Lower Alloways Creek Township have increased significantly since 1970, due to construction and operation of the Salem Generating Station. These increased revenues have enabled the Township to build a new municipal building, new high school, new sewage treatment plant and new recreational facilities. Operation of HCGS will add to these revenues.

8.1.2.2 Payroll and Employment

The Applicant anticipates an operating staff of 378 persons for HCGS, with an associated payroll of $13.9 million in 1987. Total present worth of the payroll in 1987 dollars is $241.3 million. The payroll will result in federal and state income tax revenues, but no municipal income taxes are collected.

Perhaps five to 10 percent of the operating staff will come from the local community.

8.1.2.3 Increase in Primary Market Area Expenditures and Generating of Secondary Employment

The Primary Market Area is defined as Lower Alloways Creek Township and the City of Salem, for these purposes. Secondary employment is that which is created in retail and service establishments because of increased demand due to new residents and employees.

The City of Salem has experienced a historical decline in its economic base since it is no longer an active port. Its increasingly isolated geographical position has resulted in out-migration of population and of retail and wholesale

establishments. Since the economic base is limited, only the basic needs, e.g., food services, some clothing and supplies, can be met in Lower Alloways Creek Township and the City of Salem. Therefore, much of the disposable income generated by plant employment will be spent at urban centers outside the immediate area, especially for major purchases.

It is estimated that approximately 35 percent of income is spent on non-auto related goods and services (Reference 8.1-1). In this instance, the capture rate for residents is about 60-70 percent. The capture rate for the operations workers who are not residents is estimated at 10 to 15 percent (see Table 8.1.3). The projected increase in local expenditures and services due to the operations employees is approximately 6.3 percent.

Some purchases of supplies are made at the local level. A few merchants benefit from increased sales to operations workers, especially for food and services. The number of these types of establishments will probably increase, thus creating a secondary employment benefit as a result of the presence of operations workers.

8.1.2.4 Improvement of Local Roads and Transportation Facilities

The intersection of Hancocks Bridge Road and Alloway Creek Neck Road in Hancocks Bridge has been improved, and plans are currently underway to widen Lower Alloways Creek Neck Road for a distance of approximately six kilometers (four miles).

8.1.2.5 Research, Environmental Monitoring and Environmental Education

PSE&G is currently conducting numerous environmental studies involving water chemistry, thermal data, and aquatic and terrestial biological monitoring programs. These areas will be studied throughout the operating life of HCGS. The knowledge gained from these programs will contribute to the understanding and prediction of environmental interrelationships.

REFERENCES

8.1-1 Burchell and Listokin, The Fiscal Impact Handbook, Rutgers Center for Urban Studies, 1980.

TABLE 8.1-1

HOPE CREEK OPERATION
NET PRODUCTION COST SAVINGS (PENALTY)
MILLIONS OF DOLLARS

Year	HOPE CREEK PRODUCTION		TOTAL SYSTEM SAVINGS		
	Energy Produced (GWHR)	Capacity Factor (%)	Fuel and Interchange	Variable O&M	Total Savings
1987	6350	68	266	(18)	248
1988	6350	68	327	(18)	309
1989	5773	62	377	(16)	361
1990	6494	70	479	(17)	462
1991	5773	62	457	(15)	442

TABLE 8.1-2

SOURCES OF REPLACEMENT ENERGY BY FUEL TYPE
AVERAGE HOPE CREEK AND REPLACEMENT PRICES
1987-1991 (MILLS/KWHR)

HOPE CREEK			REPLACEMENT ENERGY							
			COAL GENERATION			OIL GENERATION			INTERCHANGE	
Year	Fuel Rate	Variable O&M Rate	Percent of Replacement Energy	Fuel Rate	Variable O&M Rate	Percent of Replacement Energy	Fuel Rate	Variable O&M Rate	Percent of Replacement Energy (% Coal/% Oil)	Cost
1987	13.6	3.8	8	33.2	6.0	6	97.9	4.9	86 (73/27)	57.9
1988	13.0	4.1	6	36.4	6.5	11	111.0	5.8	83 (72/28)	65.7
1989	12.8	4.4	7	39.6	7.2	15	117.6	6.4	78 (62/38)	80.5
1990	13.4	4.7	9	43.5	7.6	17	126.9	6.9	74 (62/38)	90.4
1991	14.5	5.0	7	46.4	7.6	20	135.3	7.6	73 (56/44)	93.7

TABLE 8.1-3

PROJECTED PRIMARY MARKET AREA EXPENDITURES
LOWER ALLOWAYS CREEK (LAC) TOWNSHIP AND CITY OF SALEM

	CURRENT LAC TWP. ESTIMATE(1)	CURRENT SALEM CITY ESTIMATE(1)	1987 HCGS OPERATIONS WORKERS ESTIMATE
Primary market area population	1,547	6,959	378
Per capita income	$ 4,820	$ 5,018	$ 36,772
Portion of per capita income spent on non-auto retail goods and services (35%)	1,687	1,756	12,870
Total retail expenditures made by primary market areas residents (operations workers)	2,609,790	12,222,090	4,865,000
Capture rate of primary market area retail expenditures	0.65	0.65	0.125
Total primary market area expenditures within study area (approximate)	$1,696,363	$ 7,944,360	$ 608,125
Total	$9,640,723		

$\frac{\$608,125}{\$9,640,723}$ = 6.3% Projected Increase in Local Expenditures on Retail Goods and Services

(1) Based on 1980 Census data and 1977 per capita income.

8.2 COSTS

8.2.1 DIRECT COSTS (INTERNAL COSTS)

Direct costs associated with HCGS include variable costs, which are documented in Section 8.1.1, and fixed costs not related to production levels, but incurred as a result of HCGS operation. Table 8.2-1 documents variable and fixed costs for HCGS, presenting total lifetime costs, first year costs and levelized lifetime annual costs. A 30 year operational life is assumed. Annual variable costs are shown as mills per kilowatt-hour, and fixed costs are expressed annually as dollars per kilowatt of installed capacity. An 11.7 percent cost of money was used to determine present worth and levelized values.

Variable costs are fuel costs and those operation and maintenance costs that vary with the amount of energy produced. Total lifetime fuel cost is estimated to be $1.049 billion (1987 dollars), or $127 million per year (levelized). Variable operation and maintenance costs are estimated at $371 million (1987 dollars), or $45 million per year. Levelized costs per unit of production are 20.5 mills per kilowatt-hour for fuel and 7.3 mills per kilowatt-hour for variable O&M.

Fixed costs are independent of production levels. Table 8.2-1 describes fixed costs in dollars per kilowatt based on a generating capacity of 1067 megawatts for HCGS. Fixed operating and maintenance costs, as shown, include a number of annual costs necessary for the operation of HCGS, but not determined by level of output. These include:

a. Minimum staffing and services required to perform such activities as environmental surveillance, security, health physics, and other requirements for operating and maintaining HCGS regardless of output level. The estimated total lifetime (30 year) cost is $878 million (1987 dollars), or a levelized annual cost of $107 million.

b. Annual NRC fees for routine inspections and facility license amendments. Based on the current fee structure and estimated cost escalation rates, the total lifetime cost would be $2.3 million (1987 dollars), or a levelized annual cost of $276,000.

c. Liability, property and energy replacement insurance. Based on currently available insurance, estimated lifetime costs are $122 million (1987 dollars), or a levelized annual cost of $14.8 million.

d. Property taxes. Total lifetime cost is estimated to be $12 million, or $1.4 million per year levelized cost. This figure does not include gross receipts and franchise taxes collected in lieu of property taxes and based on total revenues.

Other fixed costs, not incurred annually, are documented separately. These include:

a. NRC operating license fee. The fee for this license is currently $1,024,500, or $1.6 million in 1987 dollars. This corresponds to a levelized annual cost of $190,000.

b. Unit decommissioning costs upon retirement. See Section 5.8 for an estimate of decommissioning costs.

8.2.2 INDIRECT COSTS (EXTERNAL COSTS)

Population Changes and Housing Demand

Population increase due to in-migration of operations workers should be minimal, especially in view of the fact that out-migration of construction workers who relocated to the project area most probably will occur at the end of the construction phase. Population has decreased within the last ten years in the City of Salem, and increased in Lower Alloways Creek Township (see Table 8.2-2).

The demand for housing in the project area (Lower Alloways Creek Township and the City of Salem) should increase minimally. Based on current residence patterns of operations workers at Salem Generating Station, the 378 workers projected should reside in a wide area encompassing eastern Delaware and Salem, Gloucester, Cumberland, Burlington, Camden and Atlantic Counties.

The single family residences which have been converted to multi-family apartments and boarding houses during the construction phase will provide lower income housing when the construction workers leave. This type of multi-unit housing was almost non-existent prior to construction of Salem Generating Station and HCGS.

A report prepared for the Office of Nuclear Regulatory Research, USNRC (Reference 8.2-1), tested the hypothesis that nuclear power plants adversely affect community growth and residential property values in nearby municipalities. Total assessed real property values equalized from 1960 to 1976 for 64 municipalities, and market sales data from 1975 to 1977 on 540 single family dwellings in areas within 32 kilometers (20 miles) of four nuclear power plants in the northeast (Pilgrim, Millstone, Oyster Creek and R. E. Ginna), formed the data base. Analysis of the time series data showed that the average annual growth rates of total assessed values, in real terms, were inversely related to distance from the plants, and that growth rates for the years following plant construction were higher than for the years before plant construction, with the largest growth rate increase observed in the host municipalities. Multiple regression analysis of the cross-sectional data explained about 80 percent of the variation in housing prices. According to this study, the plants exerted no influence on the price of housing. The original hypothesis was rejected. Most people in these areas apparently have little fear over plant-related health and safety factors, and the plant itself does not influence residential location decisions. Lower tax rates in host municipalities may even encourage development.

Community Services, Infrastructure, Public Safety, Transportation and Educational Facilities

Demand exerted by operations workers on education, public safety and social services is expected to be minimal. Inasmuch as HCGS provides its own potable water, sanitary sewage disposal facilities and security personnel, its impact on existing community services should be negligible.

School enrollment in both Lower Alloways Creek Township and the City of Salem has been dropping steadily (Reference 8.2-2). Therefore, the schools are presently under capacity. Sufficient space exists for the children of any operations workers who may reside in these municipalities. The remainder of workers will be so spread over a wide area, as to have little impact on the various school systems. Transportation facilities should not be as heavily impacted by the operations phase as they were by the construction phase. It is not anticipated that any additions to the Lower Alloways Creek Township police force will be necessary for operation of the station.

Recreational, Aesthetic and Scenic Values

Operation of HCGS should not have any adverse effects on recreational facilities. The plant's cooling tower could be visible during daylight hours under optimum visibility conditions for approximately 48 kilometers (30 miles). In reality, the presencé of trees, hills, and buildings will significantly reduce the 30-mile theoretical distance for most locations. Changes to aesthetic and scenic values due to operation of HCGS will be influenced by atmospheric plume characteristics. Plume persistence is discussed in Section 5.1.4.6. Physical appearance and aesthetics are described in Section 3.1.

Perceptions of Local Residents

Numerous studies have been completed concerning the socioeconomic impacts construction and operation of nuclear generating stations may have on local communities. The following is from a survey taken in conjunction with a socioeconomic impact analysis of the Peach Bottom Plant in Pennsylvania (Reference 8.2-3). Inasmuch as the characteristics of the local population near Peach Bottom closely resemble the characteristics of the Salem County population, many parallels can be drawn from this survey. The responses were broken into various segments of the local population.

a. Agricultural Community

Near Peach Bottom, this group was mainly concerned with changes in life-style and possible economic impact. Economic concerns included a possible loss of farm workers to the station, decrease in property values, and effects on dairy products and crops due to low-level radioactive and thermal releases. As stated in Section 8.1.2.2, approximately 5 to 10 percent of the 378 persons projected for the HCGS operating staff will come from the local community. Based on the operating staff at the Salem units, few HCGS operations personnel should come from the local farm labor force. Property values have increased since Salem Unit 1 has been in operation, and no effects on dairy products and crops have been documented.

Among social concerns voiced in the Peach Bottom study were possible loss of rural environment and life-style due to suburbanization, loss of political and cultural dominance, and change in values of youth due to association with the children of operations workers. Based on experience with Salem Generating Station, these social impacts are expected to be insignificant, due to the fact that operations workers will reside in a wide area, as stated in Section 8.2.2, thus diluting any social effects on any one community.

The agricultural community perceived positive fiscal impacts on their municipality to be the greatest benefit to be derived from station operation.

b. Business Community

In the Peach Bottom study, business owners expressed the belief that economic gains during the construction phase were temporary and that operations workers contributed little to the local economy. This is discussed in Section 8.1.2.3. Heavy traffic during peak hours and decreased expenditures during these periods were also concerns. Traffic volume is expected to decrease when construction is complete. Neighboring communities felt that they experienced all of the negative and none of the positive economic impacts (as opposed to the host community). In the case of HCGS this effect may not be as pronounced, due to the fact that Lower Alloways Creek Township has limited shopping facilities.

The business communities surveyed also expressed the belief that in-migrants contribute to the stablization of the retail business sector and to the community's social organizations, and that changes from the general store to supermarket-type retail businesses are beneficial.

c. Traditional Families/Long-Term Residents

This group expressed concern that conversion of single family houses into multi-family dwellings would lead to neighborhood decline (discussed in Section 8.2.2), and that the influx of newcomers would dissipate "the sense of community."

However, the plant was also seen as an aid to cohesiveness and spirit in the community. Increased employment of young people (thus discouraging out-migration), increased employment of women, increased income from rentals and boarders, and financial contributions to social organizations were all perceived as benefits.

d. The Suburban Group

In general, in the Peach Bottom study, the suburban group considered itself somewhat detached from the plant's impacts, since they were not active in community affairs, nor dependent on the community economically. A small number of this group were employed as operators.

In general, all the groups surveyed considered local property tax reductions to be the greatest benefit. All demonstrated an increased awareness concerning the risk of accidents since the Three Mile Island incident, and agreed that an effective evacuation plan is needed, as well as controls on shipment of nuclear wastes.

Summary and Conclusions

Findings in the previously cited reports and studies are reinforced by the results of a study of Salem County and four other counties which are host to nuclear power plants (Reference 8.2-4). This report focused on the impacts experienced by Salem residents from construction of the Salem Units. Negative impacts were found to be very minimal, while the economic benefit to Lower Alloways Creek Township was sizeable.

Overall, PSE&G believes that the economic and social benefits associated with the operation of the station will be substantial at the local, regional and national levels, while the external social and economic costs will be minimal.

REFERENCES

8.2-1 U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Effects of Nuclear Power Plants on Community Growth and Residential Property Values, NUREG/CR-0454, April, 1979.

8.2-2 New Jersey Associates, The New Jersey Municipal Data Book 1982, Montclair, New Jersey.

8.2-3 U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Socioeconomic Impacts of Nuclear Generating Stations, Peach Bottom Case Study, NUREG/CR-2749, Vol. 8, July, 1982.

8.2-4 National Association of Counties, NaCo Case Study on Energy Impacts No. 4 - Nuclear Power Plant Development, Boom or Boon? County Experiences, Washington, D. C., July, 1976.

TABLE 8.2-1

HCGS DIRECT COSTS

	TOTAL LIFETIME COSTS (MILLIONS OF 1987 DOLLARS)	30 YEAR LEVELIZED COSTS (1987-2016)	FIRST YEAR COSTS (1987 DOLLARS)
Variable Costs(1)			
Fuel	1049	20.5 mills/kWh	13.6 mills/kWh
variable O&M	371	7.3 mills/kWh	3.8 mills/kWh
Fixed Costs(2)			
Fixed O&M	1014	115 $/kW/yr or 19.9 mills/kWh	60 $/kW/yr or 10.1 mills/kWh
NRC Operating License	1.6	0.18 $/kW/yr or 0.03 mills/kWh	N/A
Decommissioning costs			N/A

(1) Variable costs are related to output, and expressed on an annual basis as mills/kWh.

(2) Fixed costs are unrelated to output, and expressed on an annual basis as $/kW of installed capacity. Fixed costs are also shown in mills per kWh, based upon an assumed lifetime capacity factor of 66.2%, and an assumed first year capacity factor of 68%.

TABLE 8.2-2

POPULATION CHANGES IN THE PROJECT AREA

	1970	1980	%CHANGE
New Jersey	7,171,112	7,364,823	+ 2.7
Salem County	60,346	64,676	+ 7.2
Lower Alloways Creek (LAC)	1,400	1,547	+ 10.5
City of Salem	7,648	6,959	- 9.0
HOUSING UNITS			
	1970	1980	
Salem County	21,[illegible]0	22,476	+ 4.4
LAC	[illegible]	572	+ 24.6
City of Salem	2,6[illegible]	2,830	+ 8.1
HOUSING SIZE			
Salem County	2.8	2.9	+ 3.6
LAC	3.0	2.7	- 10.0
City of Salem	2.9	2.5	- 13.8

Source: U.S. Census Reports 1970 & 1980

CHAPTER 9

ALTERNATIVE ENERGY SOURCES AND SITES

Final rules in 10 CFR 51.21 eliminate requirements to discuss alternative sites (46 FR 28632, May 28, 1981), and alternative energy sources (47 FR 12940, March 26, 1982).

CHAPTER 10

STATION DESIGN ALTERNATIVES

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CHAPTER 10

STATION DESIGN ALTERNATIVES

10.1 CIRCULATING SYSTEM

At the construction permit stage six alternative cooling methods were reviewed in addition to the one selected: closed cycle cooling with a natural draft cooling tower (see Section 3.4).

10.2 INTAKE SYSTEM

At the construction permit stage the applicant showed the feasibility of a traveling water intake screen with low approach velocity and other features to minimize fish entrapment. Cancelling Unit 2 and reducing the number of service water pumps in normal operation per unit from three to two significantly reduces the flow toward the intake structure, which has an overall size similar to the one originally planned (see Section 3.4).

10.3 DISCHARGE SYSTEM

The single pipe discharge selected at the contruction permit stage has been retained, although it discharges nearer to shore than originally planned (see Section 3.4).

10.4 CHEMICAL WASTE TREATMENT

At the construction permit stage, PSE&G reviewed four alternative chemical waste treatment systems, and selected one: pH adjustment and precipitation followed by discharge to the river via the cooling tower blowdown line. Also addressed at the construction permit stage were scale prevention and corrosion control methods.

PSE&G is presently reassessing chemical waste treatment alternatives, one of which is collection for off-site treatment. PSE&G has not determined the precise method to be used.

10.5 BIOCIDE TREATMENT

At the construction permit stage, mechanical condenser tube cleaning was reviewed as the principal alternative to chlorination. The applicant selected chlorine as the preferred biocide with the stipulation that, prior to power operation, the applicant would conduct further studies. Construction Permit Condition 3.E.(1) applies. See Chapter 13 for a discussion of this effort.

10.6 SANITARY WASTE SYSTEM

The principal alternative sanitary waste treatment method available at the construction permit stage would have been pumping offsite to the Salem municipal treatment plant, 11.5 kilometers (7 miles) away. During construction three onsite package type extended aeration units were placed into service, with a total capacity of 195,000 liters per day (51,000 gallons per day). All are fully licensed by the New Jersey Department of Environmental Protection with concurrence by the Delaware River Basin Commission. These units are intended for use during plant operation (see Section 3.7).

10.7 ALTERNATIVE LIQUID RADWASTE SYSTEMS

Section 3.5 describes the liquid radwaste system. Since the quantities of radioactive material in effluents will be limited to levels within the numerical guidelines for design objectives and limiting conditions for operation set forth in Appendix I of 10 CFR Part 50, no further consideration need be given to the reduction of radiological impacts in formulating alternative plant designs. This is in keeping with guidance given in Section 10.7 of Regulatory Guide 4.2.

10.8 ALTERNATIVE GASEOUS RADWASTE SYSTEMS

Section 3.5 describes the gaseous radwaste system. Since the quantities of radioactive material in effluents will be limited to levels within the numerical guidelines for design objectives and limiting conditions for operation set forth in Appendix I of 10 CFR Part 50, no further consideration need be given to the reduction of radiological impacts in formulating alternative plant designs. This is in keeping with guidance given in Section 10.8 of Regulatory Guide 4.2.

10.9 TRANSMISSION FACILITIES

At the construction permit stage, one proposed 500 kilovolt transmission line paralleled an existing 500 kilovolt line between Salem Generating Station and the New Freedom Switching Station, while a second proposed line traversed an unselected route between Hope Creek and Tuckerton, New Jersey. Plans for the second line have been abandoned (see Section 3.9).

Underground transmission, as an alternative to overhead lines, was evaluated at the construction permit stage.

CHAPTER 11

SUMMARY COST BENEFIT ANALYSIS

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CHAPTER 11

SUMMARY COST BENEFIT ANALYSIS

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11.2-1	INDIRECT ENVIRONMENTAL COSTS

CHAPTER 11

SUMMARY COST BENEFIT ANALYSIS

11.1 BENEFITS

11.1.1 DIRECT BENEFITS

The primary benefit that HCGS provides is the approximately 6.15 billion kilowatt-hours of baseload electrical energy the station will produce annually over the first five years of operation, at an average capacity factor of 66 percent (see Section 8.1.1). The station, with a net generating capacity of 1067 megawatts (electric), will produce this energy at a cost savings of between $248 million to $462 million per year during those first five years (see Table 8.1-1). Distribution of the energy based on projected demand in 1987 is:

Residential	24.8%
Commercial	35.0%
Industrial	31.6%
System use and losses	7.8%
Other	0.8%

Based on an average rate of $0.118 per kilowatt-hour for all users, the value of HCGS output in its first full year of operation is $750 million. If the equivalent energy were to be generated by oil, it would require 10.8 million barrels.

11.1.2 INDIRECT BENEFITS

Indirect benefits from the operation of HCGS include the payment to the state government, as Gross Receipts and Franchise taxes, of an estimated 12.5 percent of the revenues produced by the sale of electricity from HCGS. Based on an estimated average price of electricity of $0.118 per kilowatt-hour in 1987, these taxes would amount to approximately $94 million in 1987, or $163 million per year levelized over the life of the station (see Section 8.1.2.1). Local real estate taxes are estimated at $789,000 for 1987, or $1.4 million on a levelized basis.

Personnel directly employed in the operation of HCGS will number approximately 378, with an annual payroll in 1987 dollars estimated at $13.9 million.

Generation of electricity by HCGS operation will have other indirect benefits, such as improved system reliability, improved fuel diversity, and reduced air and water emissions and reduced solid waste production, compared with equivalent coal-fired baseload generating capacity.

11.2 COSTS

11.2.1 DIRECT COSTS (ECONOMIC)

As described in Section 8.2 and Table 8.2-1, the annual economic costs associated with HCGS operation include fuel costs, operating and maintenance costs, and NRC licensing fees. These costs total $295.7 million per year in 1987 dollars, on a levelized basis, broken down as follows:

Fuel:	$127	million per year
Variable O&M:	$ 45	million per year
Fixed O&M:	$123.2	million per year
One time and annual NRC licensing fees:	$ 0.5	million per year
	$295.7	million per year

Depending on the method chosen, decommissioning costs could range from $2.5 million (1975 dollars, mothballing method) to $71 million (1978 dollars, mothballing followed by delayed dismantlement). See Section 5.8.

11.2.2 INDIRECT COSTS

Table 11.2-1 summarizes indirect environmental costs, and references various Environmental Report sections where these costs are discussed in more detail.

TABLE 11.2-1

INDIRECT ENVIRONMENTAL COSTS (Page 1 of 4)

RESOURCE	NATURE AND MAGNITUDE OF EFFECT	ER SECTION
Land Use		
HCGS Station	Occupies 62 hectares (153 acres) of 300 hectare (740 acre) site.	2.1.1.1, 5.7.3
Transmission Lines	69 kilometers (42.9 miles) of new line constructed parallel to pre-existing line in pre-existing 106 meter (350 foot) right-of-way.	3.9, 5.5
Aesthetics	Visible from various off-site points.	3.1.1, 3.1.2, 5.1.4, 5.6.1 8.2.2
Agriculture	Salt deposition from drift has acceptably low impact	5.1.4
Surface Water		
Consumption	Withdraws average of 124,400 liters per minute (32,860 gallons per minute). Consumes average of 43,500 liters per minute (11,500 gallons per minute).	3.3, 5.7.2, 13.3
Quality	Thermal and chemical discharges are in accordance with NJPDES permit - water quality standards met for Delaware River Zone 5 outside of mixing zone. Radiological discharges are within limits of 10 CFR 50, Appendix I.	3.3, 3.6, 3.7, 5.1.1, 5.1.2, 5.2, 5.3.1, 5.4

TABLE 11.2-1 (Continued)

RESOURCE	NATURE AND MAGNITUDE OF EFFECT	ER SECTION
Groundwater		
Consumption	Withdrawal is average of 770 liters per minute (190 gallons per minute).	3.3
Quality	Withdrawal is within aquifer yield level; no routine discharge of conventional or radiological wastes to groundwater.	5.2.2.5, 5.6.4
Level	No unacceptable drawdowns are produced by production wells.	5.6.4
	Dewatering of excavation area is no longer needed; groundwater levels are re-established at normal levels.	5.6.4
Aquatic Biota		
Impingement	Water volume is small relative to river; fish return system is employed.	3.4, 5.1.3, 5.7.4
Entrainment	Water volume is small relative to river; entrainable organisms are common and good regenerators.	3.4, 5.1.3, 5.7.4
Thermal	Effect is small due to volume of discharge and small size of resulting plume.	5.1.2, 5.1.3, 5.7.4
Ambient Sound	Cooling tower produces approximately 76 dbA at 31 meters (100 feet) from base. Sound levels are within acceptable limits at nearest residential property boundary.	2.7, 3.4.4, 5.6.2

TABLE 11.2-1 (Continued)

RESOURCE	NATURE AND MAGNITUDE OF EFFECT	ER SECTION
Air		
Quality	Atmospheric emissions are too low to require PSD permit; all are in accordance with applicable NJDEP permits.	3.7.3, 5.1.4, 5.7.2
	Cooling tower visible plume is confined to 1430 meters (4690 feet); fogging, icing, precipitation, shadowing, etc., influences are small.	5.1.4, 5.2, 5.7.2
	Atmospheric radiological releases are within limits of 10 CFR 50, Appendix I.	5.2
Transportation	Radioactive materials movement is in accordance with analysis of 10 CFR 51.20.	3.8, 7.2
	Traffic levels are reduced from construction peaks.	8.2.2
Terrestrial Biota	Habitat displacement confined to site proper and to transmission line corridors. Minimum ground clearances along transmission lines are maintained primarily by trimming; farming and grazing are permitted beneath lines.	2.1.1.1, 2.2.1, 3.9, 5.5
Uranium	Approximately 5100 metric tons (5600 tons) of mined natural uranium are needed for life of the plant.	5.7.1, 5.9

TABLE 11.2-1 (Continued)

RESOURCE	NATURE AND MAGNITUDE OF EFFECT	ER SECTION
Socioeconomics		
Housing	Minimal increase in demand.	8.2.2
Property Values	No adverse impact.	8.2.2
Community Services	Minimal increase in demand.	8.2.2
Social Effects	Minimal change.	8.2.2
Accidents	Effect varies depending on type of accident and probability of occurrence. HCGS does not aggravate or augment off-site accidents.	7.1, 7.2, 7.3, Appendix C

CHAPTER 12

ENVIRONMENTAL APPROVALS AND CONSULTATION

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ENVIRONMENTAL APPROVALS AND CONSULTATION

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12.1-3	HCGS INTERSTATE PERMITS

CHAPTER 12

ENVIRONMENTAL APPROVALS AND CONSULTATION

12.1 PERMITS

12.1.1 FEDERAL PERMITS

Table 12.1-1 contains a list of Federal permits and their status for HCGS.

12.1.2 STATE PERMITS

See Table 12.1-2 for a list of State permits and their status for HCGS.

12.1.3 INTERSTATE PERMITS AND APPROVALS

A list of Interstate permits and approvals for HCGS appears in Table 12.1-3.

TABLE 12.1-1

HCGS FEDERAL PERMITS

PERMIT AND PURPOSE	AGENCY	STATUS AND APPROVAL DATE
1. Construction Permit (CPPR-120)	United States Atomic Energy Commission (AEC)	Received November, 1974
2. National Pollutant Discharge Elimination System Permit (NPDES-NJ0025411)	United States Environmental Protection Agency	Received July, 1975; PSE&G has applied for renewal
3. Operating License	Nuclear Regulatory Commission (NRC)	Not received
4. Special Nuclear Material License	Nuclear Regulatory Commission (NRC)	Not received
5. By-Product Material License	Nuclear Regulatory Commission (NRC)	Not received
6. Department of the Army Permit to Dredge for Service Water River Intake and Discharge Facilities (NAPOP-R-970)	United States Army Corps of Engineers	Received June, 1975
7. Air Navigation Determination (74-EA-995-OE)	Federal Aviation Administration	Received June, 1976; presently covered by Determination No. 82-AEA-0822-0E
8. Prevention of Significant Deterioration (PSD)	United States Environmental Protection Agency	Letter indicating project not subject to PSD regulations received October, 1981.

TABLE 12.1-2

HCGS STATE PERMITS (Page 1 of 2)

PERMIT AND PURPOSE	AGENCY	STATUS AND APPROVAL DATE
1. Subsurface Water Diversion Permit for Dewatering of Excavation (W.S. P-956)	New Jersey Department of Environmental Protection	Received July, 1974
2. Water Quality (401a) Certification for Construction Permit	New Jersey Department of Environmental Protection	Received May, 1974
3. Water Quality (401a) Certification for Operating License	New Jersey Department of Environmental Protection	Not received
4. Subsurface Water Diversion Permit for Production Water Wells (W.S.P-998)	New Jersey Department of Environmental Protection	Received January, 1975
5. Permit to Operate Sewage Teatment Plants (SO-5-76-5720A and SO-5-76-5720B)	New Jersey Department of Environmental Protection	Received September, 1976
6. Type "B" Wetlands Permit (W74-042)	New Jersey Department of Environmental Protection	Received February, 1975, extended for 5 years in September, 1980
7. Revocable License for Use of Riparian Land to Construct Waterfront Facilities (74-046)	New Jersey Department of Environmental Protection	Received February, 1975, indefinite term
8. Coastal Area Facility Review Act (CAFRA) Permit (CA #74-014)	New Jersey Department of Environmental Protection	Received September, 1975
9. Air Pollution Control Permits to Construct and Operate Diesel Generators, Storage Tanks, Heating Boilers and Cooling Tower	New Jersey Department of Environmental Protection	Received between 1977 and 1980

TABLE 12.1-2 (Continued) (Page 2 of 2)

PERMIT AND PURPOSE	AGENCY	STATUS AND APPROVAL DATE
10. New Jersey Pollutant Discharge Elimination System Permit (NJPDES NJ0025411)	New Jersey Department of Environmental Protection	Received March, 1981; Renewal applied for and pending
11. Stage 2 Treatment Works Approval - Cooling Tower	New Jersey Department of Environmental Protection	Waiver received June, 1982
12. Operate Sewer Extension (SO-76-0193-4)	New Jersey Department of Environmental Protection	Received April, 1978

TABLE 12.1-3

HCGS INTERSTATE PERMITS

PERMIT AND PURPOSE	AGENCY	STATUS AND APPROVAL DATE
1. Incorporation of HCGS into Comprehensive Plan Docket Decision (D-73-193CP)	Delaware River Basin Commission	Incorporated June, 1975

12.2 CONSULTATION

A list of Federal, State, local, and regional planning authorities that were contacted and consulted is as follows:

a. U.S. Army Corps of Engineers
b. U.S. Environmental Protection Agency
c. U.S. Federal Aviation Administration
d. U.S. Nuclear Regulatory Commission
e. New Jersey Department of Environmental Protection
f. New Jersey Board of Public Utilities
g. New Jersey Department of Agriculture
h. New Jersey Transportation Department
i. Delaware River Basin Commission
j. Lower Alloways Creek Township
k. Salem County, New Jersey, Planning Board
l. Delaware Department of Natural Resources
m. Pollution Control Financing Authority of Salem County
n. New Castle, Delaware, County Department of Planning
o. Pinelands Commission
p. Salem Soil Conservation District
q. Gloucester Soil Conservation District
r. Camden Soil Conservation District

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CHAPTER 13

SUMMARY OF ACTIONS TAKEN

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CHAPTER 13

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TABLES

Table Number	Title
13.2-1	ARTIFICIAL ISLAND SITE REPORTS

CHAPTER 13

SUMMARY OF ACTIONS TAKEN

13.0 GENERAL

The construction permit, issued on November 4, 1974, left certain topics and activities for later resolution or performance. In several instances the construction permit required additional periods of preoperational monitoring in parallel with construction. Other requirements involved analytical studies, information dissemination or licensing activities, which needed extended time to complete without affecting construction. The Atomic Energy Commission, in granting construction permit CPPR-120, listed such conditions in paragraph 3.E. Each condition and the way in which PSE&G has met it is given below:

13.1 CHLORINATION EFFECTS STUDY

"Prior to initiation of power operation the Applicants shall conduct a study of proposed chlorination methods to assure that the use of these methods will result in acceptable chlorine residuals in the station effluent under the full range of conditions anticipated during operation of the station. Acceptable chlorine residuals currently recommended by the EPA for warm fresh water are less than 0.2 mg/liter for intermittent discharge not to exceed 2 hours per day or less than 0.01 mg/liter for continuous discharge. The study shall include an evaluation of the effects of variable ammonia and organic nitrogen concentrations, chlorine demand, temperature and pH on the concentrations of both free and combined chlorine residuals in the treated water. Alternative methods of reducing chlorine residuals shall also be investigated and these are to include, but not be limited to, optimizing chlorine dosage and time of dosage, sequential treatment of sections of each condenser, blowdown scheduling, and adwater."

PSE&G has studied chlorination and related technologies including work in conjunction with the Electric Power Research Institute and the U.S. Department of Energy, with the goal of optimizing biocide use and monitoring techniques at all its generating stations, including HCGS. This work is continuing. Reports and publications resulting from efforts to date are listed as References 13.1-1 through 13.1-11.

These studies were conducted at a number of locations, providing a broad base of information not necessarily limited by site-specific considerations. These studies addressed three major areas of interest:

a. Analytical Methods - References 13.1-1 through 13.1-4 are representative of efforts made to evaluate analytical methods and instrumentation for monitoring chlorine residuals in power plant effluents under actual in-plant conditions.

b. Chlorine Optimization - All the listed references include results which are related to minimizing the amount of chlorine released to the environment. Monitoring capabilities (References 13.1-1 through 13.1-4) are necessary to insure compliance with minimum effluent standards. References 13.1-5 through 13.1-11 are results of studies aimed at comparing the performance of alternative biocides to chlorine. To do such a comparison required optimizing the chlorination process to provide a baseline

for comparison of the alternatives. Conducted over periods of time and at various locations, the optimization studies included a representative range of water quality conditions. Optimization was achieved (References 13.1-7, 13.1-10 and 13.1-11) by determining the minimum chlorine dose necessary to maintain acceptable condenser performance. In addition, environmental effects were studied by exposing indigenous aquatic species to chlorinated effluents (References 13.1-8, 13.1-9 and 13.1-11).

c. Alternative Methods - Several biocides, including BrCl (References 13.1-1 and 13.1-2) and ozone (References 13.1-7 through 13.1-11), have been studied as possible alternatives to chlorine. Studies continue on the utilization of ozone or dechlorination to minimize the impact of utility operations on the aquatic environment.

REFERENCES

13.1-1 T. R. McGuire and G. Levine, Chlorine Analyzer Evaluation Program: An On-Site Comparison of Free Chlorine Analyzers for Use in Estuarine Waters, Public Service Electric and Gas Company, 1975.

13.1-2 C. Sengupta, G. R. Helz, J. W. Gretz, P. Higgins, J. C. Peterson, A. C. Sigleo and R. Sugam, A Survey of Chlorine Analytical Methods Suitable for the Power Industry, Report EA-929, Electric Power Research Institute, 1978.

13.1-3 R. Sugam, W. Swallow and J. Trout, Field Evaluation of Chlorine Monitoring Techniques, Report EA-2070, Electric Power Research Institute, 1981.

13.1-4 R. Sugam, "Chlorine Analysis: Perspectives for Compliance Monitoring," in: Water Chlorination: Environmental Impact and Health Effects, Vol. 4, Book 1, Chemistry and Water Treatment (ed., R. L. Jolley, R. B. Cumming, J. S. Mattice) Ann Arbor Science (1982), pp. 653-666.

13.1-5 E. C. Wackenhuth and G. Levine, An Investigation of Bromine Chloride as a Biocide in Condenser Cooling Water, Paper No. IWC 74-1, presented at 35th Annual International Water Conference, Pittsburgh, PA, 1974.

13.1-6 E. C. Wackenhuth and G. Levine, Experience in the use of Bromine Chloride for Antifouling at Steam Electric Generating Stations, presented at Workshop: An Assessment of Technology and Ecological Effects of Biofouling Control Procedures at Thermal Power Plant Cooling Water Systems, Johns Hopkins University, Baltimore, MD, 1975.

13.1-7 R. Sugam, C. R. Guerra, J. L. DelMonaco, J. H. Singletary and W. A. Sandvik, Biofouling Control with Ozone at the Bergen Generating Station, Report CS -1629, Electric Power Research Institute, 1980.

13.1-8 C. R. Guerra, R. Sugam, J. W. Meldrim, E. R. Holmstrom and G. E. Balog, Comparative Evaluation of Effects of Ozonated and Chlorinated Thermal Discharges on Estuarine and Freshwater Organisms, Final Report, U. S. Department of Energy (1980), 125 pages.

REFERENCES (Continued)

13.1-9 J. W. Meldrim, E. R. Holmstron, G. E. Balog and R. Sugam, "A Comparative Evaluation of the Effects of Ozonated and Chlorinated Condenser Discharges on the White Perch, Morone Americana," Ozone: Science and Engineering, 3 (1981), 155-158.

13.1-10 R. Sugam, J. H. Singletary, W. A. Sandvik and C. R. Guerra, "Condenser Biofouling Control with Ozone," Ozone: Science and Engineering, 3 (1981), pp. 95-107.

13.1-11 R. Sugam and C. R. Guerra, "Comparison of Chlorine and Ozone for Power Plant Cooling Water Treatment," in: Ozone Treatment of Water for Cooling Applications, ed., R. G. Rice, International Ozone Association (1981), pp. 63-74.

13.2 ECOLOGICAL MONITORING PROGRAM

"Prior to initiation of power operation, the Applicants shall complete a pre-operational ecological monitoring program as proposed in the Applicants' Environmental Report, with amendments."

PSE&G has sponsored ecological monitoring at Artificial Island since 1968. The Artificial Island Ecological Studies were designed to meet the ecological monitoring requirements of both HCGS and the adjacent Salem Generating Station. The original ecological studies program, started in April, 1968, subsequently evolved from an inventory-type investigation to a series of cohesive, semiquantitative baseline ecological studies. The program consisted of regular monitoring of plankton-detritus, aquatic invertebrate fauna (microzooplankton, macroinvertebrates and benthos), aquatic vertebrate fauna, amphibians, birds and vegetation. The study area encompassed approximately 32 kilometers (20 miles) of river centered about the two stations.

Baseline aquatic studies ended in 1978 as emphasis shifted toward the study of a group of species specific to the Salem 316(b) Demonstration. These species included white perch, weakfish, bay anchovy, striped bass, spot, Atlantic croaker, American shad, alewife, blueback herring, Gammarus sp. and Neomysis americana. Program changes were approved by the NRC, the NJDEP and the USEPA. This program was designed specifically for these species. Although the occurrence of the non-target species was recorded, no further reports were generated on them.

The study area for this intensive species-specific program was expended to encompass an area between river kilometer 0 (river mile 0) to river kilometer 117 (river mile 73). The program was scheduled to end in June, 1982 with the submittal of the Salem 316(b) Demonstration. A one-year extension was granted due to delays in the start-up of Salem 2. The additional year was used to collect additional data on white perch, weakfish and bay anchovy. The program, as modified in 1979 for Salem, continued to yield data useful for the assessment of the impact of HCGS operation on the Delaware River. The Salem 316(b) Demonstration is scheduled for submittal to the NJDEP in 1983.

Numerous reports have been prepared presenting data from the monitoring programs, copies of which PSE&G has submitted to the NRC. A list of these reports is attached as Table 13.2-1. Although some reports were prepared for Salem Generating Station, they are applicable to HCGS due to the proximity of the two stations.

TABLE 13.2-1 (Page 1 of 2)

ARTIFICIAL ISLAND SITE REPORTS

Progress Reports

Ichthyological Associates, Inc. 1977. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1976. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1977. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1975. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1976. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1974. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1974. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1973. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1974. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1972. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1974. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1971. Prepared for PSE&G, Newark, N.J. 5 vols.

Ichthyological Associates, Inc. 1971. An Ecological Study of the Delaware River in the vicinity of Artifical Island: Progress Report for the period January through December, 1970. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1970. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period January through December, 1969. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1969. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Progress Report for the period June through December, 1968. Prepared for PSE&G, Newark, N.J.

TABLE 13.2-1 (Continued) (Page 2 of 2)

Miscellaneous Reports

M. C. Wyllie, E. R. Holmstrom, and R. K. Wallace. Ichthyological Associates, Inc., 1976. Temperature Preference, Avoidance, Shock, and Swim Speed Studies with Marine and Estuarine Organisms from New Jersey; Report for the Period January through December, 1975. Prepared for PSE&G, Newark, N.J.

M. C. Wyllie, E. R. Holmstrom, and R. K. Wallace. Ichthyological Associates, Inc., Temperature Preference, Avoidance, Shock, and Swim Speed Studies with Marine and Estuarine Organisms from New Jersey; Report for the Period January through December, 1976. 1977. Prepared for PSE&G, Newark, N.J.

Public Service Electric and Gas Company. 1978. Summary Assessment of Weakfish Impingement: Summer, 1978. Newark, New Jersey. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1969. An Ecological Study of the Delaware River in the Vicinity of Artificial Island: Delaware Miscellaneous Report 1. Prepared for PSE&G, Newark, N.J.

Ichthyological Associates, Inc. 1969. A Report on the American Shad and other Anadromous Fishes Taken in Drifted Gill Nets in the Delaware River in the Vicinity of Artificial Island During March through June, 1969. Prepared for PSE&G, Newark, N.J.

Public Service Electric and Gas Company. 1980. An Interpretive Analysis of Impingement and Entrainment April, 1977 through December, 1978. Newark, New Jersey.

Public Service Electric and Gas Company. 1980. First Interim Report; 316(b) Studies; March through November, 1979. Weakfish; Spot; Bay; Anchovy; Gammarus spp.; Neomysis americana. Newark, New Jersey.

Public Service Electric and Gas Company. 1980. Second Interim Report 316(b) Studies January, 1979 through March, 1980: Blueback herring; Alewife: American shad; White perch; Stripped bass; Atlantic croaker. Newark, New Jersey.

Public Service Electric and Gas Company. 1980. An Ecological Study of the Delaware River near Artificial Island, 1968 through 1976: A Summary. Newark, New Jersey.

13.3 COMPENSATING WATER SUPPLY

> "The Applicants will take those measures necessary to assure the availability of compensating water storage capacity at the time of initial power operation if such storage capacity is required by the Delaware River Basin Commission. A schedule identifying significant milestone dates to achieve this objective, developed in coordination with the Delaware River Basin Commission and based on the assumption that the Tocks Island project will not be constructed, shall be submitted to the Director of Licensing within six months after the issuance of construction permits for the station."

In a letter dated May 2, 1975, from Mr. R. L. Mittl, PSE&G, to Mr. A. Giambusso, Atomic Energy Commission, PSE&G described the proposed schedule for assuring compensating water.

On December 30, 1977, PSE&G, along with six other utility participants from the Delaware River Basin Electric Utilities Group, applied to the DRBC for approval of a compensating water supply reservoir on Merrill Creek, a tributary of the Delaware River (Docket D-77-110 CP). The Merrill Creek Reservoir Project will be located in Harmony Township, Warren County, New Jersey.

In June, 1981, the Merrill Creek Owners Group revised both the Environmental Report and Design Report (References 13.3-1 and 13.3-2), which are part of the application, to reflect current design and environmental data.

The DRBC issued a Draft Environmental Impact Statement on July 23, 1982 (Reference 13.3-1), describing the utility proposal as the most desirable alternative, and held a public hearing on September 2, 1982. According to the DRBC's schedule, the earliest opportunity for Commission action is August, 1983. The Merrill Creek Owners Group is proceeding with other licensing and will commence project construction after all approvals are received. On this schedule, the owners anticipate a filled and ready reservoir by Spring, 1986.

REFERENCES

13.3-1 Merrill Creek Owners Group, "Environmental Report for the Merrill Creek Reservoir Project," May, 1981.

13.3-2 Merrill Creek Owners Group, "Design Report for the Merrill Creek Reservoir Project," May, 1981.

13.3-3 Delaware River Basin Commission, Draft Environmental Impact Statement, Merrill Creek Reservoir Project, July 23, 1982.

13.4 SALEM ECOLOGICAL IMPACT

> "If the operation of Salem Units 1 and 2 is found to cause significant adverse affects on the aquatic ecosystem due to passage of organisms through the cooling system, design modifications to prevent such adverse effects on operation of the Hope Creek Generating Station shall be considered and reported to the Commission."

To date, Salem has not been found to cause significant adverse entrainment effects on the aquatic ecology system in the area. PSE&G plans to submit a 316(b) Demonstration to the NJDEP on June 15, 1983. It will assess the effects of the Salem Generating Station cooling water intakes on target species mutually selected by PSE&G and involved regulatory agencies (see also Section 13.9).

13.5 COOLING TOWER DRIFT AND SALT DEPOSITION

> "The Applicants shall demonstrate prior to initial power operation that the low drift goal of 0.002% for cooling tower operation and low salt deposition rate can be achieved and maintained throughout the life of the plant. A preoperational and operational monitoring program acceptable to the Regulatory staff shall be conducted to evaluate the effects of salt deposition on terrestrial life and structures."

Research Cottrell, Inc., manufacturer of the natural draft cooling tower, has guaranteed a drift loss rate of 0.0005 percent of the circulating water flow. Performance tests required by the NJDEP will determine actual drift rate at the time of tower startup. The Research Cottrell natural draft cooling tower at B. L. England Generating Station, Unit No. 3, Beesley's Point, New Jersey was tested and determined to have an average drift loss rate of 0.000424 percent of the circulating water flow (Reference 13.5-1).

Although the applicant anticipates no detrimental environmental effects from such an extremely low drift rate, there will be a preoperational and operational monitoring program. Although this monitoring program is still in the planning stage, it will consist of:

a. An updated vegetation survey to determine the location of salt-sensitive species

b. Samplers to collect airborne particulates for ambient salt monitoring

c. One-time measurement of salt drift at the cooling tower outlet

Two years of preoperational data and two years of operational data for b. above should be sufficient to evaluate the effects of salt drift and deposition.

REFERENCES

13.5-1 Research-Cottrell, Inc., Hamon Cooling Tower Division, "Report of the Thermal and Drift Performance Tests, Natural Draft Cooling Tower, Atlantic City Electric Company, B. L. England Generating Station," May, 1975.

13.6 HOPE CREEK - TUCKERTON 500 KILOVOLT TRANSMISSION LINE

"Prior to initiating construction of the Hope Creek - Tuckerton 500 kV transmission line facility, the Applicants shall amend their application and furnish an environmental assessment acceptable to the Regulatory staff, to assure that the route selection and design of the proposed system appropriately considers environmental factors."

PSE&G no longer plans to construct this transmission line. See Section 3.9.

13.7 CONSTRUCTION IMPACT CONTROL

"The Applicants shall take the necessary mitigating actions, including those summarized in Section 4.6 of the Final Environmental Statement, during construction of the station and associated transmission lines to avoid unnecessary adverse environmental impacts from construction activities."

See Chapter 4 of this Environmental Report.

"A control program shall be established by the Applicants to provide for a periodic review of all construction activities to assure that those activities conform to the environmental conditions set forth in the construction permits."

See Chapter 4 of this Environmental Report.

"Before engaging in a construction activity which may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in the Final Environmental Statement, the Applicants shall provide written notification to the Director of Licensing."

Construction activities were within the scope of those assessed at the construction permit stage.

"If unexpected harmful effects or evidence of irreversible damage are detected during facility construction, the Applicants shall provide to the Regulatory staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage."

PSE&G has detected none.

13.8 AUDIBLE SIGNALS

"Applicants will, subject to approval of regulatory agencies, install an audible signal which shall:

a. "Be clearly audible within a six-mile radius from the plant on a still day;

b. "Be sufficiently distinctive so that they will not be confused with existing audible alarms;

c. "Be testable at periodic intervals; and

d. "Be operable by July 1, 1975."

"It is understood that New Jersey Civil Defense or its successor agency will control utilization of such signal."

PSE&G has installed a siren system operable within a 16 kilometer (10 mile) radius of the Artificial Island site. The upgraded siren system was installed to meet emergency public notification requirements set forth by the NRC in NUREG-0654, Revision 1. PSE&G tests the system periodically.

13.9 HOPE CREEK ECOLOGICAL MONITORING PROGRAM

"Applicants shall monitor aquatic life in the Delaware River in the vicinity of the plant for a period of ten (10) years subsequent to July 1, 1975, unless subsequently modified by mutual agreement by the parties. Said monitoring shall be similar to the program that Ichthyological Associates have been heretofore conducting for the Applicants with the following conditions:

a. "Nets sufficient to catch fish of all species up to 20 pounds in weight shall be used;

b. "Reports of the monitoring and measuring of aquatic life, to be issued at no greater than annual intervals, shall be issued within six months of the close of the period to which they pertain. The U.S. Atomic Energy Commission retains the right to require reporting at more frequent intervals;

c. "The Applicants agreed to monitor the impingement and entrainment of aquatic life at the plant throughout the lifetime of the Hope Creek facility. If, after consultation with the U.S. Fish and Wildlife Service, the commission determines that such impingement or entrainment is excessive, corrective measures shall be instituted by the Applicants; and

d. "Measurements of radioactivity in fish in the vicinity of the plant shall be made on a regular basis throughout the lifetime of the plant."

See Chapter 6 of this Environmental Report and Sections 13.2 and 13.4 above.

13.10 RADIATION MONITORING OF WELLS

"Radiation monitoring as presently being conducted of various deep and shallow wells and the Salem Water Company facility near Quinton shall be continued throughout the lifetime of the plant, unless subsequently modified by mutual agreement to the parties."

See Sections 6.1 through 6.4 of this Environmental Report.

13.11 MEDICAL PREPAREDNESS

> "The Applicants shall provide seminars by a proper medical specialist for Salem County doctors at a time and place agreeable to the Salem County Medical Association and deemed adequate by the Salem County Medical Association to prepare Salem County doctors for emergency treatment of radiation injury or sickness."

As part of the Emergency Medical Assistance Program (EMAP) agreement between PSE&G and Radiation Management Corporation (RMC), annual training/retraining is presented to the Salem County Memorial Hospital medical staff in conjunction with a radiation emergency medical drill. In addition, RMC sponsors a one-day seminar for physicians each year. This seminar allows hour-for-hour Category I credit for physicians (an AMA and state medical board continuing education requirement for licensed physicians). Since PSE&G has participated in RMC's Emergency Medical Assistance Program since 1974, a minimum of eighteen training programs has been presented for PSE&G associated physicians (twice each year).

Also, Dr. Roger Linnemann of RMC has lectured to the local county medical association on radiation accident management.

> "The Applicants shall distribute to each doctor in Salem County a brochure setting forth emergency treatment for radiation injury or sickness."

Since the CP stage, PSE&G has entered into agreements with certain Salem area physicians to assist in treating victims of radiation sickness or of an accident involving radioactive contamination. Each coordinating physician associated with PSE&G has received a controlled copy of a document prepared by Radiation Management Corporation entitled, "Salem County Memorial Hospital Plan for the Decontamination and Treatment of Radioactivity Contaminted Patient." Revisions are periodically supplied.

> "The Applicants shall make payments to or arrangements with the Salem County Memorial Hospital to provide a treatment facility for victims of radiation accidents pursuant to AEC regulations. Such facility shall meet requirements deemed suitable by the Salem County Memorial Hospital."

Such a treatment facility was completed in 1977. It is fully equipped and is periodically audited by RMC. In a letter dated May 5, 1980, the Executive Director of Salem

Hospital stated, "We realize that [PSE&G] is financially responsible for any modifications of the existing hospital facility which may be required by regulations of the [NRC] or others for the treatment of patients exposed to radioactive materials. This responsibility also includes any special training of hospital personnel which may be required and special equipment as may be necessary." (Reference 13.11-1)

REFERENCES

13.11-1 Letter from Joseph Michael Galvin, Jr., Executive Director, Salem County Memorial Hospital, to Mr. H. J. Midura, Salem Nuclear Generating Station, May 5, 1980.

13.12 PUBLICATION OF REPORTS

"Copies of all reports called for by this agreement and all environmental reports to all governmental agencies, federal, state or local, regarding the environment in Lower Alloways Creek Township shall be mailed or delivered to the Clerk of Lower Alloways Creek Township and Salem Public Library upon their issuance throughout the lifetime of the plant."

PSE&G complies with this requirement and will do so in the future.

13.13 COOLING TOWER PERFORMANCE MEASUREMENT

> "Applicants shall monitor the performance of the plant cooling towers at reasonable intervals to evaluate the salt and chemical deposition rate and possible effects on the environment. If such deposition causes detrimental effects to the environment in Lower Alloways Creek Township or if the deposition rate or amounts exceed those that are deemed nondetrimental to human, plant or animal life, then remedial steps will be taken"

The NJDEP requires a "stack test" (see Section 13.5) upon initial tower operation to determine salt drift rate (NJDEP Permit No. 041832). Thereafter a quarterly report must be sent to the NJDEP including:

a. A log of the total dissolved solids concentration of the circulating water flow. A sample will be taken and recorded a minimum of every 14 days.

b. The calculated maximum hourly particulate emissions in pounds per hour.

c. The calculated maximum cumulative particulates emissions in tons per year.

d. Maintenance procedures applied to the towers.

In view of the extremely low drift rate and the salt-tolerant vegetation within the areas of maximum salt deposition, PSE&G considers this to be an adequate cooling tower performance monitoring program. See Section 13.5 also.

13.14 TELEVISION RECEPTION

> "If the plant, cooling towers, or transmission lines cause interference to or distortion of existing television reception, Applicants shall correct, at their own expense, the reception to the original condition by modification of antennas, improvements of receivers or other appropriate means."

PSE&G will comply with this construction permit requirement.

13.15 RIVER TRAFFIC STUDY

> "No concrete shall be poured for safety related structures until the Applicants have completed a study of the probability of interaction between river traffic and safety related plant features and applied the results of the study in the design and planned construction of the facility in a manner acceptable to the Regulatory staff."

This study is complete and was presented to the NRC as part of the testimony of Dr. Ashok L. Kalelkar before the Atomic Safety and Licensing Board, on November 1, 1977 (Reference 13.15-1).

REFERENCES

13.15-1 Testimony of Dr. Ashok L. Kalelkar, ALAB-429, October 11, 1977, Dockets Nos. 50-254 and 50-355, pp. 5-21.

CHAPTER 14

REFERENCES

A list of the references cited in each two-digit section (i.e., Section 2.1) appears at the end of that section.

APPENDIX A

THERMAL MODELING METHODOLOGY

APPENDIX A

THERMAL MODELING METHODOLOGY

A.1 Selection of Models and Modeling Approach

Available thermal dispersion models were reviewed to identify a suitable simplistic model for simulating the dilution and dispersion behavior of HCGS. The majority of these models are applicable for steady state deep water discharge conditions. Since HCGS discharge is located in shallow water (depth from low water varies from 8 feet at the discharge point to a 14 feet depth at 120 feet into the river), these models can not be used directly to analyze dispersion of the discharge. The EPA model, PDS (Shiraji and Davis, 1974), is one such model which is generally accepted and is designed for deep water conditions. This model, when applied to shallow water discharge conditions will produce dilution greater than actually will occur. Therefore, in order to apply the deep water model in shallow water conditions, modifications to the model were required.

Preliminary analysis showed the Hope Creek discharge plume to be negatively buoyant during most of the year. This was an important factor in model selection.

Since the DRBC Regulations specify a maximum mixing zone of 3,500 feet, analysis of the HCGS discharge was necessary for both near and far field areas. Two MIT models were selected for the near field and far field analysis:

1. Simplified MIT Desktop Model for Near Field Analysis.

2. Three-dimensional MIT Transient Plume (TPM) Model for Far Field Analysis.

The Simplified MIT Desktop Model was modified to incorporate shallow water effects (predominantly bottom interactions) and the TPM Model was directly applied for shallow water far field analysis.

During most seasons of the year, the HCGS discharge will be negatively buoyant. A negatively buoyant discharge, emanating from a pipe lying on the river bottom, is analygous to a buoyant surface jet discharging from a pipe at the free surface. As such, the plume was modeled as an "inverted surface discharge".

A combined near field-far field analysis was undertaken. In the near field, which extends a distance of several hundred feet from the discharge, formulae describing overall (bulk) properties of a surface jet were modified to account for bottom influences. In the far field, the MIT Transient Plume Model was used to predict plume temperatures from the end of the near field to a distance of 3,500 feet from the discharge.

A.2 Near Field Analysis

A.2.1 Conservative Approach

The simplified MIT Desk Top model was modified conservatively to incorporate the interaction of bottom and surface on the dilution of plume. Analysis of HCGS near field plume using conservative MIT desktop model under conditions of worst case of HCGS discharge temperature rise (exceeded only less than 5 percent of the time) coupled with the highest expected densities will provide the most conservative results. In this study, this overall approach of conservative conditions was used.

A.2.2 General

In the near field region, inertia force dominates the behavior of plume velocity and dilution. As the center line velocity of plume decreases due to dilution and lateral spreading, inertial effects become dominated by buoyancy and the jet stratifies towards the bottom or the surface depending on its density relative to the ambient.

Figure 3-1 illustrates the near field schematization of the jet as used in the analysis. The primary variables of interest are the discharge length scale ℓ_o, and a discharge densimetric Froude number F_o'. The discharge length ℓ_o is defined as the square root of one half of the discharge cross-sectional area or

$$\ell_o = \sqrt{\frac{D_o^2 \cdot \pi}{8}}$$

where D_o = the pipe diameter. For the Hope Creek Station, D_o = 4 feet, so ℓ_o = 2.5 feet. F_o' is a densimetric Froude number using ℓ_o as the length scale:

$$F_o' = \frac{U_o}{\sqrt{g \frac{\rho_o - \rho_a}{\rho_a} \ell_o}}$$

where U_o = discharge velocity = $4Q_o/\pi D_o^2$, Q_o = discharge volumetric flow rate, g = acceleration of gravity, ρ_o = discharge density and ρ_a = density of ambient receiving water. Note that, for discharge from a circular pipe, F_o' is larger than the conventional densimetric Froude number (based on D_o rather than ℓ_o) by a factor of 1.26.

Densities were calculated as a function of temperature and salinity using the following expression:

$$\rho = 0.9997 - 0.0000063(T-4)^2 + 0.0007615(S)$$

where:

ρ = density in gm/mL
T = temperature in °C .
S = salinity in PPT.

Densities were calculated for ambient and discharge conditions. The relatively density between the discharge and ambient water determines whether the plume will sink or float. The relative densities were calculated as :

$$\frac{\rho_o - \rho_a}{\rho_a}$$

Comparing simulations with the Stolzenbach and Harleman (1971) surface jet model against laboratory and field data, Jirka et al. (1981) developed a number of correlations between bulk near field properties of a surface jet and the variables F_o' and ℓ_o. The properties are described briefly below and some are illustrated in Figure A-1.Use of the formulae, rather than the full surface jet model, is appropriate when only approximate (or conservative) analysis is required (as in the present case where the near field analysis is used to supply boundary conditions to the far field analysis). A comparison of the formula predictions with the full model predictions of Stolzenbach-Harleman (1971) and of Shirazi-Davis (1974) indicated good agreement.

Transition Distance, ℓ_t: The extent of the near field of a surface jet can be defined as that distance for which momentum flux dominate buoyancy flux; i.e., the distance over which the plume remains jet-like. For a circular discharge,

$$\ell_t = 10 F_o' \ell_o \qquad (1)$$

Maximum Jet Thickness, h_{max}. This length describes the maximum vertical penetration of the surface jet (Figure 3-1) and is given by

$$h_{max} = 0.42 F_o' \ell_o \qquad (2)$$

The location of the maximum penetration is designated ℓ_{max} (Figure 3-1) and is given by

$$\ell_{max} = 5.5 F_o' \ell_o \qquad (3)$$

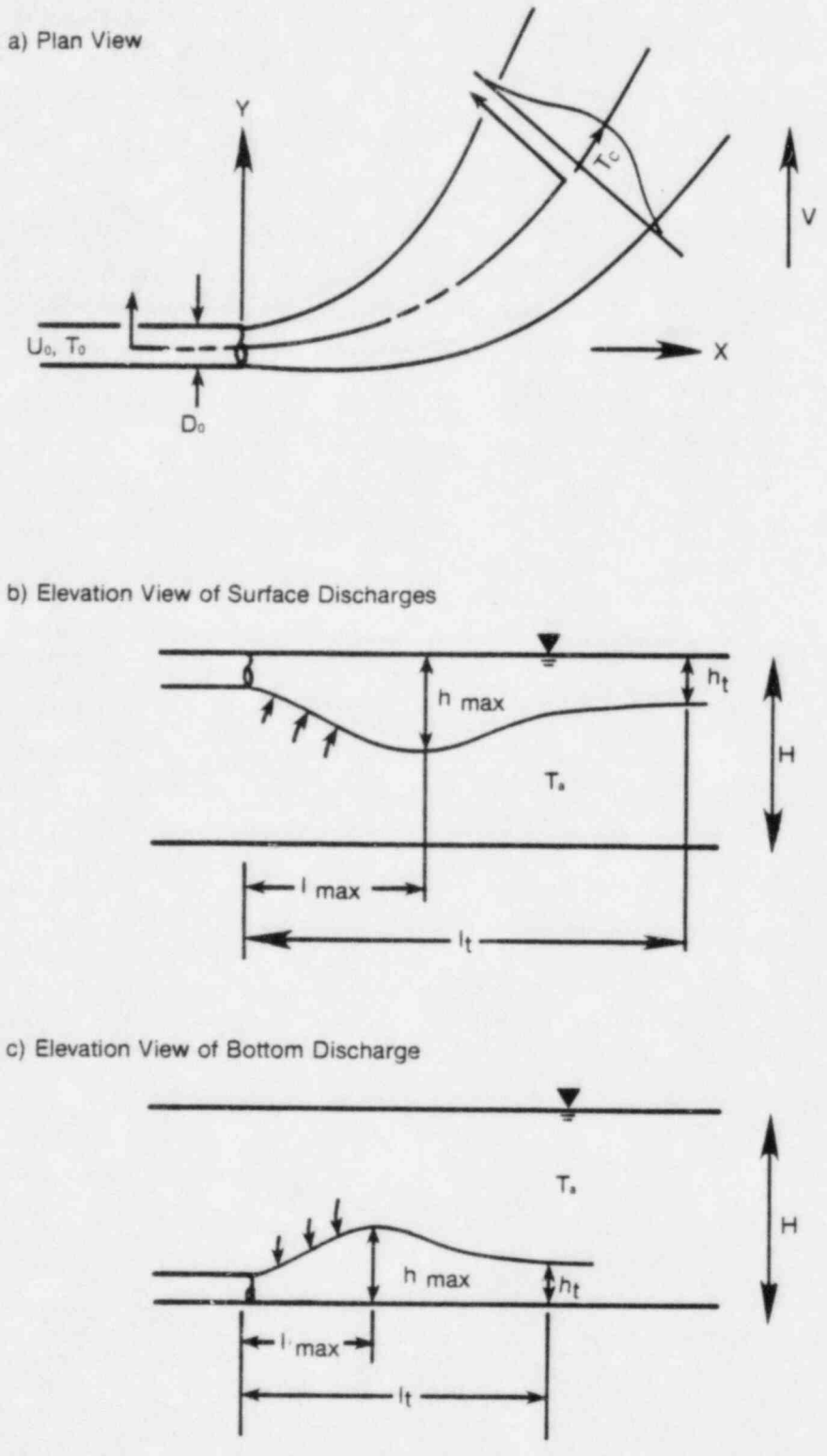

FIGURE A-1 NEAR FIELD PROFILES OF BUOYANT SURFACE AND NEGATIVELY BUOYANT BOTTOM DISCHARGES

Collapse Thickness, h_t: At distances between ℓ_{max} and ℓ_t, the plume begins to collapse. At a distance of ℓ_t (Figure 3-1) the plume thickness h_t is approximately constant and equal to about one-half of h_{max}. Thus

$$h_t \approx 0.21 F_o' \ell_o \quad (4)$$

Stable Bulk Dilution, S_t: The bulk dilution is defined as the ratio of plume volumetric flow rate at the transition distance, Q_t, to the volumetric flow rate at the discharge Q_o; i.e., $S_t = Q_t/Q_o$. S_t also denotes the ratio of jet-average excess temperature (or concentration) at the transition to excess temperature (or concentration) at the discharge. This dilution is given by

$$S_t \approx 1.4 F_o' \quad (5)$$

Stable Center Line Dilution, S_{tc}: Excess temperature (or concentration) is highest along the plume center line. At the transition distance, the center line dilution S_{tc}, defined by $S_{tc} = (T_o - T_a)/(T_c - T_a)$ where T_o, T_a and T_c = discharge, ambient and center line temperature respectively, is given by

$$S_{tc} \approx 1.0 F_o' \quad (6)$$

The properties defined above are for surface discharge into stagnant, deep receiving water. The presence of an ambient cross current generally improved dilution, so the use of these formulae in a current is conservative (i.e., erring on the side of overpredicting temperatures or concentrations). However, at HCGS the conditions of shallow water and the fact that the discharge is in contact with the bottom (where it experiences more friction) rather than the surface, make the formulae non-conservative. The following analysis corrects for these factors.

A.2.3 Effect of Shallow Water

In shallow water a buoyant surface discharge will "touch the bottom" or a negatively buoyant bottom discharge will "touch the surface." In either case, vertical entrainment will be reduced. In such cases, two questions arise: 1) Is the water "shallow"? and 2) If so, what is the impact on dilution? Answers to these two questions are provided by Jirka et al. (1981), who present data which indicate that dilution is reduced when $h_{max}/H \gtrsim 0.75$ where H = water depth at ℓ_{max}. Laboratory and field data were then examined to derive an expression for the ratio r_s of dilution in shallow water to dilution in deep water (predicted by the formulae above);

$$r_s = \left(\frac{0.75}{h_{max}/H}\right)^{0.75} \quad \text{for } h_{max}/H > 0.75 \qquad (7a)$$

$$r_s = 1.0 \quad \text{for } h_{max}/H < 0.75 \qquad (7b)$$

During conditions of high $_o'$ (and thus high h_{max}), conditions at the HCGS discharge will be "shallow" (requiring correction) while at other times then will be "deep".

A.2.4 Effect of Negative Buoyancy

While similar to an "inverted buoyant surface discharge," a negatively buoyant bottom discharge will experience additional friction which will tend to reduce the size of the near field and the resulting dilution. Few experiments have been performed with negatively buoyant bottom discharges. However, Jirka et al. (1981) have analysed laboratory data of Baddour and Chu (1978) using the same dimensional analysis as discussed above. In comparison with surface discharges, the transition distance was observed to be reduced by about 50% while the center line dilution was observed to be reduced by about 65%. Thus the following formulae are assumed, appropriate for negatively buoyant bottom discharges in deep water:

$$\ell_t \simeq 5 F_o' \ell_o \qquad (8)$$

$$S_t \simeq 0.5 F_o' \qquad (9)$$

In shallow water, the dilution given by Equation (9) may be modified according to Equation (7). In such case, the variables h_{max} and ℓ_{max}, required in the evaluation of Equation (7) are computed from the surface discharge relationships, Equations (2) and (3), respectively. It should be noted that, because of the importance of bottom friction, laboratory experiments with bottom discharges are more sensitive to scale effects (small Reynolds numbers) than are surface discharge experiments. The relatively small Reynolds numbers obtained in Baddour and Chu's experiments should make their results conservative as applied to HCGS conditions (Jirka et al., 1981).

A.2.5 Effect of Ambient Current

As discussed previously, an ambient current will tend to increase dilution, thus making the above analysis more conservative when applied to conditions with a flowing ambient current. This effect of cross flow on dilution has been checked using the nomographs of Shirazi and Davis (1974). Therefore, the above results for dilution and transition distance were used in the plume analysis regardless of current speed. However, analysis of plume behavior in a cross flow was necessary to provide estimates of near field plume trajectory so that an appropriate location for the boundary between near and far fields could be established.

Data compiled by Jirka et al. (1981) show that jet trajectories can be adequately described by the relationships:

$$\frac{XV}{u_o \ell_o} = 2 \left(\frac{yV}{u_o \ell_o}\right)^{1/2} \quad \text{for} \quad \left(\frac{yV}{u_o \ell_o}\right) < 1 \tag{10a}$$

$$\frac{XV}{u_o \ell_o} = 2 \left(\frac{yV}{u_o \ell_o}\right)^{1/3} \quad \text{for} \quad \left(\frac{yV}{u_o \ell_o}\right) > 1 \tag{10b}$$

where V = ambient current speed, x = distance offshore from point of discharge, and y = distance along shore (downstream) from point of discharge. The coordinates of the transition boundary between the near and far fields can be approximated by simultaneously solving Equation (10) (with $x = x_t$ and $y = y_t$) and

$$\ell_t = \sqrt{x_t^2 + y_t^2} \tag{11}$$

A.3 Far Field Analysis

A.3.1 General

Mixing in the far field is achieved primarily through the processes of ambient diffusion and dispersion (as distinct from jet entrainment which characterizes near field mixing). Far field mixing was analyzed using the MIT Transient Plume Model (TPM), (Adams et al., 1975 and Adams et al., 1980), based on boundary conditions supplied by the near field analysis described above.

Figures A-2a, b and c depict the far field plume. As with the surface jet analysis, the TPM has been formulated for surface plumes. However, it may be applied to bottom plumes by "inverting the z axis" as shown in Figure A-2c. This is reasonable as long as appropriate values of ambient current velocity and diffusion coefficients are used. Because currents and diffusion in the Delaware River are generated primarily by the tide (a pressure face which acts over the entire water depth as opposed to, e.g., a wind-driven surface stress), this analogy is reasonable. A previous application of the TPM to a situation with a bottom plume, is the analysis of brine discharge (Stolzenbach and Adams, 1980). Previous applications of the TPM to heated discharge plumes from power plants include Adams and Stolzenbach (1976), Adams, et al. (1976) and Stolzenbach, et al. (1976).

The TPM predicts three-dimensional, time-varying differentials temperature (or concentrations) distributions in receiving water of uniform depth H and time-varying, spatially uniform current. The ambient current can be represented by either two components (onshore-offshore, U; along shore, V) or

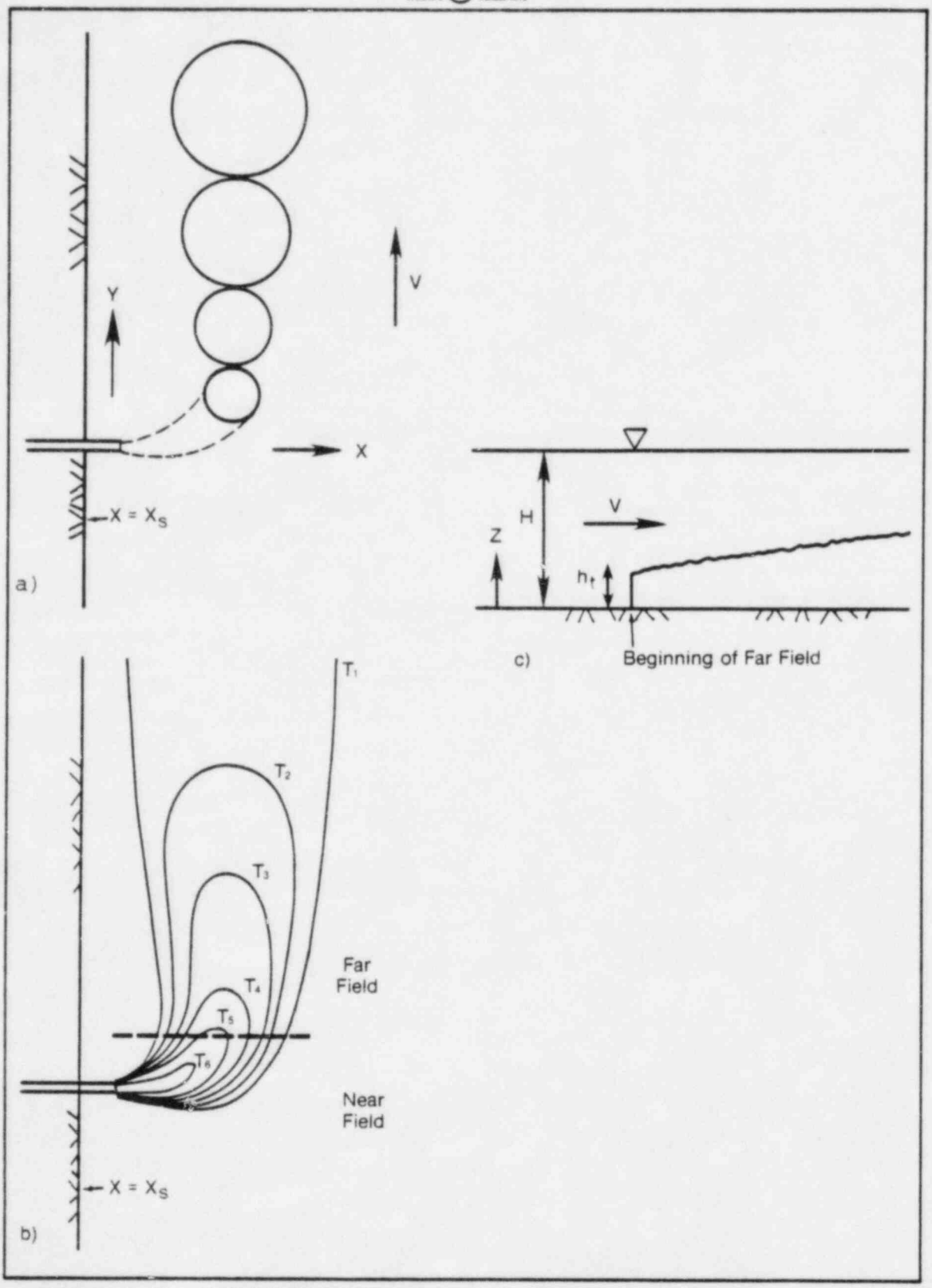

FIGURE A-2 SKETCHES OF TRANSIENT PLUME MODEL SHOWING PLAN VIEWS OF ENTIRE PLUME (b) IN TERMS OF DISCRETE PUFFS. (a). (c) DEPICTS ELEVATED VIEW OF BOTTOM DISCHARGE

one component (along shore). Because of the strong tidal influence, the latter option was used to analyze the HCGS discharge. The shoreline may be represented by a vertical plane described by $x = x_s$.

The plume is assumed to be composed of a number of discrete puffs, each with Gaussian excess temperature (concentrations) distributions given by

$$\Delta T\ (x, y, z, t, t_o) =$$

$$\frac{m\ (z,t,t_o)}{2\pi\ \sigma_x(t,t_o)\ \sigma_y(t,t_o)}\ \exp\left\{\frac{[x-x_c(t,t_o)]^2}{2\sigma_x^2(t,t_o)} + \frac{[y-y_c(t,t_o)]^2}{2\sigma_y^2(t,t_o)}\right\} \quad (12)$$

where Δt = excess temperature, t = present time, t_o = time at which puff "was released,"

m = vertical heat distribution function,

x_c, y_c = horizontal coordinates of the puff center of mass and

σ_x^2, σ_y^2 = horizontal variances of the puff distribution about the center of mass.

The values of m, x_c, y_c, σ_x and σ_y are determined by applying the method of moments to the governing equation of heat conservation for each puff:

$$\frac{\partial \Delta T}{\partial t} + V\frac{\partial \Delta T}{\partial y} = K_x\frac{\partial^2 \Delta T}{\partial x^2} + K_y\frac{\partial^2 \Delta T}{\partial y^2} + K_z\frac{\partial^2 \Delta T}{\partial z^2} \quad (13)$$

$$K_z\frac{\partial \Delta T}{\partial z} = 0 \quad \text{at } z = 0, H$$

Note that this equation is written for conditions of along shore current only with neglect of surface heat transfer. The latter assumption is conservative and appropriate because of the negative plume buoyancy and the relatively short travel times in the far field.

Time-varying boundary conditions at the edge of the near field are given by the near field variables of plume thickness h_t (computed from Equation 4), dilution (computed from Equations 7 and 9) and width B given by

$$B = \frac{S_t \, Q_o}{V \, h_t} \tag{14}$$

The initial standard deviations in the horizontal directions are given by

$$\sigma_x = \sigma_y = B/\sqrt{12} \tag{15}$$

The excess temperature distribution for the entire plume is developed by superimposing temperature distributions for all puffs as suggested in Figure 3-2a. The effect of a parallel shoreline is treated using the method of images. Further details concerning the model may be found in Adams et al. (1975) or Adams et al. (1980).

It can be noted that the physical processes modeled by the TPM are similar to those represented in other commonly used models such as Brooks (1960) and Koh and Fan (1970) with the exception that the TPM Model handles transient currents, thus yielding transient temperature (ΔT) distributions. Analysis by Adams (1975) shows that, under steady-state conditions, solutions from the MIT Far Field Transient Plume Model compares to those of the Brooks (1960) model.

A.3.2 Dispersion Coefficients

The TPM requires that values of horizontal dispersion coefficients, K_x and K_y, and vertical dispersion coefficient K_z be specified. The horizontal and vertical dispersion coefficients, K_x, K_y and K_z are assumed to be constant as well. For the Hope Creek discharge, the following base case values were used:

$$K_x = K_y = 0.1 \text{ Ft}^2/\text{s} \quad \text{and} \quad K_z = 0.01 \text{ Ft}^2/\text{s}.$$

The resulting values of K_x and K_y are consistent with documented horizontal dispersion coefficients over a range of length scales (Koh and Fan, 1970) while the value of K_z is consistent with documented vertical dispersion coefficients under conditions of high velocity shear and mild vertical density gradient (Koh and Fan, 1970). These dispersion coefficients are also consistent with the values found by Shirazi and Davis (1974) in their calibration.

APPENDIX A

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APPENDIX B

(NOT USED)

APPENDIX C

CLASS 9 CONSEQUENCE ANALYSIS

APPENDIX C

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1.0 INTRODUCTION

As discussed in Section 7.1, Environmental Reports at the Construction Permit or Operating License, submitted on or after July 1, 1980, must contain an analysis of the consequences of Class 9 accidents. The purpose of this section, therefore, is to provide an estimate of the public risk associated with class 9 accidents, that is, hypothetical severe accidents involving melting of the core.

2.0 RISK DOMINANT SEQUENCES

2.1 DEVELOPMENT OF ACCIDENT SEQUENCES

Table C-1 contains the source terms and their associated frequencies developed specifically for Hope Creek. Table C-2 gives the definitions of the symbols used in Table C-1. In brief, this set of source terms was developed by drawing on the results of recent research and probabilistic risk assessments. These assessments include WASH-1400 (the Reactor Safety Study, Ref. C-1), the "rebaselined" BWR (Ref. C-2), the IREP analysis of Brown's Ferry 1 (BF1; Ref. C-3) and the analyses performed for Limerick (Ref. C-4), Shoreham (Ref. C-5) and Grand Gulf (Ref. C-6). The BF1 is a BWR4 with a MARK I containment and is very close to Hope Creek in overall design. The Limerick and Shoreham plants are BWR4s but with a Mark II containment. The Grand Gulf plant is a BWR6 with a Mark III containment. Although the overall design of the latter plants differs somewhat from Hope Creek, some aspects of the design of particular systems were found to be very similar. In addition, insights gained from PWR analyses were applied where appropriate.

2.1.1 TYPES OF ACCIDENT SEQUENCES

After a review of the Hope Creek design and of the accident sequences found important for the Peach Bottom, Browns Ferry and Limerick plants, it was concluded that the types of sequences found important to risk for the latter three plants were those that would be important at Hope Creek. It was also judged that because of the similarity of the Hope Creek design to the other plant designs, there would not be additional accident sequences important to risk at Hope Creek. However, factors such as developments in PRA methodology, plant specific data and system design differences would likely result in differences in the frequencies of accident sequences for Hope Creek and other reactors. These differences are summarized in the following sections.

2.1.2 INITIATING EVENT FREQUENCIES

In NUREG-0773 and in the BF1 IREP study, the LOCA frequencies used were the same as those developed in the RSS: $1x10^{-4}$/RY for the large (A) LOCA, $3x10^{-4}$ for the medium (S_1) LOCA and $1x10^{-3}$/RY for the small (S_2) LOCA; however, the BF1 analysis partitioned the frequency according to break location. Other recent PRAs have used LOCA frequencies which may be as much as an order of magnitude higher. In particular, the small LOCA category is the most commonly modified, based on experience with, for example seal leaks. For the Hope Creek analysis, the BF1 approach of partitioning the frequencies was used because ECCS success criteria vary with break location. It is believed that a higher small break LOCA frequency is appropriate; however, this had little impact on the results of the analysis.

The transient frequencies for Hope Creek were based on recent industry experience as described in EPRI NP-2230 (Ref. C-7). This report is based on experience of operating BWRs which are largely BWR4 designs with MARK I containments, similar to Hope Creek. From EPRI NP-2230 a frequency of approximately 1.6 events per year was used for transients in which the feedwater is lost and 6.9 per year for transients in which the feedwater system remains available.

An additional accident initiator which also leads to loss of feedwater is that of the loss of offsite power (LOOP). The LOOP frequency was taken from a review of industry experience as described in EPRI NP-2301 (Ref. C-8). This report indicated a LOOP frequency for the Salem site, which is adjacent to Hope Creek, to be 0.046/RY for a loss of offsite power of more than half an hour; this frequency was assumed to apply to Hope Creek.

2.1.3 RELIABILITY OF ACCIDENT MITIGATING SYSTEMS

In the RSS, BF1, Limerick and other risk assessments, extensive fault tree analyses have been performed on plant systems which are very similar to those designed for Hope Creek. Because of the limited nature of this study, detailed plant specific reliability assessments of the Hope Creek systems were not performed. Rather, comparisons between the Hope Creek system and similar systems for which detailed analyses have been performed were made and estimates of Hope Creek system reliabilities were made based on their similarity to these systems.

2.1.3.1 Reactor Core Isolation Cooling (RCIC) System

The Hope Creek, Peach Bottom and BF1 RCIC systems are similar, with the main differences being the use of a single closed MOV in the suction line from the Hope Creek torus rather than two closed MOVs used in the other designs. This design difference would tend to make the Hope Creek system slightly more reliable, although assumptions regarding maintenance outages can, in principle, overshadow the effects of these minor design differences. The Hope Creek RCIC unavailability was taken to be the same as that in the BF1 IREP study, approximately 4×10^{-2} per demand. This is dominated by a number of single failures, most importantly the rupture disk failure on the turbine exhaust line, faults of control circuitry of active valves and the pump unavailability.

2.1.3.2 High Pressure Coolant Injection (HPCI) System

The Hope Creek HPCI system differs only slightly from those at Peach Bottom and BF1; for example, the Hope Creek system has only one closed MOV in the suction line from the torus whereas the other designs have two. However, the hardware differences are slight and differences in estimated unavailabilities of the systems could be more strongly affected by differences in assumptions regarding maintenance outages. The BF1 system unavailability of 4.4×10^{-2} per demand was judged to apply to Hope Creek. This unavailability is dominated by the failure of the turbine exhaust rupture disk, control circuit faults and pump/turbine unavailability.

It is pertinent to note that the Hope Creek HPCI turbine trips on high exhaust pressure, which is set at 50 psig. This set-point has some significance in determining the severity of

anticipated transient without scram (ATWS) sequences because of its effect on the timing of containment failure relative to core melt. This is discussed further below.

2.1.3.3 Core Spray System

The Hope Creek system is very similar to that used for Peach Bottom and BF1. The Hope Creek system uses a separate line for each pump, whereas the BF1 system uses a common suction line for each loop; minor differences also exist in the valving of the Hope Creek injection path. These factors imply a somewhat better reliability than that for BF1. However, these differences would be small and it was judged that the BF1 estimates of 6.6×10^{-4} per demand for transients where normal power is available and 9.6×10^{-4} per demand for loss of offsite power transients would adequately depict the unavailability of the Hope Creek system.

2.1.3.4 Reactor Shutdown System

The Hope Creek design for reactor shutdown (defined as failure to scram and failure of the reserve shutdown method) differs from the Peach Bottom and Browns Ferry designs. The difference arises from the decision to implement the Alternate 3A ATWS modification as described in NUREG-0460 with the exception of automatic initiation of the standby liquid control (SLC) system; the Hope Creek SLC system will be manually actuated.

The additional hardware associated with Alternate 3A increases the flexibility of the plant response to an ATWS. This is reflected in a variety of ATWS sequences rather than a single sequence as was assumed in WASH-1400 and the rebaselined

analysis. Furthermore, the consequences associated with ATWS sequences differ. This difference is associated with the timing of containment failure relative to core melt, which is tied primarily to the capability of the HPCI system. Thus, the meaning of a probability of failure to shut down becomes much more complex than was the case in the rebaselined analysis.

The Hope Creek analysis was based on the Limerick PRA which included a detailed study of the effects of Alternate 3A. The study used the NUREG-0460 estimate for failure to scram of 3.0×10^{-5} per demand (Ref. C-9). Given that manual injection of the SLC will be used at Hope Creek, 50% credit was allowed for operator action to initiate the SLC. This is a judgment value based on a 60 second time indicated as necessary by the FSAR analysis for boron injection (Ref. C-10); rigorous operator training and carefully defined procedures must be in place for even this operator credit within 60 seconds. However, the FSAR calculation is a design basis one and it is expected that the operator has somewhat longer than 60 seconds to inject boron in time to avoid containment failure. This observation was also factored into the judgment that 50% credit is plausible.

The effects of the Alternate 3A hardware are such that a variety of ATWS sequences with differing consequences are possible. Thus, the net effect of the design can best be depicted in the estimate of the total ATWS probability as presented in Section 2.1.4.1, rather than a single probability of failure to shutdown.

2.1.3.5 Residual Heat Removal (RHR) System

The residual heat removal system serves two functions; (i) it removes decay heat from the reactor after it is shut down;

(ii) it provides makeup to the reactor when it is operated in the low pressure coolant injection (LPCI) mode.

In the LPCI mode, Hope Creek employs four independent trains, each train consisting of a pump, separate suction lines from the torus and separate injection lines into the vessel.

In the RHR mode, the Hope Creek system utilizes two of the four LPCI pumps, each supplying one of two heat exchangers. The other two pumps cannot be crossconnected to flow through these. This design differs significantly from others (for example, the rebaselined analysis was based on a four pump, four heat exchanger design); thus, a plant specific analysis was required. This analysis was performed by constructing a simplified Boolean expression to model the unavailability of the RHR system in its various modes of operation. This approach was also used in the RSSMAP program.

The data and assumption used to quantify the unavailability expressions were largely take from the BF1 report. Failure to achieve flow from LPCI trains for coolant makeup was estimated as 5.4×10^{-5} per demand. Failure in the RHR mode (including support systems failures) was estimated as approximately 1.1×10^{-4} per demand. (It should be noted that this value does not include the probability of failure of the operator to align the system for RHR operations, which is sequence dependent and is considered in the quantification of individual sequences as discussed in Section 2.1.4.2).

2.1.3.6 Emergency Power (Diesel Generator) System (EPS)

Emergency power at Hope Creek is provided by four diesel generators supplying power to four 4.16kv essential service

buses. Detailed analyses have been performed of similar designs. Using the Limerick PRA as a basis, each EPS train was assigned an unavailability of 2.6×10^{-2} per demand, with a common cause failure of all 4 trains assessed to be 1.0×10^{-3} per demand. These values were used in the Hope Creek assessment.

2.1.4 SEQUENCE QUANTIFICATION

The following sections briefly describe the quantification of the frequencies for the Hope Creek source terms. Event trees developed in the BF1 and Limerick analyses were used to identify accident sequences. Initiating event frequencies and system unavailabilities found specifically for Hope Creek were used where possible. The limitations of this project did not permit an extensive plant specific analysis of potential common mode failures. Rather, the common mode failures found important in the Browns Ferry analysis were assumed to be important for Hope Creek also.

2.1.4.1 Anticipated Transients Without Scram (TC)

As stated in Section 2.1.3.4, the implementation of the Alternate 3A hardware modifications allows the identification of a number of ATWS sequences, rather than simply a single ATWS sequence as was analyzed in WASH-1400 and in NUREG-0773. Furthermore, an analysis of the phenomenology associated with the various ATWS sequences reveals that the consequences associated with all sequences are not equal.

The analysis of the Hope Creek TC source term was based on an ATWS analysis performed for Limerick using the Alternate 3A design. A number of ATWS sequences were identified from the Limerick event trees. These sequences are also applicable to

Hope Creek; however, in the present work, the quantification used Hope Creek initiating event frequencies and system unavailabilities where possible. Failure rates for components (e.g. ARI) associated with the 3A design, common mode failures and operator error rates were generally assumed to be the same as was used in Limerick. The major exception to this was made to reflect the current PSE&G commitment to using manual rather than automatic initiation of the standby liquid control system. It is assumed that the operator would initiate this system within 60 seconds when required for effective operation. As explained below, a 50% chance of successful operator action was credited for this act.

The distinction in consequences associated with various accident sequences is based primarily on the timing of containment failure relative to core melt. That is, if the course of the ATWS is such that the makeup systems (HPCI; RCIC) continue to operate until the containment fails due to flow disruptions, the consequences will be severe. In this scenario, which was the basis for the rebaselined analysis (Ref. C-2), the core melts in a failed containment. Conversely, if makeup systems fail prior to containment failure the consequences are less severe. The makeup systems may "fail" due to high water temperature, a deliberate operator trip or a high turbine pump exhaust trip. This is the ATWS scenario that was assumed to occur in WASH-1400. The Limerick analysis estimated that makeup will be unavailable prior to containment failure in 80% of cases. These ATWS sequences are less severe and have a phenomenology similar to that of a TQUV sequence. Thus, this fraction of the ATWS probability (3.6×10^{-5} per year) was considered as a contributor to the TQUV class. The remaining 20% (9.0×10^{-6} per year) which are the ATWS cases in which containment

failure precedes core melt, become the frequency of the TC category.

2.1.4.2 Transients with Loss of Decay Heat Removal (TW)

This accident sequence represents a transient in which the reactor is shutdown and isolated from its normal heat sink, the power conversion system (PCS). Makeup of inventory is being supplied to the reactor; however, there is no removal of decay heat from the containment, which eventually fails as a result of overpressure. The failure disrupts the makeup systems, causing loss of core cooling and subsequent melting of the fuel.

There are a number of accident sequences involving loss of residual heat removal which make up the TW source term. The sequences vary according to the transient initiator, the presence of a stuck open relief valve and the availability of the HPCI system for makeup. These factors influence the time allowed for operator alignment to the RHR mode and for recovery of failed components. The accident sequences making up the Hope Creek TW source terms were identified from the BF1 analysis. The quantification of these sequences was based on the following set of assumptions. (i) failure to recover PCS was assumed to be independent of RHR recovery and to have a probability of 0.1; (ii) recovery times were based on 8 or 20 hour intervals depending on the particular sequence; (iii) a failure probability of 10^{-4} was assigned for operator alignment of the RHR in an 8 hour period and 10^{-5} was assigned for failure in the 20 hour period; (iv) recovery of the failed RHR (or diesels in a loss of offsite power sequence) was based on an exponential distribution of recovery times; (v) recovery of offsite power was based on EPRI NP-2301 (Ref. C-8).

Note that the above mentioned operator failures of 10^{-4} per demand in 8 hours, or 10^{-5} per demand in 20 hours, may briefly be described as failure by the team of operators to recognize the need for RHR. The reasons for operator errors of this nature are discussed in Reference C-11. In that reference, a group consisting of an engineering physiologist, a systems analyst with human factors experience and a systems analyst with extensive operational and training experience in nuclear power plants developed Figure C-1, which shows the relationship between the time available for action and the probability of success. It can be seen that, after about 4 hours, the probability of failure is predicted to remain constant at a value 10^{-4} or 10^{-5} per event. The lower value is used for situations in which the operators can be expected to have experience, such as in implementing long-term heat removal. For recovery in 20 hours 10^{-5} per event was chosen and, conservatively according to Figure C-1, 10^{-4} for recovery in 8 hours.

Sequence frequency estimates were very close to those used in BF1 because of the similarity in systems reliabilities and initiating event frequencies. The various sequences in which there is a failure to remove decay heat result in an estimated frequency of the TW class of $1x10^{-5}$ per reactor year.

2.1.4.3 Transients with Failure of Core Cooling (TQUV)

There are a number of accident sequences that contribute to the TQUV class. For the Hope Creek analysis this class was made up of transient sequences with loss of makeup and, as stated in Section 2.1.4.1, ATWS sequences in which core melt preceded containment failures. The transient sequences with

loss of makeup were identified from the results of the BF1 analysis. Given the similarity in reliabilities of the makeup systems involved to those in Browns Ferry, the BF1 probability estimates were judged appropriate for Hope Creek with a modification to account for the Hope Creek initiator frequencies. Loss of coolant accident sequences were found to be unimportant contributors to this class. The ATWS contribution to this class from Section 2.1.4.1 was included.

The probability for this class from all sequences composing it was estimated as 3.6×10^{-5} per year. This probability was dominated by the ATWS contribution.

2.1.4.4 Large LOCA with Failure of Emergency Core Cooling (AE)

The AE class is composed of a group of LOCA sequences, which were identified from the BF1 analysis. Sequence frequency estimates were very close to those used in BF1 because of the similarity in systems reliabilities and initiating event frequencies. The estimated frequency of this class from all contributing sequences is 8.0×10^{-8}, which is small: this class was not considered further in the consequence analysis.

3.0 CONTAINMENT EVENT TREE

Figure C-2 displays a simplified containment event tree which was developed for the present study. In practice, the most important failure mode is gross rupture by overpressure, γ or γ' and it is first necessary to consider where this failure might take place.

3.1 FAILURE LOCATION AND PRESSURE, GROSS RUPTURE

Figure C-3 is a simplified diagram of half of the containment. In the Reactor Safety Study, the failure pressure for the Peach Bottom Mark I containment was assessed to be 160 $\pm$ 25 psig. Failure was assumed to occur when the stress was halfway between yield and ultimate. The location of the failure was determined to be in the top half of the toroidal suppression chamber (wetwell).

A recent, more detailed study of steel containment strength (Ref. C-12) has been carried out by the Ames Laboratory at Iowa State University. This study indicated that the failure pressure for the Browns Ferry Mark I containment is near 117 psig. The failure criteria used was that the failure strain in the base material would be twice that occurring at yield. The failure location was determined to be in the drywell at the knuckle, (Point K on Figure C-3). Both approximate shell theory and 3-D finite element analysis were used.

In the RSS analysis, two possible flow paths for the fission products were identified. The first (γ') is directly to the atmosphere since it was assumed that the walls AB or BC on Figure C-3 might break, leading to a direct path to the atmosphere. The second pathway, labelled γ, is through the annulus between the drywell shell and the surrounding concrete wall. It was judged that the individual probabilities of γ and γ' are 0.8 and 0.2 respectively.

In the present work, with failure at the knuckle, rather than in the wetwell, the scope of the analysis did not allow a detailed study of whether the adjacent wall would also fail, thus allowing the fission products to bypass the annulus: nor

was this question addressed in Reference C-12. It was decided to assign a 50% probability to γ and a 50% probability to γ'.

The combined probability of the γ + γ' failure modes, given containment failure is almost unity since the probability of all other containment failure modes is small, as described below.

3.2 STEAM EXPLOSIONS

The in-vessel steam explosion, α, that is vigorous enough to fail containment has been the subject of considerable experimental work since 1975. In-depth evaluations of steam explosions were carried out in the Zion and Limerick PRAs. These experiments and analyses have established, first, that it is extremely unlikely that a large portion of the molten core will drop coherently into the water remaining in the reactor vessel, or that it will mix intimately with the water in a short time. Second, in small scale experiments, the efficiency of conversion of heat into mechanical energy has been found to be lower than was postulated in WASH-1400. Third, the upper internal structure in a BWR reactor vessel tends to absorb some of the energy from a steam explosion. For these reasons, the likelihood of occurrence of event α is assumed to be negligibly small.

For steam explosions in the drywell that are sufficiently vigorous to fail the containment (event β), the probability is also expected to be small. First, as mentioned above, the efficiency of the conversion from heat to mechanical energy is small. Second, as discussed in the Limerick study the likely failure mode of the reactor vessel is the melt through of penetrations at the bottom of the vessel. Such a failure mode

allows only a small amount of fuel to come into contact with water on the drywell floor. Third, the amount of water on the drywell floor is relatively small and is limited to a depth of approximately two feet because of the location of the vent pipes. Fourth, for transient events, most of the water in the reactor vessel is boiled off to the suppression pool before core melt and this will not be deposited on the drywell floor. These considerations lead to the assignment of a negligibly small value to β for transient events (TW, TC and TQUV) and a small value, 10^{-4}, for LOCA events (AE).

3.3 HYDROGEN BURN OR EXPLOSION

As far as hydrogen burns (μ) or explosions (μ') are concerned, their probability of occurrence is limited by the availability of oxygen. The containment is normally inerted and is expected to remain so during operation for all but approximately 70 hours of the year. Hence, there is an upper limit of about 10^{-2} for this probability. Hydrogen burns or hydrogen explosions are not considered further in the present work because of this low probability relative to that of γ and γ'.

3.4 OTHER CONTAINMENT FAILURE MODES

The probability of all other potential containment failure modes (δ, containment isolation failure in the drywell; ϵ, containment isolation failure in wetwell; ζ, containment leakage greater than 2,400 volume percent per day; η, reactor building isolation failure; and θ, standby gas treatment system failure) is taken to be very small relative to overpressure. These negligibly small release probabilities are consistent with those used in WASH-1400 and in the Brown's

Ferry IREP study for the transient core melt sequences (TC, TW, TQUV) that were found to dominate risk.

4.0 SOURCE TERM MAGNITUDES

Source term magnitudes are displayed in Table C-1. Major factors controlling these source terms are as follows.

4.1 SEQUENCE TQUV- γ'

This is a sequence in which the ability to cool the core is lost and the core subsequently melts in an intact vessel and containment. The radiologically important volatile fission products I, Cs and Te are mostly released from the fuel during this phase (90%, 90% and 80%, respectively). These melt release fractions are based on NUREG-0772 (Ref. C-13) and the SASCHA experiments (Reference C-14) and are greater than those used in WASH-1400 and in the rebaselined analysis (88%, 76% and 15%, respectively), especially the Tellurium. It is assumed that these melt release fission products are blown through the main steam relief valves into the pool. The pool remains subcooled throughout this sequence: a review of experimental data on pool scrubbing shows that a decontamination factor (DF) of at least 100 can be justified in this case. Hence, less than 1% of the melt release will pass through the pool and be available for release to the atmosphere.

Once the core has melted, it will slump to the lower head of the vessel, which will subsequently fail. The core will fall to the concrete floor beneath and non-condensable gases will be generated by the core-concrete interactions. The buildup

of these gases eventually causes containment failure at the drywell knuckle (see Figure C-3) due to overpressure. Any fission products emitted during this vaporization phase, (10% I, 10% Cs and 20% Te) will be available for release to the atmosphere, together with the 1% quantities that have previously passed through the pool. The extent of radionuclide retention in the containment was estimated based on analytical results presented in the NRC rebaseline study. The vaporization release is the most important in this sequence.

In summary, the source term magnitude for TQUV- γ' given in Table C-1 is controlled by two factors; (i) a DF of 100 in the pool for the melt release; (ii) details of the plateout and deposition of the vaporization release in the containment. In addition, a major difference between the present work and the rebaselined analysis (Ref. C-2) is that a significantly larger fraction of the volatile tellurium is assumed to be released from fuel during the melt phase, based on NUREG-0772 and the SASCHA experiments.

4.2 SEQUENCE TC- γ'

In this sequence, it is assumed that there is a transient followed by failure to shut down the reactor. Meanwhile, High Pressure Core Injection continues to operate so that the reactor continues to run at a significant fraction of full power. The heat generated at this time is discharged to the suppression pool at a rate greater than the capability of the containment heat removal systems. The pool temperature and containment pressure rise until containment failure occurs. The containment failure is assumed to damage the systems required to maintain coolant inventory, so that the core uncovers and melts. At this stage, the vessel is still intact

so that the fission products released during the melt phase pass through the pool and out of the containment. It is the assumed pool DF that controls the magnitude of the source term for the volatile fission products.

Analysis of this sequence with the MARCH code indicates that the suppression pool may still be depressurizing while the core is melting. There is no experimental evidence on the expected DF in such a case. However, experiments on DFs in saturated pools suggest that a DF of 10 can be justified; for a flashing pool, a smaller DF is to be expected and a DF of 5 has been chosen. This accounts for volatile fission product source terms of about 20% in Table C-1, the balance being due to the subsequent vaporization release after vessel failure.

In summary, the factor that controls the magnitude of the TC-γ' source term is the assumed DF of five in the depressurizing pool.

4.3 SEQUENCE TW-γ'

The TW-γ' sequence is initiated by a transient followed by a successful scram and ECCS cooling of the core. However, the ability to remove heat from the suppression pool is lost due to a failure in the residual heat removal system. The suppression pool temperature rises because decay heat is being rejected to it by ECCS operation. The pressure in the containment rises until there is a failure by gross rupture, at which time it is assumed that ECCS also fails. The core uncovers and begins to melt and the melt release of fission products passes through a saturated pool, for which there is an assumed DF of 10. After vessel failure, as in sequence TQUV, the vaporization release bypasses the pool. It,

together with 10% of the melt release that passes through the pool, is subject to plateout and deposition processes in the containment.

In summary, the magnitude of the TW-γ' source term is controlled by (i) the assumed DF of 10 in the pool and (ii) depletion mechanisms in the containment acting on the vaporization release and the part of the melt release that passes through the pool.

4.4 THE γ - CONTAINMENT FAILURE MODE

As has been explained, the γ failure mode is one in which the fission products are assumed to travel through the annulus (see Figure C-3) before being released to the atmosphere. In WASH-1400, which assumed a containment failure in the wetwell, the length of this pathway essentially equals the full height of the vessel. For a failure at the knuckle, K, the length of this pathway is much reduced so that there is less potential for depletion.

Another consideration influencing the likely DF in the annulus is the particle size. According to the treatment in WASH-1400, particulate matter with diameters less than about 10 μm does not deposit effectively in the annulus. However, for the sequences TC and TW, the most important component of the release has first passed through the pool, where the particles of larger diameter will be much more efficiently scrubbed. Hence, in sequences TC and TW, no credit is taken for deposition of the melt release in the annulus. This is why the source terms TC-γ and TW-γ do not differ very much from those for TC-γ' and TW-γ', respectively. By contrast, as has been explained in Section 4.2, the TQUV source term is

dominated by the vaporization release, which does not pass through the pool. Hence, it is assumed that this release does contain some particulates that are larger than 10 μm in diameter and there is some noticeable reduction in the TQUV-γ source term relative to the TQUV-γ' source term.

4.5 ASSOCIATED CHARACTERISTICS OF THE SOURCE TERMS

The Hope Creek specific source terms that are given in Table C-3 include the time of release, the warning time, the duration of release and the energy of release. With the exception of the TW releases, these are the same as for the rebaselined BWR (Ref. C-2). That is, based on the analysts' general knowledge of BWR source terms, these times and energies are within a plausible range of uncertainty.

For most of the TW sequences, the analysis given in Section 2.1.3.4 is based on the need to recover long term decay heat removal within 20 hours. This is assumed to be the time to the failure of the containment. In typical analyses of TW sequences, the onset of core melt and the consequent release of fission products to the atmosphere takes a further four hours. Hence, the time to release is taken to be 24 hours. Because of the nature of the operator error that is an important contributor to this sequence - failure to recognize the need for long term heat removal - it is assumed that the need for a declaration of a general emergency will not be recognized until the containment fails at 20 hours. Hence, the predicted warning time is four hours. This, of course, is conservative for those sequences in which the unavailability of the RHR system is due to mechanical failure.

5.0 CLASS 9 CONSEQUENCE ANALYSIS

The Class 9 Consequence Analysis has been carried out with the CRAC2 code (Ref. C-15) using the source terms described above. This is a revised version of the code CRAC (Calculation of Reactor Accident Consequences) which was developed for use in the Reactor Safety Study. The organization of CRAC2 is given in Figure C-4. CRAC2 requires a considerable amount of input data, which is described below.

5.1 CURIES OF FISSION PRODUCTS AND ACTINIDES RELEASED TO THE ATMOSPHERE

The amounts (curies) of each radionuclide released to the atmosphere for each accident sequence or release category are obtained by multiplying the release fractions given in Table C-1 by the amounts that would be present in the core at the time of the hypothetical accident. These amounts are shown in Table C-3 for the Hope Creek Unit 1 reactor at a power level of 3293 MWt and are derived from a BWR specific inventory prediction carried out at Sandia National Laboratories with a recently revised version of the ORIGEN code (Ref. C-16).

5.2 METEOROLOGICAL DATA

The CRAC2 input data file contains a full year of consecutive hourly values of windspeed, wind direction, stability class and precipitation. These were processed from measurements taken at the site during the year May 1979 - April 1980. The stability category was determined from joint measurements of the atmospheric temperature gradient and the mean windspeed according to a scheme developed at Sandia National Laboratories (Ref. C-17), which was subsequently recommended in the Procedures Guide (Ref. C-18).

It is pertinent to note that one of the major differences between CRAC2 and CRAC lies in the methods used to sample a limited number from the 8760 different weather sequences that are possible in the course of a year. This sampling is necessary because, in general, it is prohibitively expensive to run CRAC or CRAC2 for all 8760 sequences. The "stratified sampling" method generally used with CRAC, in which 91 sequences are chosen at intervals of 4 days and 13 hours, may lead to a considerable underestimation of peak early effects (Ref. C-19). In CRAC2, all the 8760 sequences are first sorted into 29 "bins" which encompass the most common patterns of weather throughout the year. The code then samples from each bin, thus ensuring greater accuracy than does CRAC.

5.3 POPULATION DISTRIBUTIONS

The population distribution around the site has been assigned to a grid consisting of sixteen sectors, the first of which is centered on due north, the second on 22½° east of north, and so on. There are also twenty-eight radial intervals as shown in Table C-4, which contains the predicted permanent resident population for the year 2010.

The population within 50 miles was taken directly from elsewhere in this Environmental Report. Since the grid given there is coarser than the one employed in Table C-4, the population was assigned to a finer grid by simply factoring by area. Beyond 50 miles, the population distribution was derived using the same methods as were used previously to derive the population within 50 miles. That is, the population distribution used in the Class 9 consequence analysis is consistent with that used elsewhere in this Environmental Report. CRAC2 also requires the habitable land fraction for

each element of the grid given in Table C-4 and this has been worked out simply by reference to maps as that fraction of land not covered by water.

5.4 EVACUATION MODELING AND OTHER PROTECTIVE MEASURES

5.4.1 EVACUATION WITHIN THE EPZ

As for all reactors in the USA, there is a plan for the evacuation of the population within the plume exposure EPZ (Emergency Planning Zone), which is approximately a circle of radius ten miles, centered on the Hope Creek site. A site specific evacuation study has been carried out by Parsons, Brinckerhoff, Quade & Douglas, Inc. (Ref. C-20) and the evacuation modeling employed for the Class 9 analysis is at least in part based on this study.

According to Table 9 of Reference C-20, it is assumed that the public notification system has the capability of warning all people within the EPZ within 45 minutes. In fair weather conditions, there is then a further 20 minutes of preparation time, so that the important delay time parameter is about one hour.

Table 2 of Ref. C-20 indicates that 88% of the population have cars and 12% do not. During a working day, car owners would all have left the EPZ within four hours, an effective evacuation speed of 2.5 mph for a ten mile journey. The remainder of the population would evacuate in five hours, at an effective speed of 2.0 mph.

Evacuation speeds at the weekend or night time would be greater than this, so that using the weekday evacuation speeds

introduces an element of conservatism. For the purposes of the present study, it was assumed that only 95% of the people within the EPZ in fact participate in the evacuation. The remaining 5% either cannot or will not evacuate and are assumed to go about their normal activities for 24 hours.

In addition, it is assumed that, for 1% of the time, foul weather will interfere with the evacuation process. From Table 10 of Ref. C-20, in such circumstances, the preparation time is increased from 20 to 40 minutes (i.e. the delay time is about 1½ hour) and the subsequent clear time is about 8 hrs at an effective speed of 1.25 mph. For simplicity, this is assumed to apply to all sections of the population.

Strictly speaking, further allowance should be made for people in special institutions such as schools, hospitals, or prisons. Within the EPZ there are four hospitals or nursing homes; Salem County Memorial Hospital, Salem County Nursing and Convalescent Center, the Association of Retarded Citizens (all in New Jersey) and the Governor Bacon Health Center in Delaware. There are two jails; Salem County Jail in New Jersey and the Delaware Correctional Center. There are also a number of schools. Special equipment or personnel may be needed to facilitate evacuation from these institutions. Because of this, evacuation effectiveness could be greater or less than that assumed for this report but, according to evacuation time estimates given in Ref. C-20, would not be expected to be very much less.

It is pertinent to note that it has proved necessary to modify the evacuation model employed in CRAC2 in order to accomodate the evacuation scheme outlined above. The CRAC2 evacuation model (Ref. C-21), which itself differs considerably from

that developed for CRAC, allows the possibility of several different evacuation scenarios. In its conventional mode of operation, CRAC2 is operated with three alternative scenarios; 1, 3 or 5 hour delay times and a subsequent evacuation speed of 10 mph, with assigned probabilities of 30%, 40% and 30%. This is consistent with US evacuation experience (Ref. C-22). The analagous scenarios outlined above would be fair weather (99%) and foul weather (1%). However, within a given scenario, CRAC2 assumes that all of the population behaves in the same way. Hence, a modification was made to CRAC2 to incorporate different behavior within the fair weather scenario for the car owning population, the non-car owning population and those who do not evacuate.

5.4.2 EMERGENCY RESPONSE BEYOND 10 MILES

In recommending that the plume exposure EPZ should be about 20 miles in diameter, the USNRC (Ref. C-23) did not envisage that the boundary should be a rigid barrier beyond which no emergency countermeasures would be contemplated. Rather, evacuation within the EPZ would provide a suitable foundation for the expansion of evacuation or other countermeasures, if need be. Hence, it can be assumed that some emergency response measures would be contemplated beyond ten miles. A particularly effective response would be to assume that people would shelter in basements or large buildings for a few hours or a day, followed by rapid relocation.

Since such measures would have to be implemented on an ad hoc basis, however, it was conservatively assumed that people beyond ten miles would continue their normal activity for seven days, after which they would be relocated, unless the predicted radiation dose to the bone marrow would exceed 200 rem, in which case relocation would take place after one day.

5.4.3 OTHER COUNTERMEASURES

The other protective actions include: (a) either complete denial of use (interdiction) or permitting use only at a later time after appropriate decontamination of crops and milk; (b) decontamination of severely contaminated land and property when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels; (c) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced by radioactive decay and weathering to such a level that decontamination is economically possible as in (b) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment. In CRAC2, these protective actions are modeled in the same way as in WASH-1400.

5.5 EXPOSURE PATHWAYS

The exposure pathways modeled by CRAC2 are the following. First, there is inhalation of radioactive material from the passing cloud. The inhalation dose conversion factors, which relate the curies inhaled to the subsequent radiation dose to various body organs, remain the same as those used in WASH-1400 and are contained in the standard CRAC2 data file. Second, there are cloudshine and groundshine, the irradiation of body organs by gamma rays emitted by the passing cloud or by fission products deposited on the ground. The cloudshine and groundshine dose conversion factors also remain the same as in WASH-1400 and are contained in the CRAC2 data file. Third, there are chronic exposure pathways, which include (a) resuspension of deposited radioactive material by the wind

(which is relatively unimportant for typical LWR source terms); (b) long term exposure to gamma rays from deposited fission products, especially cesium, including the effects of weathering; (c) the consumption of milk; (d) the consumption of milk products; (e) the consumption of contaminated vegetation; and (f) the consumption of crops contaminated by root uptake. The treatment of these chronic exposure pathways remains precisely the same as in WASH-1400.

The present work also contains a treatment of liquid pathways, which, however, are not modeled in CRAC2. Instead, they are discussed in Section 7.0.

5.6 HEALTH EFFECTS

In CRAC2, the calculation of the health effects caused by radiation doses delivered to various organs is still handled in virtually the same way as was done in the RSS. This is in accordance with the recommendation contained in the Procedures Guide (Ref. C-18), which concluded that, although the cause-and-effect relationships between radiation exposure and health effects are quite complex (Refs. C-24 and C-25) and have been extensively studied since the writing of the RSS, the time is not yet ripe to recommend a change.

A whole body radiation exposure resulting in a dose greater than about 10 rems for a few persons and about 25 rems for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 10 to 20 times larger than the latter dose, also received over a relatively short space of time (hours to a few days), can be expected to cause some fatalities. The dose-response relationship for acute

fatalities that was used in this study is the one for "supportive" medical treatment found in WASH-1400.

Lower levels of radiation may cause randomly occurring cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. Cancer in the exposed population may begin to develop 2 to 15 years (latent period) after the time of exposure and then continues over a 'plateau' period that extends over the lifetimes of the individuals in question. In the case of fetuses, however, cancer may begin to develop at birth and end at age 10. The health effects model currently being used is based on the 1972 BEIR report of the National Academy of Sciences (Ref. C-26) and is consistent with the BEIR III (1980, Ref. C-27) report.

Most authorities agree that a reasonable -- and probably conservative -- estimate of the randomly occurring number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 cancer deaths (although zero is not excluded by the data) per million person - rems. The range comes from the latest report of the Advisory Committee on the Biological Effects of Ionizing Radiation (Ref. C-27), which also indicates a probable value of about 150. This number is very close to the value of 168 discussed in the Procedures Guide (Ref. C-18); this is the value used in the present work. In addition, the BEIR III report predicts approximately 220 genetic changes per million person-rems over succeeding generations.

5.7 ECONOMIC COSTS

The necessary input to the calculation of economic costs in CRAC2 includes several unit costs such as the cost of evacua-

ting or relocating a person and the cost of decontaminating farm land or developed land. These costs are given in WASH-1400 and have been updated to 1980 to allow for inflation. They include land use statistics, farm land values, farm product values, dairy production, and growing season information. These statistics are provided on a countywide basis from the County and City data book (Ref. C-28) within 50 miles and on a statewide basis for larger distances.

6.0 RESULTS

6.1 HEALTH EFFECTS

The results of calculations of dose and health impacts performed for the Hope Creek unit 1 reactor are presented in the form of Complementary Cumulative Distribution Functions (CCDFs) in Figures C-5 through C-8 and are included in Table C-5. All of the accident sequences and release categories shown in Table C-1 contribute to the results, the consequences of each being weighted by the associated frequency.

Figure C-5 shows the CCDFs for the number of persons who might receive bone marrow or whole-body doses from early exposure* equal to or greater than 200 rems and 25 rems,respectively, or thyroid doses equal to or greater than 300 rems. The 200 rem whole-body dose figure corresponds approximately to a value above which hospital treatment would be required. The 25 rem whole-body dose (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and 300

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* Early exposure to an individual includes the radiation dose due to the inhalation of radioactive material, the external dose due to cloudshine, and the external dose due to groundshine for the period up to seven days, after which relocation is assumed. Other exposure pathways are excluded.

rem thyroid figures correspond to the Nuclear Regulatory Commission's guidelines for reactor siting in 10CFR100.

Figure C-5 shows at the left-hand end that there are approximately 6 chances in a million to 4 chances in a hundred thousand per reactor year that one or more persons may receive doses equal to or greater than those specified. The fact that the three curves run almost horizontally shows that, if one person were to receive such doses, then the chances are that several tens or hundreds would be so exposed at the same time. The chances of larger number of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about one in ten million that 10,000 or more people might receive doses of 200 rem to the bone marrow or greater.

Figure C-6 shows the CCDF for the total population exposure in person-rems (that is, the probability per reactor-year that the total population exposure will equal or exceed the values given). For perspective, the population doses shown in Figure C-6 may be compared with the annual average dose to the population within 50 miles of the Hope Creek site due to natural background radiation of 490,000 person-rems.

Figure C-7 shows the CCDF for acute fatalities, representing radiation injuries that would produce fatalities within about one year after exposure. Virtually all of the acute fatalities would be expected to occur within 20 miles (32/km) radius.

It is pertinent to note that the peak* early fatalities given on Figure C-7 are smaller than those given in the Sandia Siting Study (Ref. C-29) and the associated microfiche of

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* The peak is defined as the magnitude of the consequences occurring with a predicted frequency of once in a billion reactor years.

CRAC2 results on which the study was based. In general, there are three requirements for generating large peaks with CRAC2; (a) a large source term, such as the TC-γ' source term in the rebaselined BWR; (b) a high rainfall rate coinciding with the passage of a plume over a large center of population beyond ten miles, thus ensuring a heavy deposit of gamma-emitters in an area inhabited by a large number of people; and (c) assumptions that people beyond ten miles do not evacuate for at least 24 hours and continue their normal activities in the meantime, thus accumulating a large radiation dose as a result of groundshine. In the current analysis for the Hope Creek BWR, condition (a) was not satisfied, since the TC-γ' source term (the largest in Table C-1) is smaller by about a factor of two than that used in the Sandia Siting Study, which in turn took the source term from the rebaselined BWR analysis. The trend towards smaller source terms can be justified in the light of current research such as that reported by the NRC in a preliminary document, "Radionuclide Release Under Specific Conditions" (Draft NUREG-0956).

Figure C-8 gives the CCDFs for latent cancer fatalities. These would appear in the surrounding population over a period of many years. The impact on the total population and the population within 80 km (50 miles) are shown separately, and the latent cancer fatalities have been subdivided into those attributable to exposures of the thyroid and all other organs.

6.2 ECONOMIC IMPACTS

As noted in Section 5.7, the various measures for avoiding adverse health effects have an associated cost; these include: (a) evacuation costs; (b) value of crops contaminated and condemned; (c) costs of decontamination; (d) indirect costs

due to loss of property and incomes derived therefrom. Figure C-9 shows the CCDF for ex-plant costs, in 1980 dollars. In general, these costs are dominated by decontamination. At the extreme end of the accident spectrum, the costs are measured in tens of billions of dollars, but the predicted frequency with which this cost would be incurred is exceedingly small, less than one chance in a million one chance in a hundred million per reactor year. The magnitude of the largest source term (TC-γ') has a very significant influence on the peak consequences.

Additional economic costs include decontamination of the facility itself and the cost of replacement power. These impacts are discussed in the section on risk considerations below.

The cost of health effects has not been included in the calculation of the CCDF for early fatalities. However, a calculation in Reference C-30, using a cost of $1,000,000 for an early fatality and $100,000 for an early injury or a latent cancer, shows that the offsite property damage is typically increased by only about 10% if the cost of health effects is added.

7.0 RELEASES TO GROUNDWATER

In the event of an accidental escape of radioactive material to groundwater, the main concern would be that the material would make its way to the Delaware river and eventually reach man as a result of the consumption of aquatic foods, swimming and shoreline usage.

A Class 9 accident liquid pathway analysis has been carried out using the "Liquid Pathway Generic Study" (LPGS) as the basis (Ref. C-31). That study contains a detailed analysis of the potential consequences of a core melt accident liquid pathway release of radioactive material for generic sites (i.e., river site, great lakes site, estuary site, and ocean site) for both floating and land-based nuclear power plants. Among the conclusions of that study were: a) the liquid pathways are not as significant a source of acute radiation as are the airborne pathways. No acute fatalities from the liquid pathway are expected and b) Biota mortalities for either type of plant (land-based or floating) are not expected to impact populations significantly; ecosystem recovery is expected. Accordingly, demonstration that a Hope Creek Class 9 accident results in liquid pathway consequences less than those of the LPGS estuary site is sufficient to demonstrate that the former is not uniquely hazardous vis-a-vis such an accident.

7.1 RADIONUCLIDE SOURCE TERMS

The Hope Creek reactor is of the boiling water type (BWR). Barring any special design features, such as a groundwater underdrain system, the only major release to the hydrosphere for a BWR meltdown in a MARK I containment is expected to be by leaching of the melt debris (Ref. C-32). This is in contrast to a pressurized water reactor (PWR), from which sumpwater and depressurization releases could cause "prompt" sources, i.e., releases prior to melting of the basemat. There are no special design features at Hope Creek which would cause a prompt release.

The most probable release category analyzed in the LPGS is PWR 7. The most probable BWR release category is BWR 3. These release categories result in the largest nuclide

fractions available for groundwater leaching, the "delayed" source of the LPGS, and hence, the largest population doses from this liquid pathway. Since groundwater leaching of melt debris is the only liquid pathway for Hope Creek, and since PWR 7 and BWR 3 have identical leach release fractions, the delayed PWR 7 source term (reduced by the ratio of the Hope Creek thermal power, 3293 MWt, to the LPGS thermal power, 3425 MWt) source is used as the basis for population dose comparisons.

7.2 GROUNDWATER TRANSPORT

From the FSAR, it can be seen that the Hope Creek reactor basemat lies near the top of the Vincentown Formation, a mid-level, 65 foot thick artesian site aquifer. This aquifer is overlain by the Kirkwood clay and underlain by the Hornerstown and Navesink formations, all of which act as confining aquitard beds for the Vincentown. Above the Kirkwood lies a shallow 35 - 50 foot thick unconfined aquifer, composed of fine grained hydraulic fill along with river sands and gravels. To facilitate construction dewatering, sand drains were installed between the shallow and Vincentown aquifers. Accordingly, the head driving the groundwater flow is assumed to be that of the shallow aquifer which is conservatively assumed to be at ground level, 102 feet PSD.

The Vincentown aquifer is hydraulically connected to the Delaware River, where the mean tide level of 89.3 feet PSD is taken to represent long term river levels. The distance from the center of the Unit 1 reactor building to the plant property line is approximately 850 feet, which is a conservative estimate of how far the leached radioactive material would have to travel to the river. Based on the above and permea-

bility pump tests performed in the Vincentown aquifer and sieve analyses, a conservative groundwater velocity is estimated to be 1.38 feet/day, implying a groundwater travel time of 617 days. The corresponding figures for the LPGS estuary site are 6.7 feet/day and 224 days, respectively.

In order to relate the above to population doses, the isotopes affecting the magnitude of the population doses need to be identified. Of those isotopes whose half lives were long enough to be evaluated in the LPGS groundwater transport study, only Ru-106 has a significant impact on salt water population doses from radioactive material entering an estuary. Accordingly, Ru-106 is chosen to represent the effect of the transported debris on the population dose. The half life of Ru-106 is 1.01 years and it is assumed that it forms a soluble complex which moves at the same rate as the water (elemental Ru-106 would be subject to adsorption and would take much longer to reach the river). The ratio of the fraction of Ru-106 reaching the river from Hope Creek to that of the LPGS is proportional to the decay occurring during their respective travel times, 617 and 224 days. This ratio 0.478, is conservative because of the conservative assumptions inherent in the Hope Creek travel time.

7.3 SURFACE WATER TRANSPORT

The steady state estuary model presented in the LPGS has been used to calculate the integral I of radionuclide concentration in the river over the length of the estuary. For aquatic foods, the population dose is proportional to this integral. The site specific parameters used are given in Table C-6.

7.4 AQUATIC FOODS

The ratio of aquatic food harvest in the Hope Creek area to that at the LPGS is taken to represent the relative effects on dose of aquatic food ingestion at the two sites (for equivalent values of the concentration integral).

The edible weight of seafood catch from the entire Delaware Estuary and that from the LPGS, using .5 as the ratio of edible weight to total weight for finfish and .3 as the ratio of shellfish, is:

	Edible Weight (million pounds)	
	Hope Creek	LPGS
Finfish	1.63	11.68
Invertebrates	1.083	6.77

The ratio of edible seafood catch for the Hope Creek area to that of the LPGS is, therefore, 0.122.

7.5 SWIMMING AND SHORELINE EXPOSURES

The human population potentially exposed to Hope Creek effluent in the Delaware Bay and Estuary is 1.35×10^6 users. Exposure time is 1 hour/year for swimming and 5 hours/year for boating. Taking one-half of the boating usage as equivalent swimming (immersion) usage and assuming this immersion usage is in a typical proportion to shoreline usage, results in annual Hope Creek affected swimming (immersion) and shoreline usage of 4.73×10^6 and 1.79×10^7 user-hours. Comparing these values with those of the LPGS (swimming and shoreline of 7.3×10^7 and 2.6×10^8 user-hours, respectively) results in usage

ratios of Hope Creek to the LPGS of 0.0648 and 0.0688 for swimming and shoreline, rspectively.

7.6 POPULATION DOSE

The liquid pathway population dose resulting from Class 9 accident at Hope Creek can be estimated from the values calculated for the LPGS by applying the ratios derived previously. The resulting dose (total body dose is used as a representative quantity) is:

$$D_t = R_S R_{GT} R_{ST} (R_{AF} D_{AF} + R_{SW} D_{SW} + R_{SH} D_{SH})$$

where:

R = ratio of quantity at Hope Creek to that at LPGS
D = total body population dose

and subscripts

t = total of all paths at Hope Creek
S = radionuclide source
GT = groundwater transport
ST = surface water transport
AF = aquatic foods
SW = swimming
SH = shoreline

Using the mid-range of the maximum doses indicated for the LPGS (instantaneous release of all core melt debris) and the values derived previously results in a total body dose of 2.52×10^5 man-rems, less than 3% of the LPGS value (8.9×10^6 man-rems). This establishes that the Hope Creek environs are not uniquely vulnerable to the impacts of a Class 9 accident.

8.0 RISK CONSIDERATIONS

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

A common way in which this combination of factors is used to estimate risk is to multiply the frequencies by the consequences. The resultant risk is then expressed as the number of consequences expected per unit time. Table C-7 shows average values of risk associated with population dose, acute fatalities, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the frequency multiplied by the consequences over the entire range of distributions. Because the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

For perspective and understanding, the above figures can be interpreted as follows.

First, a comparison of population exposures and latent cancer fatality risks (excluding exposure to the plant personnel) shows that accidents risk are small. This can be seen first, by comparing the person-rem/year (460 person-rem/year) with the 490,000 person-rem per year calculated from natural background radiation for the population within 50 miles. Second, the population within 200 miles of Hope Creek is

predicted to be about 42 million by the year 2010. This is the population within which most of the latent cancer fatalities would be predicted to occur. In modern industrialized societies, the individual risk of death due to cancer is about $2.5 \times 10^{-3} yr^{-1}$. This figure may be deduced by reference to the Statistical Abstract of the United States. It implies that there would be about 100,000 deaths due to cancer each year among the population in question. By contrast, even the peak event would cause only about 1,500 deaths each year for some 30 years or so, beginning a few years after the accident (1500x30=45,000, the peak of Figure C-8).

The acute fatality risk of $3.3 \times 10^{-5} yr^{-1}$ may be put in perspective by noting that an approximation of the population at risk is that within about 16 km (10 mi) of the plant, about 27,400 persons in the year 2010. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 8 from motor vehicle accidents, 3 from falls, 1 from burns, and one every three years from firearms (Ref. C-24).

The individual risk of early fatality as a function of distance is displayed on Figure C-10. As can be seen, these risks are all small. For comparison, the following risks of fatality per year to an individual living in the United States may be noted: automobile accidents, $2.2 \times 10^{-4} yr^{-1}$ and firearms $1.2 \times 10^{-5} yr^{-1}$ (Ref. C-24).

The economic risk associated with offsite property could in principle be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels--coal or oil, for example--would emit substantial

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The economic risk associated with offsite property could in principle be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels--coal or oil, for example--would emit substantial

quantities of sulfur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (Ref. C-24). This effect has not, however, been sufficiently quantified for a useful comparison to be drawn at this time.

However, the mean risk of $\$33{,}000 yr^{-1}$ is small compared with the estimated property damage caused by other accidents within 50 miles of the Hope Creek site (e.g. of the order of $\$10^{7} yr^{-1}$ for automobile accidents).

There are other economic impacts and risks that are not included in the calculations discussed above. These costs would be for decontamination and repair or replacement of the facility, and for replacement power. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. Estimates of the total cost of such an accident given in NRCs Class 9 accident analyses (as reported in various Final Environmental Statements - e.g. that for Palo Verde (Ref. C-33)) - are around $5 billion. For the Class 9 accidents that are the subject of this report, with an estimated frequency of $5.5 \times 10^{-5} yr^{-1}$, this implies an economic risk of $2.8 \times 10^{-5} yr^{-1}$.

9.0 UNCERTAINTIES

No quantitative uncertainty analysis has been carried out for Hope Creek. However, in principle, each of the CCDFs presented in Figures C-5 to C-9 should be replaced by a family of CCDFs giving an upper bound (e.g. 95th percentile), lower bound (5th percentile), median and (perhaps) the mean.

In WASH-1400, the CCDFs were presented with an estimated range of errors. For example, the approximate uncertainties on the

CCDF for early fatalities were estimated to be represented by factors of ½ and 4 on consequence magnitudes and by factors of 1/5 and 5 on frequencies, while for property damage the range was represented by factors of 1/5 and 2 on consequence magnitudes and 1/5 and 5 on frequencies. Nowadays, it is generally believed that these error bands are too small. For example, the Lewis Report (Ref. C-34) found that it was difficult to determine whether the overall frequency of core melt given in WASH-1400 was too high or too low, but concluded that the error bands were understated. In the Zion PRA (Ref. C-35), which contains one of the most comprehensive uncertainty analyses carried out to date, the range of predicted frequency (between the 10th and 90th percentiles) for a given number of early fatalities is more than four orders of magnitude. For early injuries (equivalent to the number of people with bone marrow doses in excess of 200 rem), the range is about four orders of magnitude for a few injuries, and increasing towards the more uncertain peaks. For latent cancer fatalities, thyroid fatalities and person-rems, the range is 1-2 orders of magnitude over most of the range of consequence magnitudes except near the peak.

The uncertainty in early effects is much greater than that in latent effects because many more factors contribute to uncertainty in the former. For example, the choice of evacuation delay time and of effective shielding factors in the 10-25 mile range can make orders of magnitude difference to the CCDF for early fatalities (Ref. C-18). Furthermore, the dose threshold for early effects can also lead to big changes in predicted magnitudes, given relatively small changes in the source terms.

The magnitude of latent effects, however, is principally dependent on the magnitude of the source term (Ref. C-36) and

many of the parameters (such as evacuation delay time) to which early effects are sensitive do not influence latent effects.

No modern uncertainty analysis has been carried out on the uncertainty bands on ex-plant property damage. However, it is expected that the range of uncertainties will be closer to that for latent effects since property damage is also principally affected by the magnitude of the source term.

The Zion analysis appears to represent ranges of uncertainties that are typical of those being found by other workers. The principal question is where the point estimates of Figures C-5 to C-9 lie in relation to the upper and lower bounds. Experience with codes such as CRAC2 and with PRA uncertainty analysis suggests that the point estimate always lies above the median and sometimes approaches or lies above the 90th or 95th percentile. As a general judgment, the range of uncertainties on the CCDFs for early effects may be four orders of magnitude or more on the frequency axis, but the CCDFs shown in Figure C-5 (dose impacts/early injuries) and C-7 (early fatalities) probably lie within a factor of ten of the upper bound, except perhaps near the extremely uncertain peaks. For latent effects and property damage, the range of uncertainties on the CCDFs may be about two orders of magnitude in frequency. The point estimates given on Figure C-6 (person-rem), C-8 (latent cancer fatalities) and C-9 (economic effects) are likely to lie well within an order of magnitude of the upper bound.

10.0 CONCLUSIONS

The previous sections consider the potential environmental impacts of Class 9 accidents at the Hope Creek facility.

These have covered a broad spectrum of possible accidental releases of radioactive material into the atmosphere or into groundwater.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of early and latent health effects, and potential economic consequences of the accidental contamination of the environment. Some of these impacts could be severe, but the likelihood of their occurrence, and hence, the public risk, is judged to be small. This judgment is based on a probabilistic assessment of risk based upon the methodology developed in the Reactor Safety Study, with some refinements in the consequence odel. The systems analysis, the analysis of containment failure and the prediction of source term magnitudes have also been updated.

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TABLE C-1

HOPE CREEK SPECIFIC SOURCE TERMS

Accident Sequence	Frequency $(yr)^{-1}$	Time[a] (hr)	Duration[b] (hr)	Warning[c] (hr)	Energy 10^8 Btu/hr	Fraction of Core Inventory Released					
						Xe-Kr	I[d]	Cs-Rb	Te-Sb	Ba-Sr	Ru[e]	La[f]
TC-γ'	4.5×10^{-6}	1.5	2.0	1.0	1	1.0	0.28	0.22	0.23	0.02	0.02	0.001
TW-γ'	5.0×10^{-6}	24.0	2.0	4.0	1	1.0	0.19	0.12	0.13	0.013	0.02	0.003
TQUV-γ'	1.8×10^{-5}	2.0	0.5	1.0	15	1.0	0.01	0.05	0.095	0.005	0.02	0.005
TC-γ	4.5×10^{-6}	1.5	2.0	1.0	0	1.0	0.23	0.22	0.20	0.02	0.015	0.002
TW-γ	5.0×10^{-6}	24.0	2.0	4.0	0	1.0	0.14	0.10	0.10	0.011	0.007	0.001
TQUV-γ	1.8×10^{-5}	3.5	0.5	1.0	0	1.0	0.01	0.02	0.05	0.002	0.002	0.002

[a] Interval between start of hypothetical accident and release of radioactive material to the atmosphere.

[b] Total time during which the major portion of the radioactive material is released to the atmosphere.

[c] Interval between recognition of impending release (decision to initiate public protective measures) and the release of radioactive material to the atmosphere.

[d] Organic iodine is combined with elemental iodines in the calculations. Any error is negligible since the release fraction is small for all large release categories.

[e] Includes Ru, Rh, Co, Mo, Tc.

[f] Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

TABLE C-2

KEY TO BWR ACCIDENT SEQUENCE SYMBOLS

A	-	Rupture of reactor coolant boundary with an equivalent diameter of greater than six inches.
B	-	Failure of electric power to ESFs.
C	-	Failure of the reactor protection system.
D	-	Failure of vapor suppression.
E	-	Failure of emergency core cooling injection.
F	-	Failure of emergency core cooling functionability.
G	-	Failure of containment isolation to limit leakage to less than 100 volume percent per day.
H	-	Failure of core spray recirculation system.
I	-	Failure of low pressure recirculation system.
J	-	Failure of high pressure service water system.
M	-	Failure of safety-relief valves to open.
P	-	Failure of safety/relief valves to reclose after opening.
Q	-	Failure of normal feedwater system to provide core make-up water.
S_1	-	A small pipe break with an equivalent diameter of about 2 inches to 6 inches.
S_2	-	Small pipe break with an equivalent diameter of about 1/2 inches to 2 inches.
T	-	Transient event.
U	-	Failure of HPCI or RCIC to provide core make-up water.
V	-	Failure of low pressure ECCS to provide core make-up water.
W	-	Failure to remove residual core heat.

TABLE C-2 (Continued

α - Containment failure due to steam explosion in vessel.

β - Containment failure due to steam explosion in containment.

γ - Containment failure due to overpressure - release through reactor building.

γ' - Containment failure due to overpressure - release direct to atmosphere.

δ - Containment isolation failure in drywell.

ϵ - Containment isolation failure in wetwell.

ζ - Containment leakage greater than 2400 volume percent per day.

η - Reactor building isolation failure.

θ - Standby gas treatment system failure.

μ - hydrogen combustion

μ' - hydrogen detonation

TABLE C-3

END-OF-CYCLE EQUILIBRIUM ACTIVITY IN THE

HOPE CREEK REACTOR CORE AT 3293 Mwt

Group/radionuclide	Radioactive inventory (million of Curies)	Half-life (days)
A. NOBLE GASES		
Krypton-85	0.83	3.919
Krypton-85m	30	0.187
Krypton-87	55	0.0528
Krypton-88	74	0.117
Xenon-133	179	5.29
Xenon-135	42	0.382
B. IODINES		
Iodine-131	85	8.04
Iodine-132	125	0.0952
Iodine-133	178	0.867
Iodine-134	195	0.0365
Iodine-135	168	0.274
C. ALKALI METALS		
Rubidium-86	0.046	18.7
Cesium-134	13.9	752
Cesium-136	3.7	13.0
Cesium-137	8.3	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	7.4	0.390
Tellurium-127m	1.0	109
Tellurium-129	24.9	0.049
Tellurium-129m	6.6	33.4
Tellurium-131m	12.6	1.25
Tellurium-132	123	3.25
Antimony-127	7.7	3.80
Antimony-129	26.6	0.181
E. AKALINE EARTHS		
Strontium-89	91	52.0
Strontium-90	6.5	10.260
Strontium-91	119	0.395
Barium-140	162	12.8

TABLE C-3 (Continued)

Group/radionuclide	Radioactive inventory (million of Curies)	Half-life (days)
F. COBALT AND NOBLE METALS		
Cobalt-58	0.50	71.3
Cobalt-60	0.60	1,921
Molybdenum-99	160	2.75
Technitium-99m	138	0.251
Ruthenium-103	121	39.6
Ruthenium-105	81	0.185
Ruthenium-106	33	369
Rhodium-105	60	1.48
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	6.9	2.67
Yttrium-91	111	58.8
Zirconium-95	147	65.5
Zirconium-97	151	0.70
Niobium-95	139	35.1
Lanthanum-140	166	1.68
Cerium-141	147	32.5
Cerium-143	143	1.38
Cerium-144	96	284
Praseodymium-143	140	13.6
Neodymium-147	63	11.0
Neptunium-239	1870	2.35
Plutonium-238	0.13	32,510
Plutonium-239	0.033	8.9×10^6
Plutonium-240	0.041	2.5×10^6
Plutonium-241	7.1	5.333
Americium-241	0.0072	1.6×10^5
Curium-242	1.9	163
Curium-244	0.1	6,611

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

TABLE C-4

PERMANENT RESIDENT POPULATION FOR THE HOPE CREEK SITE

Sector (miles)	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-4	0	0	7	62	0	0	0	0	0	15	0	0	15	129	99	4
4-5	0	36	357	89	0	0	0	0	23	0	30	15	38	30	220	296
5-6	68	1,438	333	177	156	75	7	28	54	34	101	169	596	78	134	356
6-7	79	1,699	393	209	184	88	8	33	64	40	120	200	705	93	159	420
7-8	91	1,960	454	241	212	102	9	38	74	46	138	230	813	107	183	485
8-9	103	2,222	514	273	241	115	10	43	84	52	157	261	921	121	207	549
9-10	115	2,483	575	305	269	129	11	48	93	58	175	292	1,030	135	232	614
10-15	40,491	9,418	3,675	3,102	10,181	5,598	446	0	5,626	9,938	10,697	8,390	7,027	8,924	28,102	26,020
15-20	56,687	13,186	5,145	4,343	14,253	7,838	625	0	7,877	13,913	14,976	11,747	9,839	12,494	39,344	36,428
20-25	50,119	66,948	23,855	15,885	26,579	8,902	526	99	17,593	6,620	2,646	1,485	607	10,681	13,544	53,424
25-30	61,256	81,826	29,156	19,414	32,485	10,881	643	122	21,502	8,901	3,235	1,816	741	13,055	16,554	65,295
30-35	54,614	556,325	180,706	33,266	22,440	5,886	0	335	6,326	12,614	7,169	4,662	22,965	21,539	7,593	23,090
35-40	63,017	641,914	208,507	38,384	25,893	6,791	0	387	7,299	14,554	8,272	5,380	26,498	24,853	8,761	26,643
40-45	151,349	617,133	284,645	22,440	13,284	13,174	15,973	10,371	2,276	7,323	4,118	4,947	122,485	8,537	14,853	19,488
45-50	169,155	689,738	318,132	25,081	14,846	14,724	17,853	11,591	2,543	8,184	4,602	5,529	136,895	9,542	16,601	21,781
50-60	25,605	793,142	233,674	15,391	202,438	0	0	63,994	76,793	85,549	95,055	109,288	109,313	78,217	193,662	21,184
60-70	25,605	25,605	289,968	4,583	62,497	0	0	38,396	109,687	95,055	71,291	109,288	57,033	78,217	193,662	172,970
70-80	79,237	81,889	385,866	148,422	0	0	0	0	123,571	123,571	109,313	123,543	123,471	398,890	21,184	172,970
80-90	429,057	46,666	145,961	188,368	0	0	0	0	71,291	123,571	109,313	350,159	137,830	49,700	21,184	21,184
90-100	53,632	46,666	676,520	127,071	0	0	0	0	137,830	109,313	109,313	477,721	152,088	49,700	456,490	21,184
100-150	287,359	1,590,506	13,028,305	0	0	0	0	0	4,437	166,585	756,185	1,220,003	924,094	0	75,485	390,717
150-200	573,384	312,413	2,459,262	98,673	0	0	0	0	158,588	1,578,471	1,224,679	78,296	450,693	412,080	75,485	627,790
200-300	1,234,808	1,374,121	4,649,470	277,002	0	0	0	0	31,880	1,260,252	487,244	1,113,633	1,399,705	3,737,873	953,745	1,194,220
300-400	559,430	494,425	5,279,335	48,337	0	0	0	0	0	2,352,628	1,531,216	889,096	2,041,707	4,639,792	1,906,252	4,060,674
400-500	5,726,520	5,228,475	676,674	0	0	0	0	0	0	341,576	3,877,870	2,119,215	4,291,827	7,965,801	532,311	279,715

TABLE C-5

SUMMARY OF ENVIRONMENTAL IMPACTS AND FREQUENCIES

Probability of impact per reactor-year	Persons exposed over 200 rems	Persons exposed over 25 rems	Acute fatalities	Population exposure, millions of person-rems 50 mi/total	Latent[a] cancers, 50 mi/total	Cost of offsite mitigating actions, $ millions
10^{-4}	0	0	0	0/0	0/0	0
10^{-5}	0	10,000	0	10/27	850/2,000	700
$5x10^{-6}$	2	27,000	0	21/50	1,900/3,900	1,500
10^{-6}	46	98,000	7	67/150	5,600/10,600	4,300
10^{-7}	5,000	430,000	47	120/400	10,400/28,400	9,800
10^{-8}	20,000	940,000	290	130/610	14,300/45,000	20,000
Related figure	C-5	C-5	C-7	C-6	C-8	C-9

[a]Includes cancers of all organs.

TABLE C-6

COMPARISON OF SURFACE WATER TRANSPORT

PARAMETERS FOR LPGS ESTUARY SITE AND HOPE CREEK SITE

	LPGS estuary site	Hope Creek	Source of Hope Creek information
Fresh water flow rate (cfs)	13,000	16,500	FES
Cross sectional area (ft^2)	160,000	538,000	NUREG/CR-1596
U_F, fresh water velocity (ft/sec)	0.081	0.031	Calculated from Q/A
E_L, eddy diffusivity (ft^2/sec)	1,500	1,900	Ref. C-31
L = estuary length (ft)	607,200	834,000	FES

Based on these parameters, the value of the integrated concentration in the Delaware estuary is 0.6 times that in the LPGS estuary.

TABLE C-7

AVERAGE VALUES OF ENVIRONMENTAL RISKS

DUE TO ACCIDENTS PER REACTOR-YEAR

Environmental Risk	Average/RY
Population exposure	
Person-rems within 50 mi	460
Total person-rems	1100
Acute fatalities	3.3×10^{-5}
Latent cancer fatalities	
All organs excluding thyroid	0.07
Thyroid only	0.009
Cost of protective actions and decontamination	$33,000

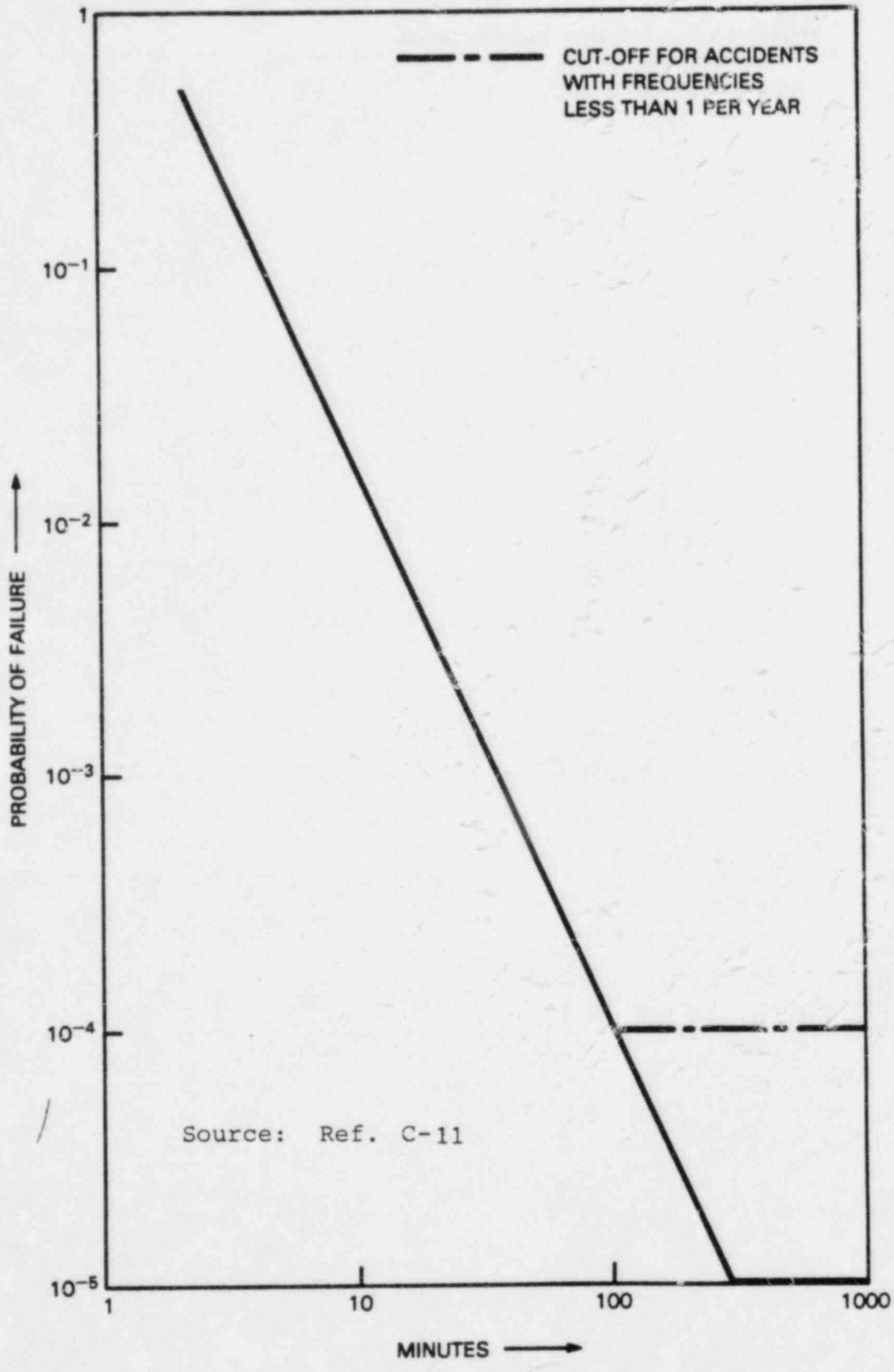
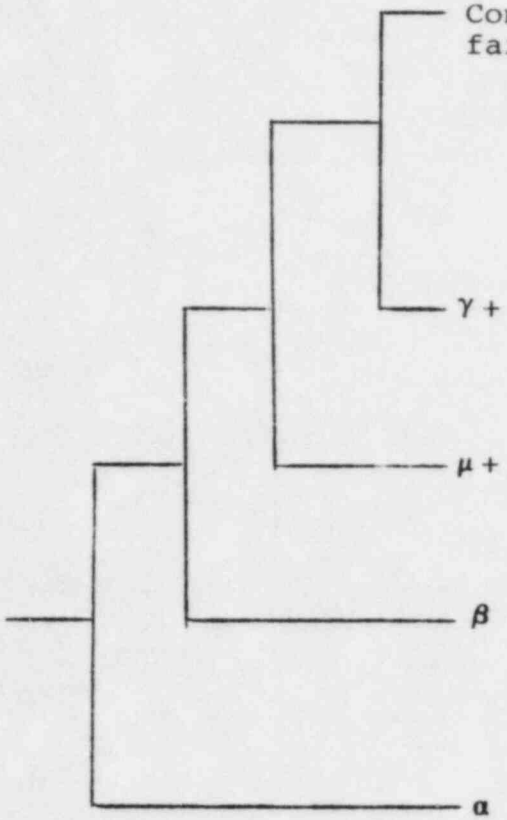


FIGURE C-1

FAILURE PROBABILITY VS TIME FOR OPERATORS

FIGURE C-2 CONTAINMENT EVENT TREE



	TW	TC	TQUV	AE	COMMENTS
Sum of other Containment failure modes	0	0	0	0	Sum of δ, ϵ, ξ, η and θ in WASH-1400. Values here consistent with WASH-1400 and IREP
γ	0.5 (0.8)	0.5 (0.8)	0.5 (0.8)	0.5 (0.8)	
γ'	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	
$\mu + \mu'$	10^{-2}	10^{-2}	10^{-2}	10^{-2}	Based on 70 hrs of de-inerting per year
β	ϵ (0)	ϵ (0)	ϵ (0)	10^{-4} (0.07)	Considerations: RPV failure mode, low energy conversion and lack of significant water in containment.
α	ϵ (10^{-2}) <10^{-4}>	ϵ (10^{-2}) <10^{-4}>	ϵ (10^{-2}) <10^{-4}>	ϵ (10^{-2}) <10^{-2}>	Considerations: lack of coherence of core melt, low energy conversion, vessel upper internals.

( ) WASH-1400
< > IREP

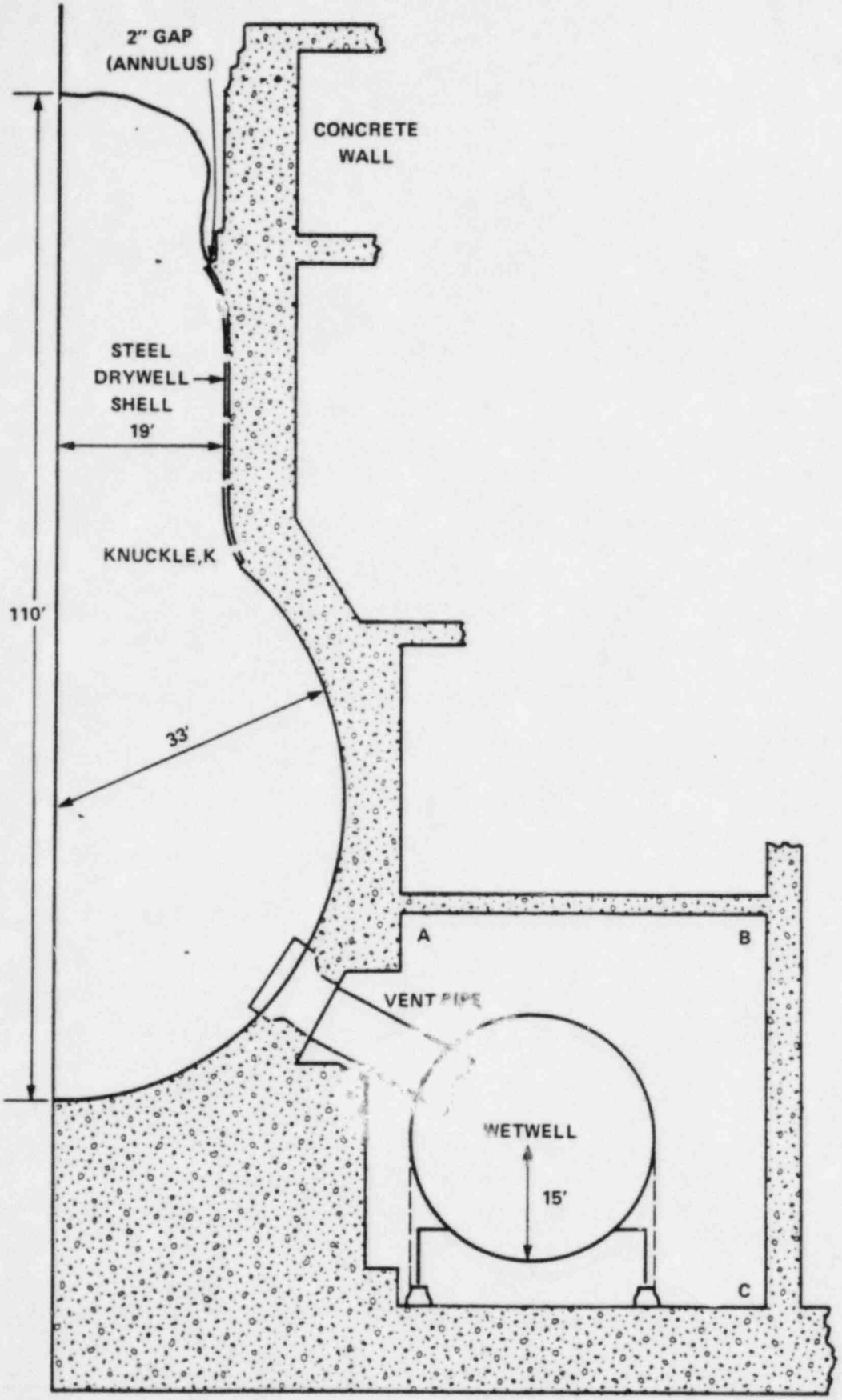


Figure C-3 SIMPLIFIED VIEW OF HOPE CREEK CONTAINMENT

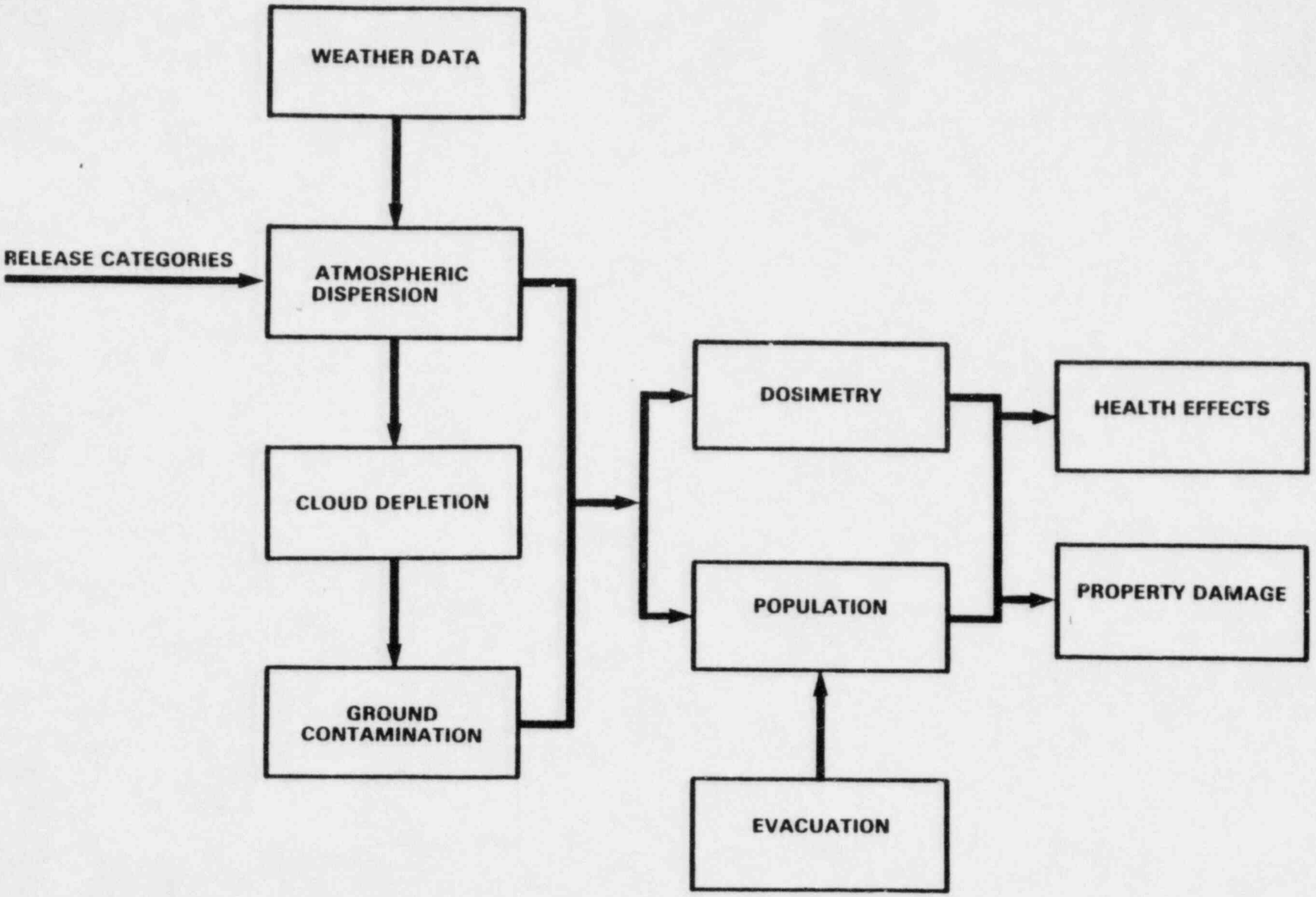


FIGURE C-4 SCHEMATIC OUTLINE OF CONSEQUENCE MODEL

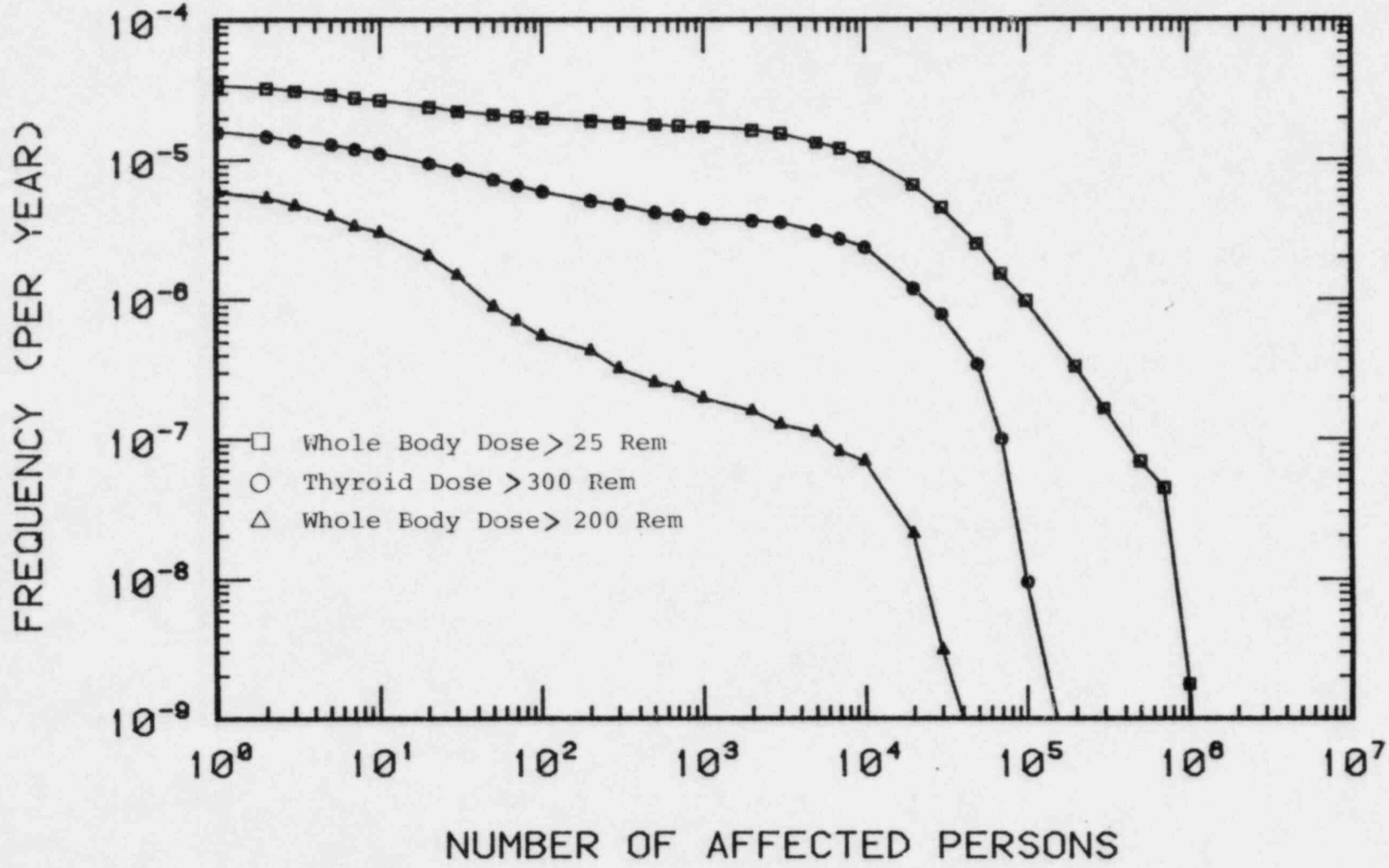


FIGURE C-5 CCDF OF INDIVIDUAL DOSE IMPACTS

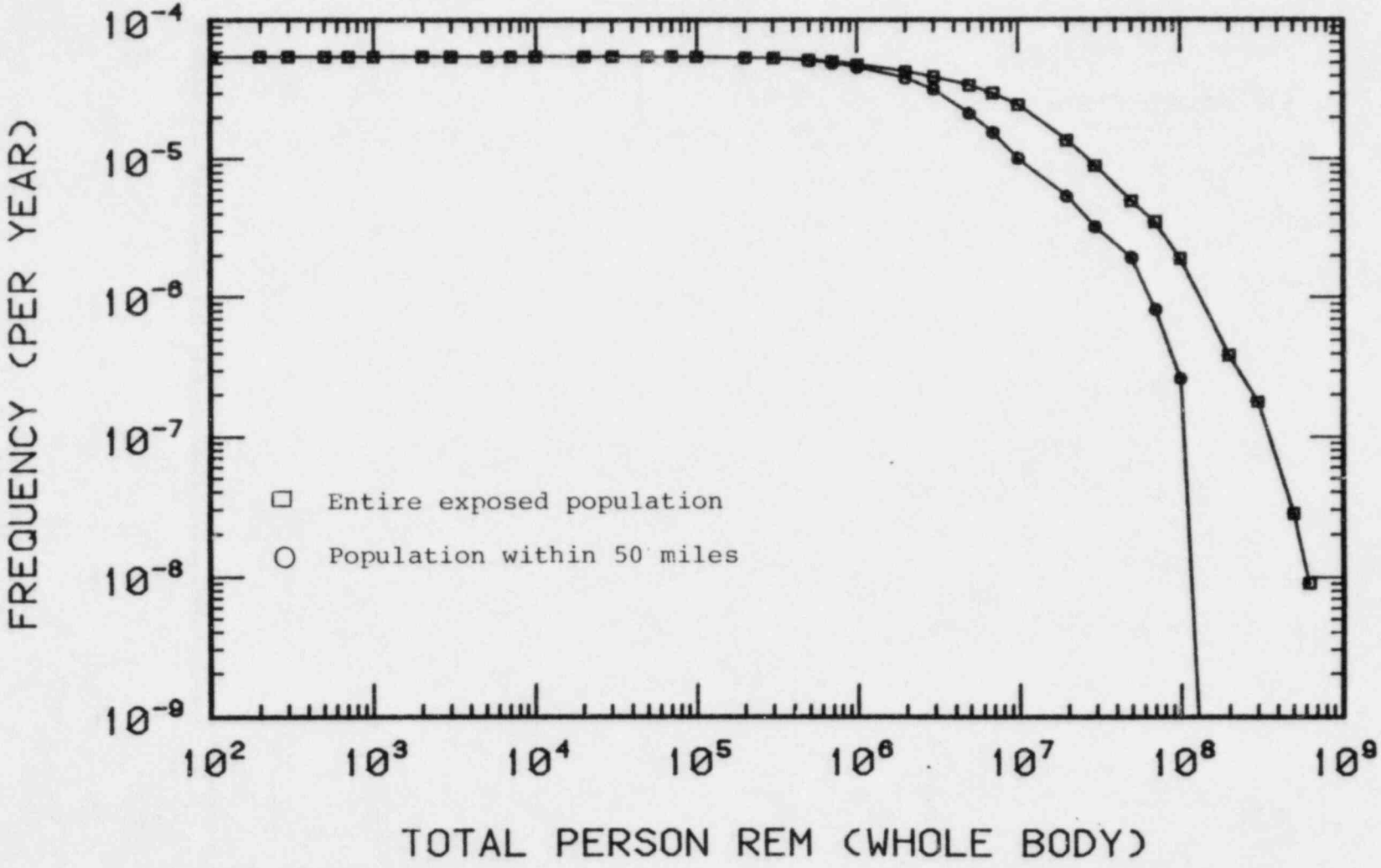


FIGURE C-6 CCDF OF POPULATION EXPOSURES

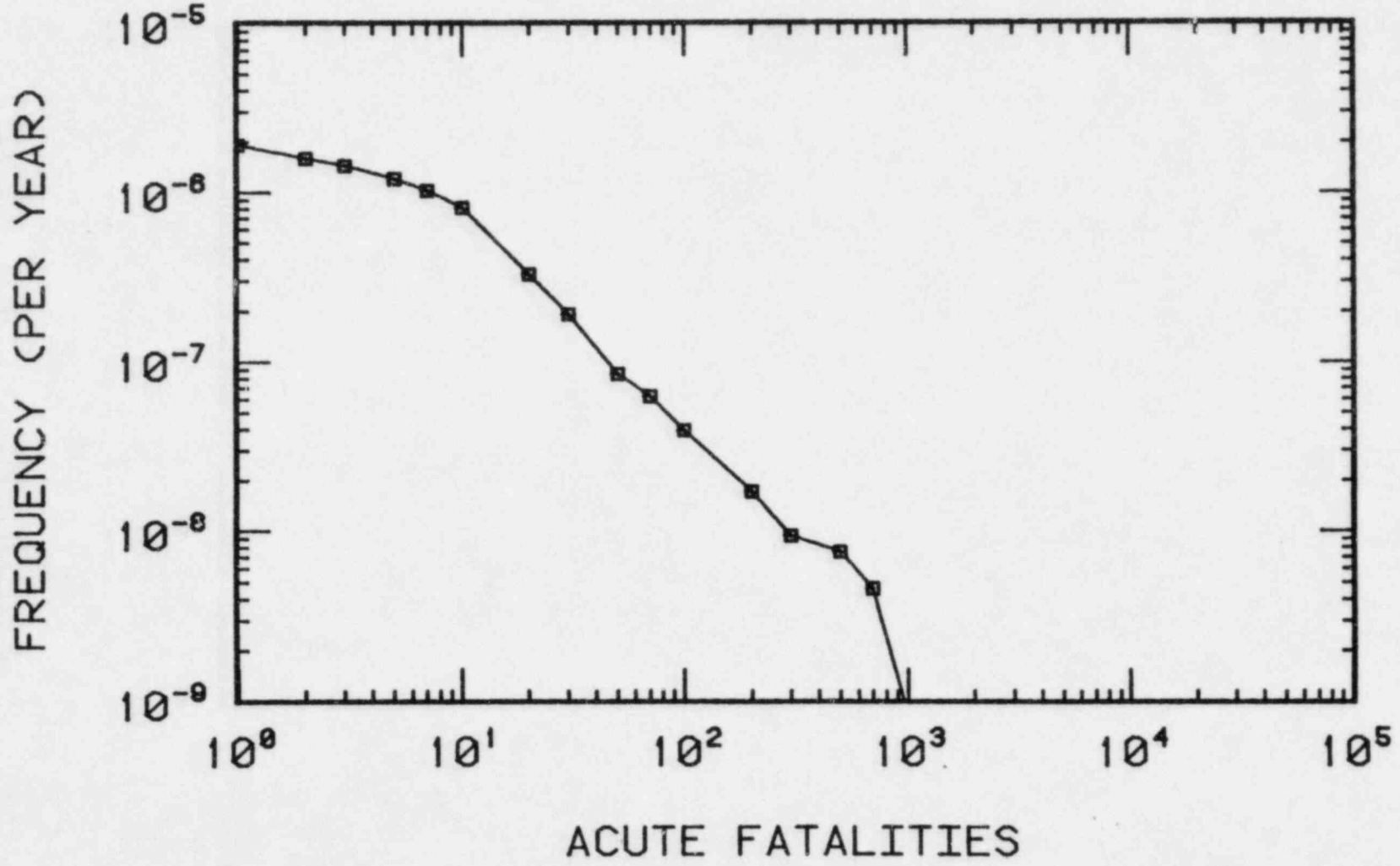


FIGURE C-7 CCDF OF ACUTE FATALITIES

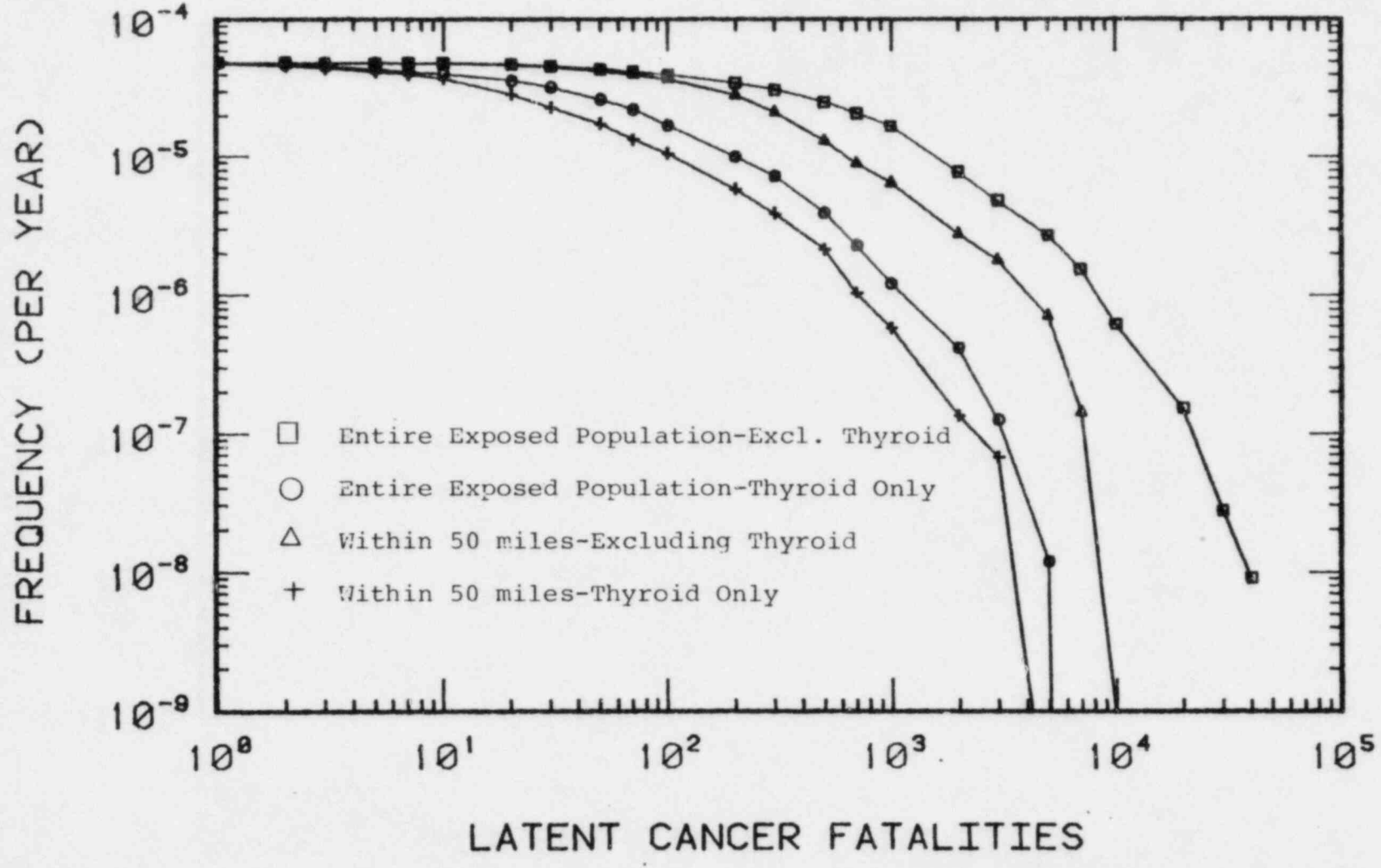


FIGURE C-8 CCDF OF LATENT CANCER FATALITIES

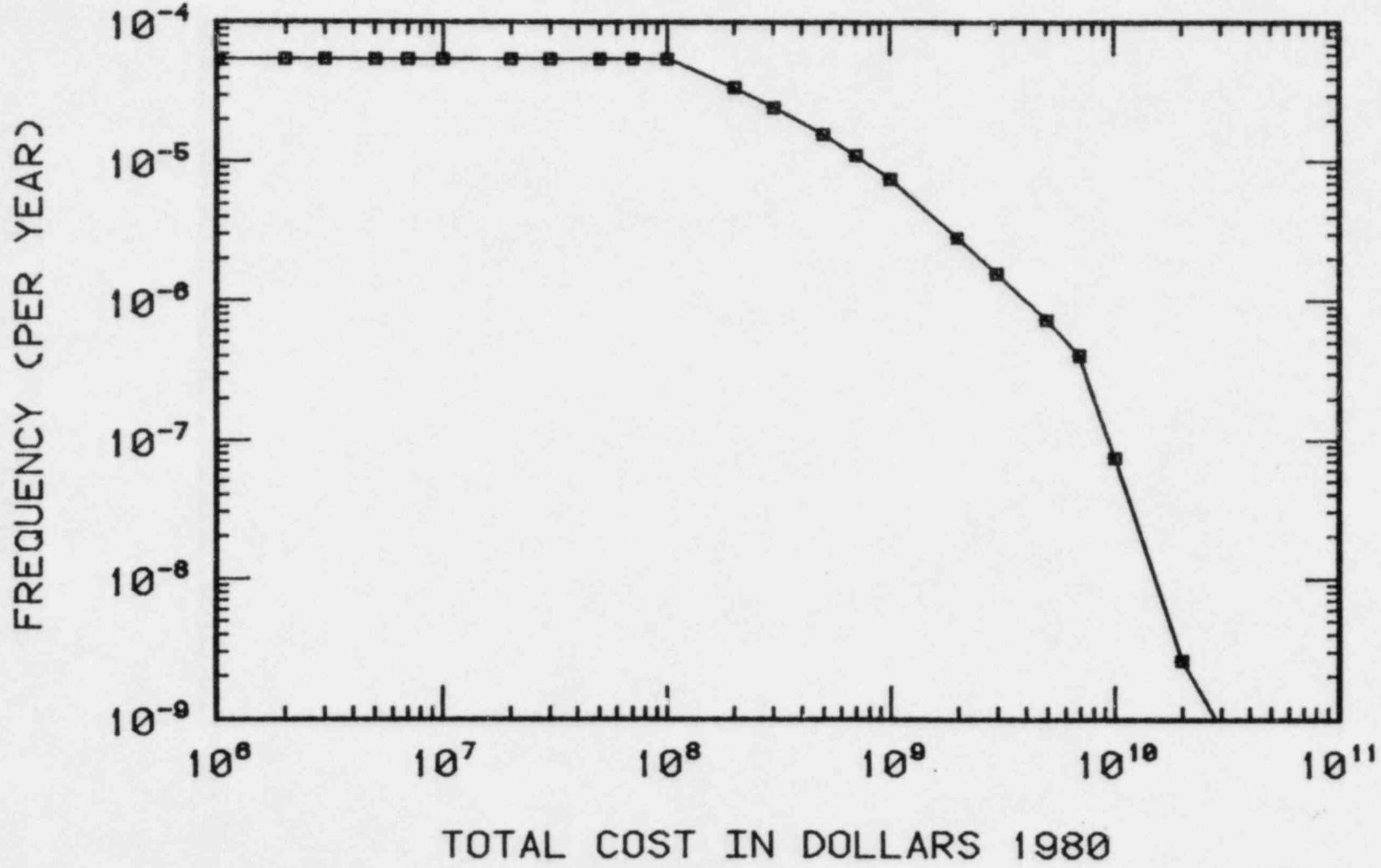


FIGURE C-9 CCDF FOR EX-PLANT COSTS

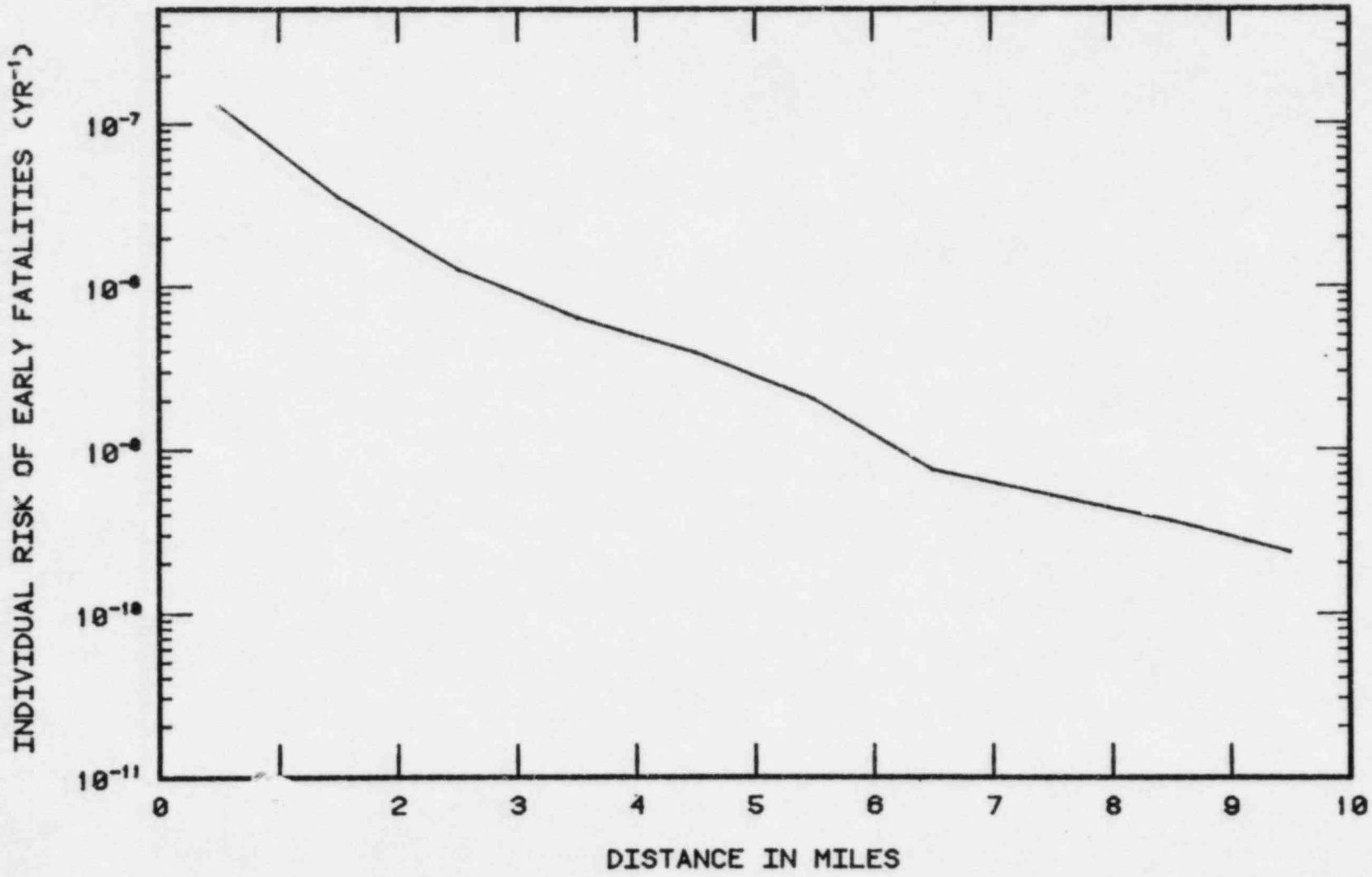


FIGURE C-10 INDIVIDUAL RISK OF EARLY FATALITY AS A FUNCTION OF DISTANCE